ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR THE PROPOSED ENCROACHER BUSH BIOMASS POWER PROJECT IN NAMIBIA

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Prepared for: NamPower

SLR Project No: 734.05062.00001
Revision No: 1
Month/Year: November 2020

DOCUMENT INFORMATION

Title	Environmental Impact Assessment (EIA) for the proposed Encroacher Bush Biomass Power Project in Namibia
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Keywords	EIB, NamPower, Bush Encroacher, Biomass Power Plant, Harvesting
Status	Final to MEFT for review and decision
SLR Project No	734.05062.00001

DOCUMENT REVISION RECORD

Rev No.	Issue Date	Description	Issued By
1	September 2018	Draft issued to client for NamPower review	WP
2	End September 2018	Revised Draft to EIB & SAEIA	WP
3	October 2019	Revised draft to NamPower, EIB and SAEIA	WP
4	July 2020	Final Draft for NamPower & EIB reveiw	WP
5	Octber 2020	Final Draft for I&AP reveiw	WP
6	Novemer 2020	Final to MEFT for review and decision	WP

BASIS OF REPORT

DISCLAIMER

The authors take full responsibility for the contents of this report. The opinions expressed do not necessarily reflect the view of the European Investment Bank.

The technical assistance operation is financed under the EU Africa Infrastructure Trust Fund. The Trust Fund, which was established in 2007, aims to increase investment in regional infrastructure in Africa by blending long term loan financing with grant resources from the European Commission and EU Member States.

EXECUTIVE SUMMARY

1. INTRODUCTION

This executive summary provides a synopsis of the Environmental Impact Assessment (EIA) report prepared as part of the EIA process executed by SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) for the proposed Encroacher Biomass Power Project (the "Project") by the Namibia Power Corporation (Pty) Ltd (NamPower) in Namibia.

1.1. Project overview

NamPower proposes the construction and operation of the Otjikoto Biomass Power Station (Project Site), which will generate electricity by the combustion of wood chips. A harvesting area of approximately 100 km radius surrounding the Project Site has been identified from where encroacher bush will be harvested, processed, and transported to the Project Site as its source of fuel.

As a result of a site selection process and the preceding EIA scoping phase, NamPower selected the site near Tsumeb for the construction of the proposed Otjikoto Biomass Power Station, which is in close proximity to their existing Otjikoto Substation. Refer to Figure 1 for the regional location of the proposed Power Station. The Otjikoto Biomass Power Station will have sufficient electricity generating capacity to evacuate 40 megawatt of electricity (MW_e) and will be connected to the Namibian electricity grid at the Otjikoto Substation via a new 66 kilovolt (kV) overhead power line.

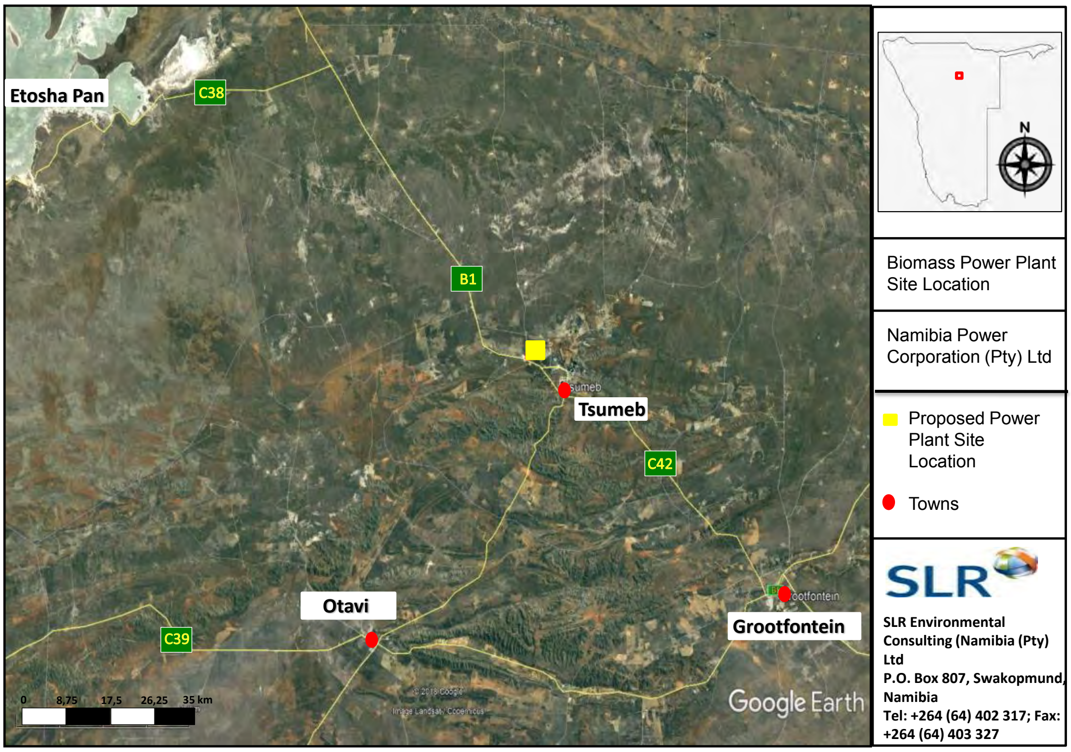

FIGURE 1 REGIONAL LOCATION OF THE PROPOSED OTJIKOTO BIOMASS POWER STATION

The proposed Project will consist of the following key components:

- Construction and operation of a 40 MW_e biomass power station and access road at the Otjikoto Site for at least 25 years which depending on the operating regime may have an annual fuel requirement of up to 245 000 tonnes of wood chips processed from encroacher bush;

- Harvesting, processing and storage of encroacher bush within the harvesting area which covers approximately 100 km radius surrounding the Project Site (roughly 3.1 million hectares (ha) excluding all no-go areas and other constraints in the harvesting area);
- Logistics, which include but are not limited to the transportation and stockpiling of the encroacher bush or wood chips from the harvesting area and delivery to the Otjikoto Biomass Power Station; and
- Construction and operation of a transmission substation at the Project Site, interconnection of the substation to the Namibian electricity grid with a 66 kV overhead power and rerouting of other power lines traversing the Project Site (in particular a 132kV power line owned by NamPower) .

1.2. Project Motivation (Need and DESIRABILITY)

It is estimated that approximately 26 million ha, mainly located in the north-central and central regions of Namibia, are covered by encroacher bush. Bush encroachment sees indigenous thorny bush and shrub species, found in natural rangelands, grow in such abundance that this encroacher bush has significant negative impacts. These negative impacts include; the suppression of grass reducing the livestock and wildlife carrying capacity of the affected areas, and the reduction of rainwater penetration required to recharge the important underground water resources. The encroacher bush provides a significant fuel resource that can be used for electricity generation.

The proposed Power Station will contribute positively to the Namibian economy allowing it to generate electricity from its own sources, thus reducing its dependency on external suppliers. It would assist with the stability of the electricity grid by delivering a base load capacity, and assist in providing ancillary support services associated with thermal Power Stations to a significant load centre, close to the Project Site, within the Namibian electricity network.

Other than the benefits associated with the electricity generation, the implementation of the proposed Encroacher Bush Biomass Power Project will have additional benefits such as; contributing to “combatting bush encroachment” and the restoration of rangeland through bush thinning practices, increasing land productivity, increased rain water infiltration, and improved business, employment and skills development opportunities. The overall goal of the Encroacher Bush Biomass Power Project is therefore to provide electricity through a sustainable and renewable forest production model. However, a secondary environmental related goal of the Project is to improve rangelands where the encroacher bush will be harvested.

The construction of the Power Station, the purchase of machinery for bush thinning, and the direct, indirect and induced economic benefits will boost the local, regional and national economy.

2. APPROACH TO THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The EIA is based on the Namibian Environmental Management Act (Act. No. 7 of 2007) and associated EIA Regulations, as well as supporting policies and guidelines. SLR has been appointed as the Environmental Assessment Practitioner to undertake the EIA process, including the public participation process and the compilation of the relevant EIA reports for the Project and its associated activities. The final EIA Report will be submitted to the Ministry of Mines and Energy (MME) (i.e. the Competent Authority) for consideration and further submission to the Ministry of Environment, Forestry and Tourism (MEFT) as regulator in order to consider the application for the two separate environmental clearance certificates (ECCs) comprising the following:

- Construction and operation of the 40 MW_e Otjikoto Biomass Power Station, near Tsumeb, which includes the transmission substation and transmission lines; and
- Related fuel supply activities, including the harvesting, processing, and logistics of supplying encroacher bush wood chips as the fuel source for the Otjikoto Biomass Power Station.

A full EIA process is required for the proposed project therefore, a screening (and project initiation) phase and scoping phase were already conducted and a final Scoping Report subsequently submitted to the relevant competent authorities and MEFT. This EIA Report is the outcome of the Impact Assessment Phase of the EIA.

2.1 Pre-application meetings and submission of Application Forms

Initiation meetings were held with the MME (the competent authority for the energy generation, transmission and storage activities) and MEFT: Directorate of Environmental Affairs (DEA). An application for environmental clearance was formally submitted to the MME on 1 June 2017.

Similarly, an initiation and introductory meeting was held with the Ministry of Agriculture, Water and Forestry (MAWF), now the Ministry of Agriculture Water and Land Reform (MAWL), and the application for environmental clearance was submitted to the MAWF on 9 October 2017. At the time, the MAWF was the competent authority for the fuel supply related and forestry activities.

Forestry activities now fall under the MEFT and the MAWL is no longer the Competent Authority for the fuel supply related and forestry activities.

Both Applications were registered on MEFT's online system in June 2020.

2.2 The Scoping Phase

During the scoping phase of the EIA which commenced in May 2017 and continued until March 2018, six potential sites were considered and investigated for the potential construction of biomass power station. Public and focus group meetings were conducted at each of the locations during the scoping phase which included; Gobabis, Windhoek, Okahandja, Otjiwarongo, Otavi, and Tsumeb.

At the end of the scoping phase, all applicable comments that were received from Interested and Affected Parties (I&APs) were addressed and included in the final Scoping Report that was submitted to the MME, the MAWF, and ultimately the MEFT. The Scoping Report was accepted by the MEFT on 21 May 2018.

2.3 The Impact Assessment Phase

Although two separate applications for ECCs were submitted to the two relevant competent authorities, respectively, a single detailed EIA Report has been compiled covering all consolidated activities related to the complete Project. The EIA Report further considers all potential and cumulative impacts associated with the Project activities.

However, due to two separate applications for ECCs being submitted to the above mentioned competent authorities, two separate Environmental Management Plans (EMPs) have been developed, as detailed below:

- EMP for the construction and operation of the 40 MW_e Otjikoto Biomass Power Station, near Tsumeb, which includes the transmission substation and transmission lines; and
- EMP for the related fuel supply activities, including the harvesting, processing and logistics of encroacher bush or wood chips for the Otjikoto Biomass Power Station as the main fuel source.

Various specialist studies were completed, and the findings were incorporated into the above mentioned documents. The specialist studies included; air quality, archaeology, biodiversity (including fauna and flora), noise, socio-economic, soil, ground and surface water, traffic, and visual impacts. Furthermore, a full greenhouse gas emission assessment of the Project was conducted in accordance with the European Investment Bank Guidelines.

2.4 Opportunity to comment

I&APs are invited to comment on this EIA Report, which is available for a 4-week comment period from **23 October to 20 November 2020**. Comments should be sent to SLR at the address, telephone number, or e-mail address shown below by no later than **20 November 2020**.

SLR Environmental Consulting (Namibia) (Pty) Ltd
Attention: Werner Petrick
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The following steps were undertaken during the remainder of the Impact Assessment Phase:

- Notify I&APs on the availability of EIA Report and EMP's:
  - The EIA report executive summary was distributed to all authorities and I&APs that are registered on the project's public involvement database via e-mail. Bulk text messages were sent to I&APs without emails (see email and text message wording in Appendix 16.1).
  - Electronic copies of the full report were available on the SLR website (SLR website: https://slrconsulting.com/public-documents and data free website: http://slrpublicdocs.datafree.co/publicdocuments) and on special request to SLR.
  - The availability of the report was advertised on the Namibian Broadcasting Corporation (NBC) national radio in various languages (see radio announcement wording in Appendix 16.1).
  - The availability of the report was advertised in the following newspapers on the 23 of October 2020: Republikein, Allgemeine Zeitung and the Sun See proof advert in Appendix 16.1) .Hard copies of the report were disseminated in the formats and at the locations listed in Table 1.
- Information sharing meetings with focus groups and key stakeholders will be held in Tsumeb during the review period of the EIA report and EMPs, as follows:
  - Focus group meetings with the Tsumeb Municipality representatives on 10 November 2020;
  - Focus group meeting with representative bodies of the San and other marginalised groups within the harvesting area on 8 November 2020; and
  - Focus Group meeting with representative Farmers Association(s) within the area on 9 November 2020.

  The minutes of meetings, attendance registers and presentation are included in Appendices 16.2 and 16.3.

TABLE 1 LOCATIONS FOR THE REVIEW OF THE EIA REPORT

Location	Name of Facility	Physical Address	Details
Tsumeb	Tsumeb Public Library	Dr Sam Nujoma Drive, Tsumeb.	Hard copy and electronic copy (CD) of the full report (including Appendices).
	Tsumeb Municipality	264 Moses Garoëb Street, Tsumeb.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).
Windhoek	National Library in Windhoek	1 Eugene Marais Street, Windhoek.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).
	NamPower Head Office	15 Luther Street, Windhoek.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).

All comments received by I&APs are included in Appendix 16.4. All comments, questions and concerns raised by IAPs are summarised in the Comments and Reports Report (CRR), with detailed responses and reference to relevant sections of the EIA reports (where relevant). See Appendix 16.5 for the IRR.

3. OTJIKOTO BIOMASS POWER STATION DESCRIPTION

The following section provides a brief description of the key aspects of the Otjikoto Biomass Power Station which were considered when assessing the potential impacts for the construction and operation of the Power Station.

3.1 Grid Connection Infrastructure

The proposed Power Station will be connected to the national grid at the existing Otjikoto Substation via a new 66 kV transmission line (±3 km in length). The tie-in at the Otjikoto Substation will include the construction of a new feeder bay and expansion of the existing 66 kV yard. There will be a new transmission substation constructed on the Power Station site in order to step up the voltage from 11 kV to 66 kV.

There are existing transmission lines that traverse the Project Site that will be re-routed to ensure minimal interference with the proposed construction activities and optimal use of the Project Site.

3.2 Otjikoto Biomass Power Station Technical Description

The proposed technical description for the Otjikoto Biomass Power Station are as follows:

- Size: 40 MW_e (net export capacity);
- Grate fired boiler technology;
- Dry cooling via an air cooled condenser;
- Net electrical efficiency at full load approximately 28~30%;
- Capacity factor (CF): 70~85%;
- Availability: 92%;
- Fuel requirements: 200,200 tonnes at 70% CF (likely scenario), 245,000 tonnes at 85% capacity factor (worst case scenario); and
- Design lifetime: 25 years, (30 years is considered typical).

The proposed Power Station will have a footprint of 10 ha at its maximum without ash storage. With onsite ash storage, fuel stockpiling, and receiving facilities, this is expected to be approximately 25 ha. It is estimated that a 7 - 90 day stockpile will be required for the Power Station to operate at full capacity and accommodate any interruption in the fuel supply.

3.3 Boiler and Energy Conversion Process

Grate fired boiler technology is proposed due to its proven track record, simplistic design, lower construction and maintenance costs, which will offset the slightly higher efficiency advantages from fluidised bed technology. In addition, the grate fired technology is considered robust and as such can handle a larger woodchip size, whereas fluidised bed technology requires a finer and smaller woodchip size, which means more processing and higher fuel costs.

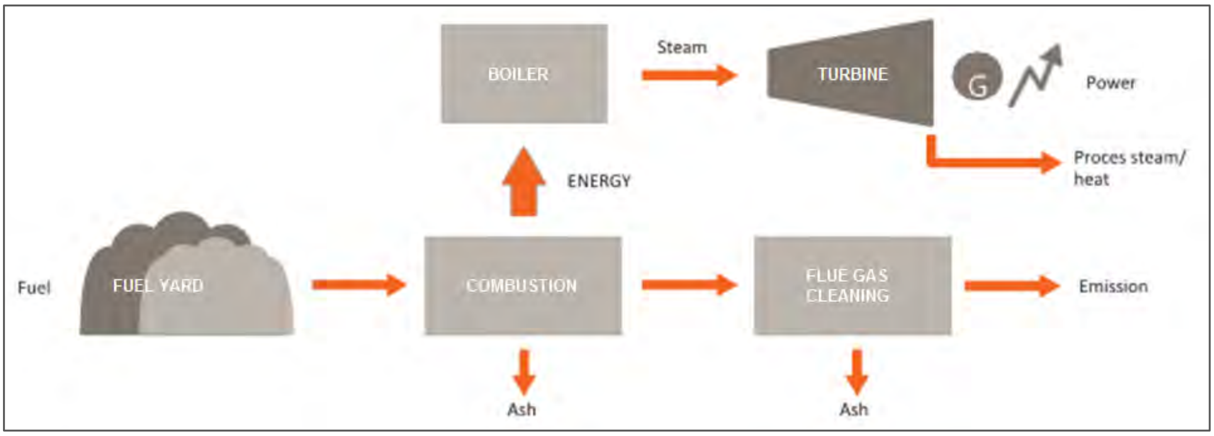

FIGURE 2 TYPICAL CONFIGURATION OF A BIOMASS COMBUSTION PLANT

Figure 2 shows that a boiler converts the energy from the combustion of woodchips into high-pressure steam. The steam is transformed into electrical energy through a steam turbine, which drives a generator producing electricity. After the steam has passed through the turbine, it is condensed back into water and recycled back to the boiler, where it is reheated into steam again. The boiler and steam turbine are the most commonly used technology to produce electricity from a conventional fuel source such as biomass.

3.4 Emissions and Flue Gas Cleaning

During combustion, various kinds of impurities and pollutants are generated and passed through the process as flue gas (i.e. the exhaust gas coming from the boiler). These include; fine ash particles, oxides of nitrogen (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), and greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The temperature in the primary combustion is insufficient to eliminate all emissions and pollutants from the process, a secondary treatment system may therefore be required. Typically for biomass boilers, dust and particulates within the air from the primary combustion system pose a problem and are considered the main pollutant of concern.

A cleaning system, such as bag house filters or electrostatic precipitators, will be installed for the removal of particulate matter (PM). If future emission values require further flue gas cleaning (based on the monitoring requirements included in the power station EMP), NOx emissions can be reduced by primary measures such as flue gas recirculation or retrofitting a selective non-catalytic reduction (SNCR) system in the combustion chamber of the boiler.

During the EIA an optimum stack height was calculated as part of the initial plant design (see the Air Quality, Climate Change, and Health Risk Assessment Report included in Appendix 5). This was based on Good Engineering Practice (GEP) and dispersion modelling. These simulations were conducted to demonstrate the reduction in ground level concentrations (GLCs) to sensitive receptors surrounding the Power Station as a result of a GEP stack design. The Power Station parameters, based on 6% oxygen, are provide in Table 4.

TABLE 2 POWER STATION STACK PARAMETERS

Stack Height	Stack Diameter	Exit Velocity	Exhaust Vol.-Flow	Exit Temp (°C)
60 – 75 m	1.75 m	15 (m/s)	36.08 m^3/s	125 °C

3.5 Bottom Ash and Fly ASH

During the combustion process, two different types of ash with different physical and chemical characteristics will be produced. Both bottom ash and fly ash are classified as non-hazardous.

Bottom ash from the residue of the combustion process, will be temporarily stored on either a demarcated concrete area designed to contain surface water runoff, or within dedicated bottom ash skips.

The fly ash, extracted from the bag-house filter or electrostatic precipitators, will be temporarily stored in a dedicated fly ash silo for easy handling and transportation off-site.

The fuel analysis completed during the Feasibility Study, shows that ash represents approximately 6% of the biomass fuel. Laboratory tests were conducted on ash samples from a smaller biomass boiler in Namibia, to analyse for total concentrations and particle grading, as well as water soluble content. Another ash sample from a bushfire was taken and analysed for the same parameters. The bottom ash and fly ash mostly differ in their particle grading with the bottom ash having much coarser fractions and the fly ash being very fine. The chemical properties of the two types of ash are very similar. Various ash disposal methods have been identified as a result of these tests, and are presented in further detail within the EIA report. In summary, these options include the following:

- Taking the ash back to the farms or areas where the bush was harvested (i.e. for use as fertilizer);
- Use the ash as a fertilizer at irrigation farms in the nearby area;
- Use the ash to cover waste facilities; or
- Use in the construction industry, possibly in combination with the other potential uses.

Other (less favourable) options include:

- Dispose of as a waste at a new facility at the Power Station site; and
- Dispose of as a waste on an existing landfill site.

NamPower will conduct a detailed ash analysis shortly after operation commences. A cost benefit analysis will then be conducted to determine the best option, from those provided above, based on the assessed impacts and potential restrictions of the local procurement regulations.

3.6 Water Source, Usage and Infrastructure Requirements

A geohydrological study indicated that the proposed Project Site is located in a high groundwater potential area where the water requirements for the proposed Otjikoto Biomass Power Station, estimated to be 5 m^3/hr, can be sustainably met without significantly impacting the water supply in the region.

3.7 Fuel Specification and Volumes

In order to derive the fuel specification for the Otjikoto Power Station, various laboratory analyses were conducted on biomass woodchips harvested at the initial six locations as part of the Feasibility Study. The fuel specification for the Power Station will be set to a P100 specification according to EN ISO 17225 (which implies biomass woodchips with majority of the size weighted between ≤ 100 mm in length). It should be noted that the Power Station will make provision to accept larger wood or bush extracts for further processing on Site.

The results from the laboratory results show that the calorific value (CV) of Namibian biomass and more specifically the samples taken from the Otjikoto region have an average net CV of 17.7 MJ/kg on a dry weight basis. The assumption for the calorific value (CV) of the fuel has been taken as 14.7 MJ/kg (as received with 15 % moisture and 6 % ash).

Table 3 shows the average fuel requirements (dry basis) for the power station operating at the worst case (base load) Capacity Factor (CF) 85%. Table 3 assumes the following:

- Effective biomass per hectare (dry weight basis) 12.65 t/ha
- Calorific value of fuel (dry weight basis) approximately 14.7 to 16.7 MJ/kg

- Expected moisture content ranging between approximately 45 % (rainy season) to 5% (dry winter months)

TABLE 3 TYPICAL BIOMASS POWER STATION FUEL REQUIREMENTS

Parameter	40 MWe
Hourly fuel demand (100% MW_{th})	26.89 tonnes/hr
Annual fuel demand (85% CF)	245 000 tonnes/a
Harvested area required p.a.	Approximately 20 000 ha/a

3.8 Construction

The construction of the Otjikoto Biomass Power Station will be executed by appointing an Engineering, Construction and Procurement (EPC) contractor, administered by NamPower through the Central Procurement Board in accordance with the Namibian Public Procurement Act of 2015. Approximately 300 jobs would be created during the peak times of the planned 35 month construction phase of the Project.

The employment of local people near to the Project Site during the construction phase would be preferred, particularly for unskilled and semi-skilled labour works.

During operations, NamPower anticipates that approximately 62 employees will be required to operate the Otjikoto Biomass Power Station. The employment will be made up of 35 operational/maintenance staff and 27 service staff; the majority of the staff will be skilled and semi-skilled workers who will be permanently employed by NamPower. As Tsumeb is a mining and processing hub, it is likely that some skilled, semi-skilled, and unskilled personnel maybe sourced locally for the operations and maintenance of the power station.

4. PROJECT RELATED FUEL SUPPLY ACTIVITIES

The following section describes and details the harvesting related activities for the Project that were considered when assessing the potential associated impacts.

4.1 Identified Harvesting Area and Resource Assessment

A detailed resource assessment was undertaken as part of the EIA scoping phase and the Feasibility Study for the Project in order to investigate the potential quantity of encroacher bush available. A harvesting radius of 100 km around the Project Site was identified as part of the resource assessment, which is approximately 3.1 million hectares including no-go zones and protected areas.

A harvesting area of approximately 396 250 ha is necessary to sustain a biomass power station of 40 MWe over its design lifetime of 25 years. To place this requirement in perspective, it translates to approximately 12.8% of the investigated harvestable area. Similarly, a total of 39.215 million tonnes of encroacher bush can be conservatively extracted from the harvesting area, which is enough to power a 40 MWe biomass power station for 195 years at baseload. NamPower is therefore confident that there is sufficient resource to sustainably operate the plant without considering any inevitable regrowth of encroacher bush. If part of the farm cuts the boundary of the harvesting area that farm is included in the harvesting area. NamPower will conduct an assessment of the specific farms falling in and out of the harvesting area, subject to approval of the ECC.

Restricted or protected harvesting locations were further identified and refined through the EIA scoping study and are indicated in Figure 3, which includes:

- National Parks (i.e. Etosha and Waterberg National Park);
- Slopes exceeding 12.5% gradient;
- Sensitive bioclimatic endemism; and
- Communal areas.

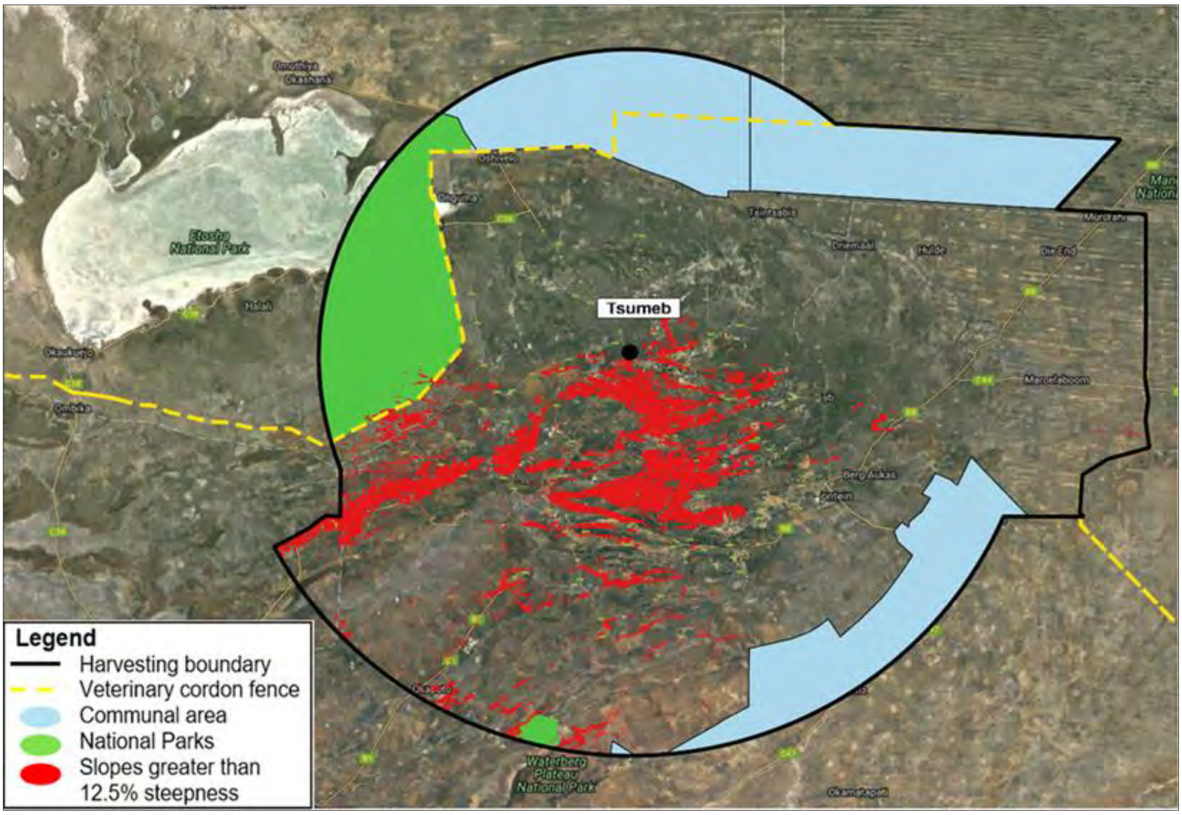

FIGURE 3: LOCALITY MAP FOR THE PROPOSED HARVESTING AREA

4.2 Target Species for Harvesting

For the purpose of this Project, only Namibian encroacher bush was selected as a fuel source. Namibian encroacher bush is available in abundance and is considered a renewable energy source due to its tendency to rapidly regrow and increase in numbers or coppice in their original habitat through inappropriate chopping or burning. The target species to be harvested are summarised in Table 4 (this list may include other species as advised by the MEFT).

TABLE 4 TARGET SPECIES TO BE HARVESTED

Target Species		Protection status
Scientific name	Common name	
Acasia mellifera	Black-thorn acacia, swarthaak, omusaona	Not protected
Acasia reficiens	Red umbrella-thorn, rooihaak, rotrindenakazie	Not protected
Acasia luderitzii	Kalahari acacia	Not protected
Acasia erubescens	Yellow-bark acacia, omungongomwi, withaak, berkebos	Not protected
Acasia fleckii	Sandveld acacia, blade-thorn, mungamba	Not protected
Acasia nebrownii	Water-thorn, /nubib, orupunguya, slapdoring, pfannenstrauch	Not protected
Dichrostachys cinerea	Sickle-bush, omutjete, sekelbos, papwielbos, farbkätzchenstrauch	Not protected

Terminalia sericea	Silver cluster-leaf, mugaro, omugolo, za'o, geelhout, vaalboom, fahlbaum, gelbholz	Not protected
Colophospermum mopane	Mopane	Protected. Thinning is only allowed in cases of high densities.[1]
Rhigozum trichotomum	Three-thorn rhigozum, //hau.b/s, okatakambindu, driedoring, dreidorn	Not protected
Prosopis	Prosopis	Not protected

4.3 Contracting Methodology and Harvesting workforce

NamPower is planning to contract long term fuel suppliers which will supply at least 140,000 tonnes/annum. In addition, NamPower plans to contract a number of ad hoc fuel suppliers to supply at least 30,000 tonnes /annum to increase the spread of social and economic benefits of the Project. The wood chip quantities allocated to both long term and ad-hoc fuel suppliers will be set to ensure the complete fuel requirements of the Otjikoto Biomass Power Station are met.

Both ad-hoc and long term fuel suppliers will be required to enter into formal fuel supply agreements with NamPower that will contain clauses enforcing compliance to the EMP and ECC conditions through a set of contractual agreements.

4.4 Access to the Resource

Access to the resource is influenced mainly by the physical infrastructure (i.e. access roads and gates, bush density, harvesting equipment and topography) as well as the related commercial arrangements with the respective resource owners.

One of the critical roles associated with the fuel suppliers is to secure access to land with suitable resource for harvesting. For the execution of this Project, it is anticipated that the majority of the encroacher bush will be sourced from agricultural (commercial) farmland, as the additional approvals required for harvesting on Communal Land (i.e. Communal Land Act of 2002 and the Forestry Act of 2001) may currently prevent harvesting of biomass on communal or state lands. Regardless of the land classification, it is important that the fuel supplier obtains the requisite consent and rights to harvest from the correct and rightful owner(s). This consent will be provided by virtue of a harvesting agreement that will be signed by the landowner and the long term fuel supplier, in the event that they are separate entities.

The fuel suppliers and respective resource owners will need to compile and submit a verifiable Site Specific Harvesting Plan (SSHP) indicating the agreed areas for harvesting, all no-go areas, access roads, and other areas to be avoided. This Site Specific Harvesting Plan will be reviewed and approved by NamPower, in accordance with the EMP and will form part of the harvesting agreement.

4.5 Harvesting methodologies

Different felling equipment can be used to harvest bushes and will vary depending on the size of the bushes to be harvested and the level of mechanisation of the harvesting operation.

For small-scale harvesting; manual (labour intensive) felling methods are typically used. These manual and semi-mechanised harvesting methods involve the use of one or more of the following equipment :

[1] The conditions under which the *Colophospermum mopane* is classified as a protected plant is not for its population size, but due to its extent of use (EU). The species is heavily utilised by humans and animals (browse and forage) - charcoal, timber, fuel wood, construction, medicine, host to important edible caterpillar, its slow growth rate and its cultural value. (Forest Regulations 2015: Forest Act (Act. No. 12 of 2001)).

- Axe, panga / machete, pruning and pruning shears, hand saws;
- Trolley with power driven saw type cutters or bit type circular cutters;
- Tractor drawn slasher (‘Power take-off (PTO) driven);
- Multi-circular saw PTO driven (limited application); and
- Hand held chain saws (limited application, mainly because of the bush shape and high abrasive de-bushing conditions in Namibia).

For larger harvesting operations larger, fully mechanised methods are used to harvest. These fully mechanised biomass harvesting methods involve the use of one or more of the following equipment in combination:

- Skidsteer harvester equipped with horizontal rotary cutter or circular sawblade;
- Three wheel loader equipment with buncher and hydraulic cutter;
- Hydraulic grab and or buncher with blade cutter;
- Hydraulic grab and tree puller/bush lifter (for soft, wet sandy soils and riverbed clearing); and
- Bush combined harvester and grinder plant on tracks with shuttle bucket.

Although all methodologies were considered in the impact assessment, the fully mechanised process is likely to provide the bulk of the fuel required, as the volumes required for the Otjikoto Biomass Power Station may not be reliably met with only the manual harvesting methods.

The type of equipment and harvesting method to be used will be dictated by the requirements in the EMP and Harvesting Guidelines (SAIEA, 2017), which include but are not limited to requirements relating to bush thinning, avoiding sensitive species and habitats, and avoiding large trees.

Following the felling of bush, it is racked or pushed on to heaps and dried in windrows (typically 4 – 6 weeks), after which it is chipped, grinded or shredded to the required fuel specification. The biomass wood chips or log wood may be temporarily stored in field until a sufficient quantity has been accumulated for transportation to the Otjikoto Biomass Power Station.

5. PROTECTING BIODIVERSITY AND AFTERCARE COMMITMENTS

One of the benefits of the proposed Project is the restoration of degraded savannah through bush thinning practices. This will create opportunities to restore ecological structure, function, and composition in a way that will simultaneously improve agricultural rangeland productivity and should provide an overall increase in biodiversity. To maximize the potential biodiversity improvement the type of equipment and harvesting method used will be dictated by the requirements in the EMP and Harvesting Guidelines (SAIEA, 2017), relating amongst others to bush thinning, avoiding sensitive species and habitats, avoiding large trees, etc.

The biodiversity specialists confirmed through their studies that herbaceous biomass increases after woody plant harvesting, but that aftercare is required to sustain a high herbaceous production (i.e. an open savannah state) over longer time frames. How the harvesting is conducted and how the harvesting area is managed after harvesting will greatly impact on the effort required to maintain the open savannah state.

The EIA determined that aftercare will need to be conducted, and the responsibility will therefore need to be ensured and audited through the custody of the harvesting and fuel supply agreements. Aftercare in the current context deals mainly with the coppice (sprouts) of harvested plants, existing saplings of encroacher species not harvested and emerging woody recruits. Aftercare methods differ with regards to the potential impact on the environment, which may be positive or negative. The methods that were assessed as part of the EIA are summarised as follows.

- Recommended methods include the following:
    - Treatment of cut stump surfaces with registered arboricide;
    - Foliar spot treatment of resprouting / emerging woody plants between 2-8 months after harvesting with a registered arboricide e.g. arboricides with active ingredients such as Picloram; and

    - Manual uprooting of regrowth, saplings and seedlings (simply cutting/sawing of plants is not effective)
- Less desirable methods include the following:
    - Fire; and
    - Browsers such as goats. Game are considered too difficult to control to be effective as an aftercare method.
- Methods that are not recommended include the following:
    - Soil applied arboricides;
    - Heavy mechanised machinery such as rollers, bulldozers, chains, etc.

Due to the various harvesting and aftercare methods available and the limited research done on the long term effects of harvesting and aftercare, an adaptive management approach is proposed that will ensure that as the Project progresses the harvesting and aftercare methodologies can be monitored, adjusted, and improved.

6. PROJECT AND ENVIRONMENTAL BASELINE DESCRIPTION

An understanding of the environmental and social context within which the proposed Project activities are being located is important to understand the specific sensitivities and potential impacts of the Project. For this EIA, the receiving environment is defined as the geophysical system, the biophysical system (which includes flora, fauna, and the general ecosystem dynamics), the social environment (including farms, settlements, and relevant towns) and the economic environment (including livelihoods and commercial activities).

Existing knowledge and evidence suggest that the region encompassed by the proposed harvesting area is encroached by several species, with prominent species being sickle bush (*Dichrostachys cinerea*), black thorn/swarthaak (*Acacia mellifera*) and mopane (*Colophospermum mopane*). Previous rough estimates show that the density of encroacher species is relatively high in the proposed harvesting area. The receiving environment is described in detail in Section 6 of the EIA report.

7. ENVIRONMENTAL IMPACT ASSESSMENT

The current (receiving) environment was studied and the environmental aspects and potential environmental impacts associated with the activities and facilities were identified as part of the EIA process. Potential environmental impacts were identified by SLR in consultation with I&APs, regulatory authorities, specialist consultants, and NamPower. The impacts are discussed under issue headings in Chapter 7 of the EIA report.

Impacts were considered in a cumulative manner where possible, such that the impacts of the proposed Project can be compared to the baseline conditions described in Section 6 of the EIA report. Key management and mitigation measures to address the identified impacts are discussed in this section and included in more detail in the two EMPs that are attached in Appendices 14 and 15 of the EIA report.

Table 5 and Table 6 provide a summary of all the issues and impacts identified, the significance rating in the unmitigated and mitigated scenarios arising from the assessment , and a summary of key management and mitigation (or enhancement) measures and further monitoring and audit activities for the Power Station and its related fuel supply activities, respectively. For an exhaustive list please refer to the Environmental Management Plans for the Power Station and related harvesting activities respectively.

7.1 Otjikoto Biomass Power Station

TABLE 5: IMPACTS AND MITIGATION MEASURES FOR THE POWER STATION ACTIVITIES

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
Traffic	Impact on road capacity and road condition/deterioration – TR 1/10	M	L	• Proper scheduling of the biomass transport to ensure peak arrival do not occur at the same time.
	Impact at the TR 1/10 and DR 3007 Intersection	M	L	• Upgrade the intersection in accordance with Namibian Roads Authority Standards.
Soils	Soil compaction potentially affecting plants and animals above the soil surface, as well as soil macro-fauna and microorganisms below the soil surface – Power Station area	M	L	• Restrict vehicular movement to areas of development of the proposed Otjikoto Biomass Power Station and associated infrastructure, the power line servitude and the dedicated access road as far as possible.
	Loss of the natural functioning of the soil as growth medium – Power Station area	M	L	• Topsoil shall be utilised for landscaping within the proposed Power Station site boundaries.
	Soil contamination through deposition of ash material from the plant	H	L	• Analysis of fly ash and bottom ash once the plant is operational to compare with the samples analysed for the EIA. • Ash to be dispersed and used as fertilizer at the harvested farms or used for alternative applications or disposed of at an approved municipal landfill, in line with their approved EMP.
	Soil contamination through fuel and oil spills at the Power Station site	M	L	• Comply with Spill Prevention and Management Plan in the EMP.
Biodiversity	Loss of habitat, destruction of animals and plants and general disturbance of biodiversity	M	L	• Keep footprint as small as possible within the design brief and do not clear areas that are not within the infrastructure footprint or outside the fire safety buffer of infrastructure.
	Collisions and electrocution of birds on power line structures	L	L	• Monitoring of bird collisions (see Section 9.1.1 of EIA for more details). Should monitoring indicate that collisions are taking place on power line

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
				structures associated with the project, apply suitable mitigation measures the effectiveness of which should also be monitored.
Surface Water	**Decrease in downstream surface water runoff due to the Power Station and associated infrastructure**	L	L	• No mitigation required.
	Contamination of surface water from pollutants at the Power Station and associated activities	H	L	• Storm water Management Plan to be developed to determine the extent of contact water runoff and how to contain the polluted water on site and to divert clean water around the site.
	Contamination of surface water from ash from the Power Station ending up in the runoff	H	L	• Ash management plan to be developed for alternative use of ash other than stockpiling (refer to the EMP). Comply with storm water management plan.
Groundwater	**Impacts of groundwater due to over-abstraction on the underlying aquifer**	L	L	• Obtain abstraction permit and monitor the planned wells on site. • Process water should be recycled where possible and re-used.
	Contamination of groundwater from pollutants at the Power Station and associated activities	H	L	• Comply with Spill Prevention and Management Plan in the EMP. • Regular sampling at monitoring boreholes • No discharge of untreated sewage into the environment.
	Seepage of effluent (i.e. discharged brine) from the water treatment plant impacting the water quality in the underlying aquifer	M	L	• Waste water to be safely stored before it is disposed in the approved manner of designated disposal sites • Regular sampling at monitoring boreholes

	Leaching of ash constituents from the onsite storage/disposal piles, impacting on the underlying aquifer	H	L	• Analysis of fly ash and bottom ash
				• For ash disposal at the Power Station site the following will apply:
				  ○ Bunding and lining of the storage pile
				  ○ Regular groundwater monitoring
				• The ash should preferably be used for alternative applications.

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
Air Quality	**Air pollution impact on third parties i.e. nuisance impacts and third party health impacts.** • Construction phase – TSP, PM_{10} & $PM_{2.5}$ • Operational – PM_{10}, $PM_{2.5}$, SO_2 and NO_2	M	L	• The power station should be designed with a 75m stack height unless NamPower's Technical advisers or the appointed EPC Contractor submit an air quality study for approval based on their proposed emission control technologies and stack height. The air quality study should prove that the potential impacts relating to the Ground Level Contaminants remain similar to those assessed in the air quality specialist report conducted as part of this EIA. • The power station should be designed to meet the World Bank Group (WBG) and International Finance Corporation (IFC) and South African Minimum Emission Standards (SA MES). • Adopt good practice control measures onsite to avoid dust generating problems.
Noise	**Noise pollution – impact on third parties i.e. nuisance**	L	L	• Design the plant to comply with the IFC and WBG of 55dB LAeq for daytime and 45dB LAeq at night-time at the closest third party receptors.
Archaeology	**Damage to archaeological resources – Power Station and power line and the immediate landscape**	M-L	L	• Ensure that all archaeology and cultural heritage procedures recognised by the National Heritage Council of Namibia (NHC) are complied with for all activities related to the construction of the Otjikoto Biomass Power station and construction and reallocation of the transmission lines.
Visual	**Visual impact on third parties**	L	L	• Install light fixtures that provide precisely directed illumination to reduce light spillage beyond the immediate surrounds of the site and paint buildings and structures with colours that reflect and compliment the natural colours of the surrounding landscape.
Socio-economic	**Hazardous excavation and infrastructure that could impact on the safety of third parties**	H	L	• High security fencing and security access control will be provided around the entire site. All security staff will be trained to ensure no unauthorised third parties or animals enter operational areas or other potential construction/operations areas.
	Economic impacts associated with the Power Station	H+	H+	• Encourage the use of small and medium sized enterprises in supplying goods and services to the Project.
	Job creation and skills development	H+	H+	• Ensure that strategies and programs are in place prior to the construction phase, which will maximize the use of the local labour force during construction and operations. • Promote continuous learning programs to diversify and upgrade skills of employees and ensure that skills gained on the job are documented and accredited wherever possible.

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
	Community resilience to population in-migration	H	M	• Give employment preference to local and Oshikoto Region residents, particularly to women, members of the San communities and residents on group resettlement farms, to reduce the influx of workers and whole families into the project area. • Construction workers to live locally in Tsumeb to boost the local economy, as far as practically possible. • Close collaboration with the Governor of the Oshikoto region to assist with employment of local unskilled and semi-skilled workers.

7.2 Project Related Fuel Supply Activities

TABLE 6: IMPACTS AND MITIGATION MEASURES OF HARVESTING ACTIVITIES

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
Traffic	**Impact at the TR 1/10 and DR 3007 Intersection**	M	L	• Upgrade the intersection. • Pave the portion of road to the Power Station entrance. • Keep grass at the intersection cut at all times to maintain intersection sight distance.
	Impact on road capacity and road condition/deterioration – gravel roads: • DR 3007 • Other gravel Roads	M	L	• The increase of traffic on the gravel roads does not merit an upgrade to bitumen standards, but Namibian Roads Authority (RA) should be actively engaged to ensure proper maintenance is done.
		L	L	• Promote basic road safety behavior for all NamPower employees and contractors through training and awareness.
Soils	**Soil compaction potentially affecting plants and animals above the soil surface, as well as soil macro-fauna and microorganisms below the soil surface**	M	L	• Harvesters to be instructed to use appropriate harvesting techniques and experienced operators (refer to EMP for harvesting guidelines, which specifically refers to the SEA of Large-Scale Bush Thinning and Value-Addition Activities in Namibia (SAIEA, 2016) and the Forestry and Environmental Authorisations Process for Bush Harvesting Projects (Pallett & Tarr, 2017).
	Wind and water erosion in the harvesting area	M	L	• Restrict off road vehicular movement as far as possible to marked routes in order to curb damage to the grass cover. • Harvesters should be encouraged to follow biomass harvesting guidelines (see the EMP in Appendix 15). It is important not to over clear: tree equivalents/ha that should remain after thinning should follow the recommended rainfall- Tree Equivalents (TE) guidelines per dominant encroacher species.
	Reduction in nutrient transfer from deep soil layers though seasonal leaf fall in the harvesting area	M	M	• Due to the nature of the impact, mitigation does not appear possible.
	Improved soil carbon cycle and soil structure	M+	M+	• Due to the nature of the impact i.e. positive, no mitigation is required. However, to ensure the positive impact is achieved aftercare of the harvested areas needs to be implemented

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
	Soil contamination through fuel and oil spills in the harvesting area and arboricide after-effects	M	L-M	• Comply with Spill Prevention and Management Plan in the EMP. • Harvesters should be encouraged to avoid very sensitive zones and no-go areas. • Harvesters and landowners should be encouraged to use stem/foliar applied chemicals instead of soil-applied arboricides if using chemical aftercare. • When using manual aftercare, plants should be uprooted to prevent regrowth. Manual aftercare is not recommended for controlling *Dichostachys cinerea*, which readily coppices from damaged roots.
Biodiversity	**Failure to achieve rangeland improvement goals in the harvesting area**	H	H+	• Clear authority and a governance structure to be established with supervision and accountability • Appointing a dedicated Environmental Manager to conduct, but not limited to, auditing, regular training, monitoring and being a champion for responsible management • Follow Adaptive Management and continuous assessment approach • Alignment with Forest Stewardship Council (FSC) standards • Promote spatial heterogeneity in harvesting intensity according to Tree Equivalents (TE) • Regular training of harvesters and landowners on the ecological principles that underlie savanna dynamics • Develop Site-Specific Harvesting Plans • No tree, bush or shrub may be cut, destroyed or removed within 100 m of a river, stream or watercourse. Bush is naturally denser along the margins of rivers. • All trees taller than 4 m, or greater than 18 cm diameter at the base, must be retained. Large dead trees should not be cut, as they provide cavities for nesting, and perches for larger birds • Ensure aftercare is executed in line with the site specific harvesting.
	Large scale loss of protected woody species, including fruit-bearing species important for humans and other fauna, as well as rare, iconic, and timber species due to indiscriminate and excessive take-off	H	M	• Avoid harvesting of the no-go areas • Develop Site Specific Harvesting Plans for harvesters and landowners • Harvesters should be encouraged to follow biomass harvesting guidelines (see the EMP). It is important not to over clear: tree equivalents/ha that should remain after thinning should follow the recommended rainfall-TE guidelines per dominant encroacher species.

SLR

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
				• Harvesters should follow biomass harvesting guidelines (SAEIA 2017), and the management and mitigation measures in the EMP • Only use harvesting methods and/or machinery that are able to selectively harvest encroacher bush while avoiding damage to desirable species • Arrange training events • Supervision to prevent cutting of non-target plants • Long-term monitoring of population trends/health of valuable species to also include the post-harvest management efficiency
	Loss of and disturbance of animals in harvesting area	**M-H**	**L-M**	• Give preference to harvesting methods that allow smaller animals to move away i.e. slow moving machinery or manual methods. • Ongoing awareness shall be promoted about the value of biodiversity and the negative impacts of poaching, especially to breeding birds. • Ensure swift law enforcement in poaching cases by reporting immediately to the police and to community anti-poaching organisations. • Restrict harvesting activities at night where possible. Transport at night shall be limited.
Surface Water	**Bush harvesting activities causing increased salinization, causing surface water quality impacts**	**H**	**L**	• Bush thinning as opposed to bush clearing shall be practiced, specifically in the groundwater sensitive areas.
	Non environmentally friendly arborocides used after bush harvesting i.e. aftercare, impacting on surface water quality	**H**	**L**	• Use FSC approved water insoluble arboricides.
	Contamination of surface water from hydrocarbon spillages and undetected leakages from harvesting equipment and trucks transporting biomass	**M**	**L**	• Comply with Spill Prevention and Management Plan in the EMP.
	Contamination of surface water from ash from the Power Station taken back to the harvested farms	**M**	**L**	• Ash to be dispersed and used as fertilizer at the harvested farms or used for alternative applications • Preferably fly ash and bottom ash composite be deposited due to the less harmful metal and salt content compared to fly ash and bottom ash alone
Groundwater	**Impact of de-bushing on the groundwater levels**	**M+**	**M+**	• Recommendation: Soil isotope studies and other recharge assessment studies like the well-established “Chloride Method” should be carried out

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
				in areas prior to de-bushing and after de-bushing, which will give a direct result of any change in recharge
	Impact of de-bushing on groundwater and soil through salinization	**M**	**L**	• Bush thinning as opposed to bush clearing shall be practiced • No harvesting in rivers and drainage lines and within a buffer of 100m away from the water source.
	Non environmentally friendly arboricides used after bush harvesting i.e. aftercare, impacting on groundwater quality	**M**	**L**	• Harvesters and landowners should be encouraged to use stem/foliar applied chemicals instead of soil-applied arboricides and shall comply with FSC pesticides standards. • Follow harvesting guidelines set by DWAF as presented in the best practice guidelines for de-bushing of 2017. • Do not use arboricides in sensitive areas with shallow water levels of 0-20m bgl. If this cannot be avoided, the use of arboricides with short half-lives, shall be promoted as potential aftercare application.
	Contamination of groundwater from hydrocarbon spillages and undetected leakages from harvesting equipment and trucks transporting biomass	**M**	**L**	• Comply with Spill Prevention and Management Plan in the EMP.
	Impact on groundwater from ash taken back to the harvested farms	**M**	**L**	• Ash to be dispersed and used as fertilizer at the harvested farms or used for alternative applications and not stockpiled for longer periods • Preferably fly ash and bottom ash composite be deposited due to the less harmful metal and salt content compared to fly ash and bottom ash alone. .
Air Quality	**Air pollution**	**M**	**L-M**	• It is recommended that sensitive areas within harvest zones are identified via field inspection prior to the commencement of felling operations and that setback distances are determined between harvest zones and sensitive populations, taking into account the topography and prevailing wind directions. Harvest intensity shall be reduced close to sensitive land uses, apply bush thinning , and vegetation buffers shall be retained between harvesting activities and sensitive receptors to reduce the potential of windblown dust from open areas (as per access agreements).
Noise	**Noise pollution**	**L**	**L**	• Noise levels, due to harvesting activities, must be designed and sited within the harvesting area to comply with the IFC and World Bank guideline of 55dB LAeq for daytime at noise sensitive receptors.

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
				• This would be achieved based on a combined sound power level of 113dB(A) from all harvesting related plant and activities, at a distance of 200m from the closest receptor. This is, however, also dependent on the landowner's requirements, should there be a request for harvesting closer to a relevant homestead.
Archaeology	**Damage to archaeological resources**	**H**	**L**	• All harvesting contractors and workers shall be made aware that under the National Heritage Act any items protected under the definition of heritage, defined as any site that is over 50 years old, found in the course of development shall be reported to the National Heritage Council. • If there are any chance finds of archaeological sites during the harvesting activities, the harvesting contractors will follow a chance find procedure. The key component of which is to ensure that the site remains undisturbed until a specialist archaeologists or cultural heritage professional has assessed the site, assessed the potential damage, advised on the necessary management steps, and advised on the requirements for authority consultation and permitting.
Visual	**Visual impact on third parties**	**L**	**L**	• A buffer zone, no-go harvesting zones established unless otherwise mutually agreed to with the landowner, shall be recognized around sensitive tourist and or residential sites.
Socio-economic	**Job creation and skills development**	**H+**	**H+**	• Ensure that strategies and programmes are in place prior to harvesting that, where possible, maximises the use of the local labour force during operations. • Encourage recruitment and training of women and support female employees to perform well in the workplace.
	Creating business opportunities	**H+**	**H+**	• NamPower to interact with financing stakeholders from any early stage to ensure the availability of capital for the timeous start-up and up-scaling of biomass producers. • Encourage semi-mechanized woodchip producers to supply biomass.
	Impact on existing wood biomass users	**H**	**M**	• It is advised that NamPower proactively engages with harvesters and processors once harvesting begins to ensure that new or expanded charcoal and / or woodchip harvesters can meet the demand for both woodchips and charcoal. FSC standards allow anyone who complies to be considered for a Fuel Supply and Harvesting Agreement.
	Bush-thinning on land productivity i.e. improvement of rangeland productivity	**M-H+**	**H+**	• NamPower should include contractual clauses in the Fuel Supply and Harvesting Agreements to ensure that aftercare is conducted. • Refer to aftercare requirements above and in the EMP.

Environmental component	Potential Impacts	Assessment Significance Rating		Key Management and mitigation Measures, Monitoring and Auditing activities
		Unmitigated	Mitigated	
	Impact on safety, security and health in the farming community	H	M	• Adhere to all the relevant Namibian legislation and the requirements of its financing partners in terms of workers' rights and employment conditions, health and safety, the rights of indigenous peoples and other vulnerable groups and community relations. • Implement a formal health and safety management plan/system. • Harvesting contractors to have a comprehensive HIV, AIDS and TB workplace policy and wellness programme which will detail HIV awareness and prevention measures in the workplace and enable easy access to AIDS treatment, care, and support for employees.
	Community resilience to population in-migration	H	M	• Refer to Table 4.
	Upholding human rights and interests of vulnerable people and labour	M+	M+	• The organisation responsible for selecting bush harvesting sites should be encouraged to consult with San traditional authorities and San living on bush encroached resettlement farms. The aim is to prioritise their farms for bush-thinning and, where possible, to prioritise San people for jobs opportunities.

8. ENVIRONMENTAL IMPACT STATEMENT AND CONCLUSIONS

The receiving environment was studied as part of the EIA process for the proposed Biomass Power Project and environmental aspects and potential impacts associated with the activities and facilities were identified as part of the Scoping Phase, for further consideration and assessment during the assessment phase of the EIA. The full suite of facilities and activities, associated with the construction, operation, and decommissioning phases of the proposed Biomass Power Station and overhead powerline; as well as the harvesting and associated activities are described in Section 4 of the EIA Report.

Potential environmental impacts were identified by SLR in consultation with I&APs, regulatory authorities, specialist consultants, and NamPower. The impacts were assessed under the identified issue headings in Section 7 of the EIA Report. Impacts were considered in a cumulative manner where possible such that the impacts of the proposed Biomass Power Project were assessed in the context of the baseline conditions.

The project with its positive impacts envisaged from the generation of renewable power and the harvesting of the fuel source has the potential to benefit the country, society, and surrounding communities both directly and indirectly. Other than the benefits associated with the electricity generation, the implementation of the proposed Encroacher Bush Biomass Power Project will have benefits such as contributing to a reduction in bush encroachment and the restoration of rangeland through bush thinning practices, increasing land productivity, increased rain water infiltration and improved business, employment and skills development opportunities.

A number of high significant negative impacts are however specifically associated with the harvesting and associated activities in the unmitigated scenario. It is possible to mitigate the potential negative impacts by committing to apply the findings of the assessment and related mitigation objectives and actions as presented in the two EMPs. The significance of the potential impacts associated with achieving the savanna ecological restoration goals in the harvesting area, or not, is assessed as high negative in the unmitigated scenario and high positive in the mitigated scenario.

There is still a clear need for intensive monitoring of savanna dynamics under various harvesting and postcare scenarios to determine the long term outcomes and to inform careful, adaptive, and pre-emptive management. An adaptive management approach is recommended to ensure the restoration outcomes are achieved.

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ACRONYMS AND ABBREVIATIONS

Below is a list of acronyms and abbreviations used in this report:

ACRONYMS / ABBREVIATIONS	DEFINITION
ACS	African Conservation Services
ADTs	Average daily traffic volumes
APCr	Air Pollution Control Residue
ATS	Average Travel Speed
ATSDR	Federal Agency for Toxic Substances and Disease Registry
AWR	African Wilderness Restoration
BAT	Best Available Technology
BFB	Bubbling Fluidized Bed (BFB)
BID	Background Information Document
CALEPA	Californian Environmental Protection Agency
CCF	Cheetah Conservation Foundation
CRR	Comments and Response Report
CDI	Capacitive Deionization
CEDI	continuous electro-deionization
CFB	Circulating Fluidized Bed
CH4	Methane
CITES	The Convention on International Trade in Endangered Species of 1973
CO	Carbon Monoxide
CO^2	Carbon Dioxide
CTO	Comprehensive Traffic Observation
CV	Curriculum Vitae
DALYs	disability-adjusted life years
dB	decibel
DCA	Directorate of Civil Aviation
DEA	Department of Environmental Affairs
DPM	Dundee Precious Metals
DPMT	Dundee Precious Metals Tsumeb (Pty) Limited
DWAF	Department of Water Affairs and Forestry
E	Endemic
EAP	Environmental Assessment Practitioner
EAPAN	Environmental Assessment Professionals Association of Namibia

ECC	Environmental Clearance Certificate
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMA	Environmental Management Act
EMP	Environmental Management Plan
ENP	Etosha National Park
EPFIs	Equator Principles Financial Institutions
ERF	Energy Recovery Facility
ESLs	Effects screening levels
FAO	Food and Agriculture
FBC	Fluidised Bed Combustion
FBCs	Fluidised-Bed Combustors
FGD	Flue Gas Desulphurisation
FSC	Forest Stewardship Council
GBIF	Global Biodiversity Information Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographical Information System
GN	Government Notice
GWP	Global warming potential
ha	Hectare
Hg	Mercury
I&APs	Interested and Affected Parties
IBA	Important Bird Area
IFC	International Finance Corporation
IRIS	Integrated Risk Information System
LDN	Land Degradation Neutrality
IUCN	International Union for Conservation of Nature
kV	Kilovolt
LOS	Level of Service
MAP	Mean Annual Precipitation
MAWF	Ministry of Agriculture Water and Forestry
MAWL	Ministry of Agriculture Water and Land Reform
MCDM	Multiple Criteria Decision-Making

MET	Ministry of Environment and Tourism
MEFT	Ministry of Environment, Forestry and Tourism
Met. Office	Meteorological Office
MHSS	Ministry of Health and Social Services
MLR	Ministry of Land Reform
MLRS	Ministry of Labour and Social Welfare
MME	Ministry of Mine and Energy
MRL	Minimal risk levels
MW	Megawatt
MWT	Ministry of Works and Transport
N	Nitrate
N_2O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAIRS	Namibian Agricultural Resources Information System
NamPower	Namibia Power Corporation (Pty) Ltd
NASA	National Aeronautics and Space Administrator
NBD	Namibia Biodiversity Database
NBL	Namibia Breweries
NBRI	National Botanical Research Institute
NCAA	Namibian Civil Aviation Authority
NE	Near-endemic
NGO	Non-Governmental Organisations
NHC	National Heritage Council
NIMD	Namibian Index of Multiple Deprivation
NIRP	National Integrated Resource Plan
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxides
NSRs	Noise-Sensitive Receptors
ODG	Operational Directives and Guidelines
OML	Otavi Mountain Land
PFFS	Percent of free-flow Speed
PM	Particulate Matter
PPAH	Pollution Prevention and Abatement Handbook
ppb	Parts per billion
PPP	Public Participation Process

PTSF	Percentage Time Spent Following
QDS	Quarter Degree Square
RA	Roads Authority
REDs	Regional Electricity Distributors
RMS	Road Management System
RO	Reverse Osmosis
RWL	Rest Water Level
SABAP	Southern African Bird Atlas Project
SABIF	South African Biodiversity Information Facility
SAPP	Southern African Power Pool
SA MES	South African Minimum Emission Standards
SCR	Selective Catalytic Reduction
SEA	Strategic Environmental Assessment
SFC	Structure, Function and Composition
SMS	Short Message Service
SNCR	Selective Non-Catalytic Reduction
SRTM	Shuttle Radar Topography Mission
TAs	Traditional Authorities
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TKA	Tsumeb Karst Aquifer
TOC	Total Organic Compounds
TR	Trunk Road
vpd	Vehicles per day
WBG	World Bank Group
WHO	World Health Organisation
WRB	World Reference Base

1 INTRODUCTION

This chapter describes the report purpose, briefly describes the project background, summarises legislative requirements, explains the report structure, and explains how Interested and Affected Parties (I&APs) can comment.

1.1 PURPOSE OF THE REPORT AND OPPORTUNITY TO COMMENT

This Environmental Impact Assessment (EIA) Report has been compiled and will be distributed for review and comment as part of the EIA process being undertaken for the proposed Encroacher Biomass Power Project in Namibia by the Namibia Power Corporation (Pty) Ltd (NamPower).

This report summarises the following:

- Policy and legal framework;
- Approach to the EIA and process;
- Proposed project activities;
- Characteristics of the receiving environment;
- Findings of specialist studies;
- Assessment of potential impacts of the proposed project; and
- Mitigation and management measures necessary to avoid or reduce potentially significant impacts.

Interested and/or affected parties (I&APs) are invited to comment on this EIA Report (Section 3 explains how to do this).

The report will then be finalised, after considering and incorporating comments received. The final EIA Report will be submitted to the Ministry of Mines and Energy (MME) (i.e. Competent Authority relating to energy generation, transmission and storage activities) for consideration and further submission to the Ministry of Environment, Forestry and Tourism (MEFT) for decision-making.

This EIA Report was distributed for a 4-week comment period from **23 October to 20 November 2020**. I&APs had an opportunity to comment on the proposed project and the findings of the EIA process. The full report, including the Executive Summary, was available on the SLR website. Hardcopies of the Executive Summary of the main EIA Report, as well as electronic copies (CDs) of the full report, including all Appendices were made available at the venues presented in Table 1-1.

TABLE 1-1: LOCATIONS FOR THE REVIEW OF THE EIA REPORT

Location	Name of Facility	Physical Address	Details
Tsumeb	Tsumeb Public Library	Dr Sam Nujoma Drive, Tsumeb.	Hard copy and electronic copy (CD) of the full report (including Appendices).
	Tsumeb Municipality	264 Moses Garoëb Street, Tsumeb.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).
Windhoek	National Library in Windhoek	1 Eugene Marais Street, Windhoek.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).
	NamPower Head Office	15 Luther Street, Windhoek.	Hard copy of the Main EIA Report (this report) and electronic copy (CD) of the full report (including Appendices).

Comments had to be sent to SLR at the address, telephone number or e-mail address shown below by **no later than the 20 November 2020.**

SLR Environmental Consulting (Namibia) (Pty) Ltd

Attention: Werner Petrick or Marvin Sanzila

8 General Murtala Muhammed Street, Eros, Windhoek

Tel: +264 61 231 287; Fax: +264 61 231 289

E-mail: wpetrick@slrconsulting.com

1.2 PROJECT BACKGROUND

NamPower is the national power utility of Namibia, with the core business in generation, transmission, and energy trading within the Southern African Power Pool (SAPP). NamPower supplies bulk electricity to Regional Electricity Distributors (REDs) as well as to mines, farms, and Local Authorities (where REDs are not operational) throughout Namibia.

In 2013, NamPower finalised a pre-feasibility study for a biomass-to-power project, which included the assessment of technical, environmental, socio-economic, and financial aspects of the project. This study concluded that it was a viable option to develop a Biomass Power Station and to proceed with a techno-economic study. NamPower therefore proposes the construction and operation of a Biomass Power Station, which will generate electricity by the combustion of encroacher bush growing in the surrounding area of the proposed Power Station.

The result of the "Multiple Criteria Decision Making" (MCDM) process and the EIA scoping process (see Section 3.2 for more details) was that NamPower selected the "Otjikoto site", near Tsumeb for the proposed Power Station, which is in close proximity to their existing (Otjikoto) substation. The Otjikoto site, is located approximately 7 km northwest of Tsumeb, in the Oshikoto Region, close to the Trunk Road (TR) 1/10 (B1

National road). Refer to Figure 1-1 for the location the proposed Power Station, and Figure 4-2 for the Power Station and the harvesting area, which covers roughly 100 km radius surrounding the site.

The Power Station will have a net electricity generating capacity of up to 40 megawatt (MWe) and will be connected to the National Grid at the Otjikoto substation via a new maximum 66 kilovolt (kV) overhead power line. NamPower is considering implementing fixed bed (i.e. grate fired) boiler technology for the proposed Power Station.

NamPower will be responsible for the operation of the Power Station. A contractor will be appointed to construct the power station on NamPower's behalf. Suitable contractors and sub-contractors will also be responsible for the activities associated with the harvesting of the encroacher bush as a fuel source.

The proposed Biomass Power Station project includes the following components:

- The construction phase (relevant to the Power Station and overhead power line);
- The operations phase (relevant to all project components including the Power Station, overhead power line, harvesting, processing and transportation of the encroacher bush as fuel source); and
- A decommissioning and closure phase (relevant to the plant and overhead power line).

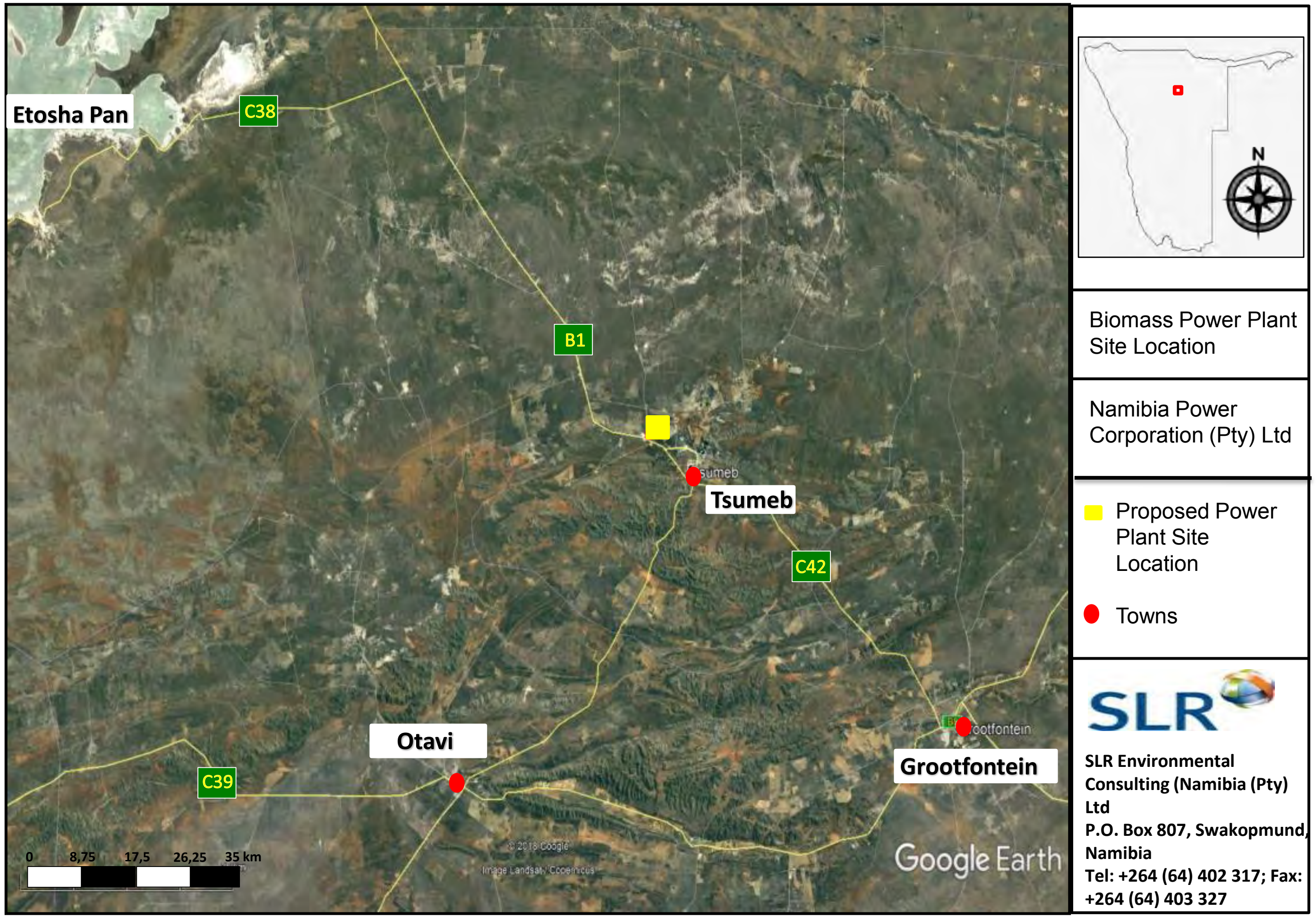


FIGURE 1-1: LOCALITY MAP FOR THE PROPOSED OTJIKOTO POWER STATION

1.3 PROJECT MOTIVATION (NEED AND DESIRABILITY)

The motivation for Namibia to support the project is economic and strategic in nature. The project with its positive impacts envisaged from the generation of renewable power and the harvesting of the fuel source has the potential to benefit the country, society, and surrounding communities both directly and indirectly.

It is estimated that approximately 26 million hectares, located in the north-central and central regions of Namibia, are covered by encroacher bush. This phenomenon is called bush encroachment and sees indigenous thorny bush and shrub species found in natural rangelands grow in such abundance that this encroacher bush increasingly suppresses the growth of grass, reduces biodiversity, and impacts the penetration of rainwater required to recharge the all-important underground water resources. With reference to 'the Forestry and Environmental Authorisations Process for Bush Harvesting Projects' (MAWF & MET, 2016), Mr Joseph Hailwa (Director of Forestry) stated in his foreword that "Namibia used to be a land of open savannas. Now, more than half of the country is covered by thorny and impenetrable bush, greatly reducing the productivity of our land. Encroacher bush in addition to decreasing the carrying capacity of rangelands also has a catastrophic effect on Namibia's water resources, drastically decreasing water inflow into underground reserves. For these reasons, the Government of Namibia has committed itself to combat bush encroachment so that our rangelands can be restored".

The Power Station will contribute positively to the Namibian economy allowing it to generate electricity from its own sources, thus reducing its dependency on external suppliers.

During the operational phase of the proposed Biomass Power Project, the assumption is that power generated is offset against imported power from the Southern African Power Pool. In net-present value terms, the reduced electricity imports (import substitution effect) over the plant's 25 year lifespan equates to a benefit of N$ 0.87/kWh, as the imported value of electricity over the 25-year period, in 2018 value terms, this is approximately N$ 3.24 billion.

The import-substitution effect of electricity is the largest contributor to the positive balance of payments, resulting in N$ 314 million less leaving Namibia per annum, working out at N$0.87/kWh (in 2018 terms) over the full 25 year period. The balance of payments sees a net positive effect, largely due to the import substitution of electricity (N$ 134 million/year in 2018 value terms). Additionally, the reduction in imported electricity will contribute between 0.036% and 0.056% of GDP over the expected 25 year life expectancy of the Power Station (Cirrus Capital. 2018).

The construction of the plant, the purchase of machinery for bush thinning, the direct, indirect and induced economic benefits will boost the local, regional and national economy (see Section 7.11 for further details on these benefits).

Encroacher bush, while not the only source of Namibia's biomass, is a substantial and as yet underutilised source of energy. The encroacher bush provides a significant fuel resource to be used for electricity generation. The harvestable area around the proposed Biomass Power Station is approximately 3.1 million ha, excluding slopes & protected areas (refer to section 4.2 and Figure 4-2). The resource available is approximately 40 million tonnes (NamPower, 2019).

Other than the benefits associated with the electricity generation, the implementation of the proposed Encroacher Bush Biomass Power Project will have benefits such as; contributing to "combatting bush encroachment" and the restoration of rangeland through bush thinning practices, increasing land productivity, increased rain water infiltration, and improved business, employment and skills development opportunities (refer to Section 7 for a detailed description/assessment of the positive impacts associated with the proposed project).

The proposed Biomass Power Station would furthermore assist with grid stability by delivering a base load capacity, and provide a portion of ancillary support services associated with thermal Power Stations with the proposed Otjikoto site located close to a significant load centre within the Namibian electricity network.

The overall objective/goal of the Biomass Power Project is therefor to provide renewable electricity through a sustainable forest production model. However, a secondary (environmental related) objective/goal of the project, is to improve rangelands where the encroacher bush will be harvested.

In this regard, the EIA not only assessed the potential impacts associated with the loss of habitat, destruction of animals and plants and the general disturbance of biodiversity during the harvesting and associated activities (section 7.4.1), but also the potential impacts associated with the failure to achieve the savanna ecological restoration goals in the harvesting area (section 7.4.3). With reference to Section 7.4 and the EMP for the harvesting and associated activities (see section 1.4), relevant management and mitigation measures (during and after the harvesting activities) and monitoring requirements were therefore developed to ensure the abovementioned "secondary objective/goal" can be achieved.

1.4 INTRODUCTION TO THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Subject to the Environmental Management Act, Act 7 of 2007 and the Environmental Impact Assessment Regulations (Government Notice (GN) No. 29 of 2012), the construction of any facilities for the generation and transmission of electricity as well as the bush harvesting activities are both considered 'listed activities' governed by these Regulations. Therefore, NamPower is required to undertake an EIA process for the construction and operation of the proposed encroacher bush Biomass Power Station and associated harvesting activities in order for MME as the competent authorities for the energy generation, transmission and storage activities and MEFT as the Competent Authority for the fuel supply related and forestry activities and regulator to consider the application for two separate environmental clearance certificates (ECCs).

NamPower will apply for environmental clearance for activities relating to all of the project components summarised in section 1.2 and detailed in section 3.

This EIA Report therefore considers the potential impacts associated with all project components/activities. However, due to the fact that two separate applications for Environmental Clearance Certificates (ECCs) were submitted to the two competent authorities and MET, two separate Environmental Management Plans (EMPs) have been developed as follows:

- EMP for the activities associated with the proposed Power Station and overhead powerline (see Appendix 14)
- EMP for the harvesting and associated activities (including the transport of the biomass to the Power Station) (see Appendix 15).

Having two separate EMPs will be beneficial to NamPower during the implementation of the project due to separate contractual arrangements for the relevant project components / activities.

EIAs are regulated by the Ministry of Environment and Tourism (MET) in terms of the Environmental Management Act (EMA), Act 7 of 2007. This Act was gazetted on 27 December 2007 (Government Gazette No. 3966) and the Environmental Impact Assessment Regulations were promulgated on 6 February 2012.

A full EIA process is required for the proposed project, a Screening (and project initiation) phase; and Scoping phase have already been conducted. This EIA Report is the outcome of the Impact Assessment Phase. Various specialists have been appointed to ensure the following:

- The baseline environment is properly described;
- All identified aspects and potential impacts are identified and properly assessed; and
- Management and mitigation measures are developed to avoid or minimize negative impacts and enhance positive impacts.

A summary of the approach and key steps in the EIA process and corresponding activities are outlined in Table 1-2. During the Scoping Phase, six potential sites were considered and investigated for the proposed Power Station in proximity to the following existing substations:

- Omaere substation near Gobabis;
- Auas substation near Windhoek;
- Osona substation near Okahandja;
- Gerus substation near Otjiwarongo;
- Ohorongo substation near Ohorongo Cement and Otavi; and
- Otjikoto substation near Tsumeb.

Public meetings and focus group meetings were conducted at each of these locations, as described in the Table 1-2.

TABLE 1-2: EIA PROCESS

OBJECTIVES	CORRESPONDING ACTIVITIES
Project Initiation and Screening Phase (March 2017– April 2017)	
• Understanding of the environmental and social baseline relating to the proposed project. • Initiate the screening process. • Notify the decision making authority of the proposed project. Initiate the environmental impact assessment process.	• Project inception and initiation meetings to discuss the project and EIA process requirements: o Project Inception Report; and o EIA Schedule. • Initiate baseline studies. • Initiation meetings with the Ministry of Mines and Energy (MME) and with the Ministry of Environment and Tourism (MET): Directorate of Environmental Affairs (DEA): o Information sharing about the proposed project and commencement of the EIA; o Confirm the EIA process to be followed; and o Submit ECC application form to MME. • Early identification of environmental aspects and potential impacts associated with the proposed project.
Scoping Phase (May 2017 – March 2018)	
• Identify interested and/or affected parties (I&APs) and involve them in the scoping process through information sharing. • Identify potential environmental issues associated with the proposed project. • Describe which alternatives have been considered to date and which alternatives will be further assessed in the EIA phase. • Identify any fatal flaws. Determine the terms of reference for additional assessment work.	• Develop Public Participatory Process (PPP) Programme: o Initial planning visit to all sites and informal meetings with some key stakeholders; o Develop I&AP database; and o Develop EIA internet site. • Prepare Background Information Document and distribute to I&APs. • Prepare site notices and place at each site (i.e. substations). • Identify the need to submit a separate Application for ECC to the MAWF[1]: o Meeting with MAWF and submission of Application form. • Notify other government authorities and I&APs of the project and EIA process (telephone calls, short message service (SMS),

OBJECTIVES	CORRESPONDING ACTIVITIES
	e-mails, newspaper and radio advertisements and site notices). • I&AP registration and comments. • Public meetings and focus group meetings with authorities and I&APs at each of the six sites. • Compilation of Scoping Report. • Distribute Scoping Report to relevant authorities and I&APs for review. • Finalisation of Scoping Report. • Forward final Scoping Report and I&APs comments to MET (now MEFT) for review.
EIA/EMP Phase (March 2018 – December 2020)	
• Provide a detailed description of the potentially affected environment. • Assessment of potential environmental impacts. • Design requirements and management and mitigation measures.	• Regsiter both Applcations on MEFT's online system. • Investigations by technical project team and appointed specialists. • Compilation of EIA Report and Environmental Management Plans (EMPs). • Distribute EIA Report and EMPs to all I&APs. • Conduct public and focus group EIA feedback meetings within the 30-day review period to present the findings of the study. These meetings will be conducted in the Otjikoto / Tsumeb area. • Obtain comments and update the EIA Report and EMP. • Submit final documents to MME for review, who will forward these (with their review comments) to MEFT for review and their final decision.

Note 1: An initiation and introductory meeting was held with the Ministry of Agriculture, Water and Forestry (MAWF), now the Ministry of Agriculture Water and Land Reform (MAWL), and the application for environmental clearance was submitted to MAWF on 9 October 2017. At the time, the MAWF was the competent authority for the fuel supply related and forestry activities. Forestry activities now falls under the MEFT and the MAWL is no longer the Competent Authority for the fuel supply related and forestry activities.

Within this framework, the required assessment approach is discussed in more detail in Section 3.

EIAs are influenced by national legislation and a range of guidelines. The legislation, as well as various international standards, applicable to this project and the EIA process are discussed further in Section 2 below.

1.4.1 EIA Team

SLR Environmental Consulting (Namibia) (Pty) Ltd was appointed by the European Investment Bank (EIB), the financiers of the Environmental (and Socio-Economic) Impact Assessment (EIA) with NamPower as the beneficiary, for the proposed Encroacher Bush Biomass Power Project in Namibia.

1.4.1.1 Key Experts

SLR identified three 'Key Experts' who were principally responsible for conducting the EIA process. The Key Experts and their designations are indicated in the table below:

TABLE 1-3 : KEY EXPERTS

ROLE	NAME
Key Expert I (SLR Project Leader)	Werner Petrick (Namibian based)
Key Expert II (SLR Power Station Expert)	Marc Scourfield (UK based)
Key Expert III (SLR Environmental Specialist)	Chris Herbert (UK based)

Werner Petrick, the Project Manager has more than twenty (20) years of relevant experience in environmental management, conducting and managing EIAs, compiling EMPs, implementing EMPs and Environmental Management Systems. Werner is certified as a lead Environmental Assessment Practitioner and Reviewer under the Environmental Assessment Professionals Association of Namibia (EAPAN).

Chris Herbert is a Chartered Town Planner with over twenty (20) years of experience in both planning and EIA development. Chris has worked on a wide range of waste, energy, and minerals proposals. Recent biomass experience in the UK includes being the lead EIA professional on a 177,000 tpa waste wood biomass CHP plant for a German company, MVV.

Marc Scourfield has over 20 year's industrial experience and is a Principal Process Engineer in the Process Engineering & Process Safety Group. Marc has extensive operational and process engineering experience in; energy from waste and biomass plants, waste treatment technologies, and EHS experience in the oil and gas and waste management industries.

1.4.1.2 Environmental Project Team

SLR's local (Namibian) Environmental Assessment Practitioners as well as the various Environmental Specialists on the Environmental Project Team, who have been appointed to undertake the identified specialist studies, are indicated in Table 1-4.

TABLE 1-4: THE ENVIRONMENTAL PROJECT TEAM

ROLE	ORGANISATION	NAME
Environmental Assessment Practitioners	SLR	Werner Petrick Immanuel Katali
Noise specialist study		Emma Parsons
Groundwater and surface water		Arnold Bittner Ester Gustavo
Archaeology		George Nash Timothy Malim
Soils study (Power Station area)		Michelle Papenfus
Socio-economic specialists		Immanuel Katali

ROLE	ORGANISATION	NAME
Socio-economic specialists	Ashby Associates CC	Auriol Ashby
Vertebrates, vegetation and integrated biodiversity	African Wilderness Restoration (AWR)	Theo Wassenaar Cornelis van der Waal
Invertebrates	Biodata Consultancy cc	John Irish
Avifauna	African Conservation Services (ACS)	Mike & Ann Scott
Visual specialist	Graham A Young Landscape Architect	Graham Young
Traffic	Burmeister & Partners (Pty) Ltd	Theo Potgieter
Air quality	Airshed Planning Professionals (Airshed)	Hanlie Liebenberg-Enslin
Climate change		
Namibia forestry stewardship committee review	Environmental Compliance Consultancy	Stephan Bezuidenhout

The relevant curriculum vitae documentation is attached in Appendix 1.

1.5 STRUCTURE OF THIS REPORT

This report has been prepared in compliance with Section 15(2) of the EIA Regulations 2012. The structure and content are outlined in Table 1-5 below.

TABLE 1-5: STRUCTURE AND CONTENT OF DRAFT EIA REPORT AND EMP

Section	Contents
Executive Summary	Provides a summary of the key EIA findings.
Chapter 1	**Introduction** Describes the report purpose, briefly describes the project background, summarises legislative requirements, explains the report structure, and explains how I&APs can comment.
Chapter 2	**Environmental legal and policy framework** Provides an overview of relevant Namibian policies, summarises the Namibian administrative framework and describes the applicable Namibian legislation, international treaties, industry standards and guidelines applicable to the proposed project. It also provides a summary of the applicable listed activities under the EIA Regulations.
Chapter 3	**Approach to EIA process and public participation** This chapter outlines the EIA process, including the assessment methodology and I&AP consultation process.
Chapter 4	**Project description**

Section	Contents
	Describes the sequence of the proposed project phases and activities, provides technical information, outlines the proposed Power Station operation, the power line specifications, the harvesting and associated activities.
Chapter 5	**Alternatives** Describes the various project alternatives that were considered and provides a comparison in terms of advantages and disadvantages that the proposed alternatives may have on the environment and the community that may be affected by the activity.
Chapter 6	**Description of the receiving environment** Provides a general overview of the current baseline conditions associated with the proposed Biomass Power Project. This chapter provides a description of the attributes of the biophysical and socio-economic receiving environment of the area of interest, i.e. the proposed Power Station site and associated harvesting area.
Chapter 7	**Impact assessment** Describes and assesses the significance of potential impacts associated with the proposed Biomass Power Station activities, overhead power line, harvesting and associated actives.
Chapter 8	**Key assumption, uncertainties and limitations**
Chapter 9	**Environmental impact statement and conclusions**
Chapter 10	**References** Provides the references used in compiling this report.
Appendices	Appendix 1: Curriculum vitae of EIA project team Appendix 2: I&AP database Appendix 3: NamPower SHEQ Policy Appendix 4: MET (now MEFT) acceptance of Final Scoping Report Appendices 5 - 13: Specialist studies Appendix 14: EMP for Power Station and overhead powerline Appendix 15: EMP for the harvesting and associated activities

2 ENVIRONMENTAL LEGAL AND POLICY FRAMEWORK

This chapter provides an overview of relevant Namibian policies, summarises the Namibian administrative framework and describes the applicable Namibian legislation, international treaties and industry standards and guidelines applicable to the proposed project. It also provides a summary of the applicable listed activities under the EIA Regulations. These are described in more detail in the relevant specialist report in Appendices 5 to 13.

The Namibian constitution makes provision for the creation and enforcement of applicable legislation. In this context and in accordance with the Constitution, Namibia has passed numerous laws intended to protect the natural environment and to mitigate against adverse environmental impacts. Namibia has five tiers of law and a number of policies relevant to the proposed project and these include the following:

- The Constitution;
- Statutory law;
- Common law;
- Customary law; and
- International law.

The Strategic Environmental Assessment (SEA) for Large-Scale Bush Thinning and Value Addition Activities in Namibia (SAIEA, 2016) provides a comprehensive overview of relevant Namibian laws and policies. This section draws information from the SEA and other legal sources in Namibia. The various Environmental Team members (section 1.4.1) also contributed to this write-up.

2.1 SUMMARY OF APPLICABLE ACTS, POLICIES AND STANDARDS

2.1.1 Policies

Namibia's policies provide the framework to the applicable legislation. Whilst policies do not often carry the same legal recognition as official statutes, policies are used in providing support to legal interpretation. Relevant policies currently in force include the following:

- The EIA Policy (1995);
- Namibia's Environmental Assessment Policy for Sustainable Development and Environmental Conservation (1994);
- National Development Plan 5 and Vision 2030;
- National Integrated Resource Plan (NIRP 2016);
- National Forest Policy (1992);
- National Agricultural Policy (2015);
- Draft Bush Encroachment Policy of Namibia (2004);
- National Guidelines on Fires and Fire Management;
- National Drought Policy and Strategy;
- National Land Policy, the National Resettlement Policy, the Agricultural (Commercial) Land Reform Act (1995);
- Land Tax and Communal Land Reform Act (2002);
- Poverty Reduction Strategy for Namibia (1998);
- National Rangeland Management Policy and Strategy (NRMPS, 2012);
- White Paper on Energy Policy (1998);
- National Industrial Policy (2012);
- Policy for the Conservation of Biotic Diversity and Habitat Protection (1994);
- The National Climate Change Policy of Namibia (September 2010);
- Forestry and Environmental Authorisations Process for Bush Harvesting Projects (MAWF, 2017); and

- Harvesting of Encroacher Bush: Compendium of Harvesting Technologies for Encroacher Bush in Namibia (MAWF, 2015).

The last two bullets relating to harvesting activities are further discussed below:

The “Forestry and Environmental Authorisations Process for Bush Harvesting Projects” is summarised in a booklet published in 2017 by the MAWF together with the MET. This booklet explains the Namibian environmental laws and regulations that must be complied with for bush harvesting and value addition projects and defines a generic EMP which includes a number of guidelines designed to allow the industry to balance the sometimes competing objectives of productivity and conservation.

The “Harvesting of Encroacher Bush: Compendium of Harvesting Technologies for Encroacher Bush in Namibia”, is a similar guideline, focusing on the actual process of harvesting and including a definition of best practice in terms of certain aspects of environmental management.

Both Namibian standards referred to above make reference to the Namibian Forest Stewardship Council (FSC) as it provides guidelines on the sustainable use of forestry resources.

2.1.2 Namibian Legislation and Standards

Relevant legislation currently in force in Namibia include:

- Environmental Management Act (Act 7 of 2007) and associated Regulations;
- The Forest Act (Act 12 of 2001) and Regulations (2015);
- The Soil Conservation Act (Act 76 of 1969) & the Soil Conservation Amendment Act (Act 38 of 1971);
- The Water Act, (Act 54 of 1956) and Water Resources Management Act, (Act 11 of 2013);
- Electricity Act (Act 4 of 2007);
- The Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act 36 of 1947);
- National Heritage Act (Act 27 of 2004);
- Nature Conservation Ordinance of 1975;
- Atmospheric Pollution Prevention Ordinance 11 of 1976;
- Draft Pollution Control and Waste Management Bill of 1999;
- Public Health Act (Act 36 of 1919);
- Road Traffic and Transport Act, (Act 22 of 1999);

2.1.2.1 *Applicable Listed Activities*

With reference to section 1.4, NamPower has applied for environmental clearance for activities relating to the Power Station and overhead power line; as well as the activities associated with harvesting of the encroacher bush. The following activities identified in the regulations apply to the proposed project:

TABLE 2-1 : LISTED ACTIVITIES TRIGGERED BY THE PROPOSED PROJECT

ACTIVITY	PROJECT COMPONENT
ENERGY GENERATION, TRANSMISSION AND STORAGE ACTIVITIES	
The construction of facilities for:	
the generation of electricity	Construction and operation of the Biomass Power Station to generate electricity.

ACTIVITY	PROJECT COMPONENT
the transmission and supply of electricity	Construction of a new transmission line from the Power Station to the nearest substation.
WASTE MANAGEMENT, TREATMENT, HANDLING AND DISPOSAL ACTIVITIES	
2.1 The construction of facilities for waste sites, treatment of waste and disposal of waste.	Construction of a new waste recovery/disposal facility for ash/ waste water disposal.
2.2 Any activity entailing a scheduled process referred to in the Atmospheric Pollution Prevention Ordinance, 1976.	Emissions from the Power Station. (There are currently no scheduled activities listed in terms of the Atmospheric Pollution Prevention Ordinance, 1976).
2.3 The import, processing, use and recycling, temporary storage, transit, or export of waste.	Storage of waste (hazardous and non-hazardous) on site. Recycling of waste water.
FORESTRY ACTIVITIES	
4. The clearance of forest areas, deforestation, afforestation, timber harvesting or any other related activity that requires authorisation in term of the Forest Act, 2001 (Act 12 of 2001) or any other law.	Clearing of the land where the Power Station will be constructed. Bush harvesting activities for the fuel supply of the Power Station
LAND USE AND DEVELOPMENT ACTIVITIES	
5.1 The rezoning of land from – (c) agricultural use to industrial use (specifically for a Power Station); and (d) use for nature conservation or zoned open space to any other land use.	Depending on the selected site, these activities might be triggered, or be exempt from the agricultural land act to construct and operate a Power Station.
WATER RESOURCE DEVELOPMENTS	
8.1 The abstraction of ground or surface water for industrial or commercial purposes.	Abstraction of groundwater for the Power Station.
8.2 The abstraction of groundwater at a volume exceeding the threshold authorised in terms of a law relating to water resources.	Abstraction of groundwater for the Power Station.
8.6 Construction of industrial and domestic wastewater treatment plants and related pipeline systems.	Waste water treatment facility.

ACTIVITY	PROJECT COMPONENT
HAZARDOUS SUBSTANCE TREATMENT, HANDLING AND STORAGE	
9.1 The manufacturing, storage, handling, or processing of a hazardous substance defined in the Hazardous Substances Ordinance, 1974	Storage and handling of hazardous chemicals. (Refer to section 4.4.4.7 for the chemicals to be used).
9.4 The storage and handling of a dangerous goods, including petrol, diesel, liquid petroleum gas or paraffin, in containers with a combined capacity of more than 30 m^3 at any one location.	Storage and handling of hazardous substances.
INFRASTRUCTURE	
10.1 The construction of – (b) Public roads; (g) Communication networks including towers, telecommunication and marine telecommunication lines and cables.	Construction of access road(s) to the Power Station site and the construction of a telecommunication tower.

2.1.3 Conventions

Relevant international conventions are summarised below:

- Convention on Biological Diversity, 1992;
- United Nations Framework Convention on Climate Change, 1992;
- The Convention on International Trade in Endangered Species (CITES) of 1973;
- Convention to Combat Desertification 1994;
- National Rangeland Management Policy and Strategy of 2012; and
- National Biodiversity Strategy and Action Plan 1 and 2 (draft).

2.1.4 International Criteria and Standards

The development of the proposed project may be reliant on finance through loans from a lending institution and as such there is need for the proposed project to be undertaken in such a manner that complies with the European Investment standards, World Bank Group Equator Principles, and International Finance Corporation (IFC) Performance Standards.

The EIA process assessed the impacts of the proposed project in terms of the relevant Namibian environmental legislative requirements. Furthermore, the EIA process followed is considered to be sufficiently robust to conform to the Equator Principles and IFC Performance Standards.

Relevant national and international criteria, and standards were considered as part of this EIA process, as described in the sections below.

2.1.4.1 *The EIB's Statement of Environmental and Social Principles and Standards (EIB, 2009)*

The European Investment Bank (EIB) adopted an Environmental Statement in 1996 to underline its commitment to protecting and improving the natural and built environment according to EU policy (EIB 2009). The Statement focuses on: a) the "principles" on which the EIB approach to environmental and social issues are based, and b) the environmental and social performance standards that ensure compliance with Bank requirements. The principles and standards are derived from EU policy and law and supplemented by other examples of international good practice. The EIB requires that all the projects it is financing are acceptable in environmental and social terms by applying appropriate safeguards to all its operations.

2.1.4.2 *The EIB's Environmental and Social Handbook (EIB, 2013)*

The EIB Environmental and Social Handbook provides an operational translation of the policies and principles contained in the 2009 EIB Statement of Environmental and Social Principles and Standards (see above). Principles include the Environmental and Social Impact Assessment process of identifying, predicting, evaluating a project's positive and negative environmental and social impacts on the biophysical and human environment as well as identifying ways of avoiding, minimising, mitigating, and compensating, including offsetting in the case of the environment and remedying in the case of social impacts, by applying the mitigation hierarchy. This process includes consultation with direct and indirect stakeholders and the elaboration of an environmental and social management plan detailing the implementation of the mitigation measures.

2.1.4.3 *The International Finance Corporation's (IFC's) Performance Standards on Environmental and Social Sustainability (IFC, 2012)*

IFC's Sustainability Framework articulates the Corporation's strategic commitment to sustainable development and is an integral part of the IFC's approach to risk management. The Sustainability Framework comprises IFC's Policy and Performance Standards on Environmental and Social Sustainability, and IFC's Access to Information Policy.

The Performance Standards are directed towards clients, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project level activities.

The IFC Performance standards, and how these were considered and incorporated as part of the EIA process are summarized in Table 2-2 below.

TABLE 2-2: IFC'S PERFORMANCE STANDARDS

High level description of Standards	Comments in relation to the proposed project
Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts	
Performance Standard 1 establishes the importance of: (i) integrated assessment to identify the environmental and social impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the client's management of environmental and social performance throughout the life of the project. Performance Standards 2 to 8 establish objectives and	The EIA process has been undertaken in accordance with the requirements of the Namibian legislative framework, Equator Principles and IFC Performance Standards. NamPower and their Contractors will be responsible for developing and implementing an Environmental Management System for the life of the proposed project.

High level description of Standards	Comments in relation to the proposed project
requirements to avoid, minimise, and where residual impacts remain, to compensate or offset the risks and impacts to employees, affected communities, and the environment.	This EIA report and EMPs address the Environmental and Social Risks and Impacts of the proposed project.
Performance Standard 2: Labour and Working Conditions	
Performance Standard 2 recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. For any business, the workforce is a valuable asset, and a sound worker-management relationship is a key ingredient in the sustainability of a company. Failure to establish and foster a sound worker management relationship can undermine worker commitment and retention and can jeopardize a project. Conversely, through a constructive worke management relationship, and by treating the workers fairly and providing them with safe and healthy working conditions, clients may create tangible benefits, such as enhancement of the efficiency and productivity of their operations.	The potential impacts relating to employment have been addressed as part of the socio-economic specialist investigation (see section 7.12 of this report) and relevant management and mitigation measure presented in the EMPs (Appendices 14 and 15). NamPower and their constructors will be responsible for the following: • adopting and implementing human resources policies and procedures, appropriate to its size and workforce, that set out its approach to managing workers consistent with the requirements of this Performance Standard and national law; • ensuring non-discrimination and equal opportunities; • providing reasonable working conditions and terms of employment; • providing a safe and healthy work environment; and • providing grievance mechanisms for workers.
Performance Standard 3: Resource Efficiency and Pollution Prevention	
Performance Standard 3 recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. There is also a growing global consensus that the current and projected atmospheric concentration of greenhouse gases (GHG) threatens the public health and welfare of current and future generations. At the same time, more efficient and effective resource use and pollution prevention and GHG emission avoidance and mitigation technologies and practices have become more accessible and achievable in virtually all parts of the world.	The Namibian government has committed to invest in renewable energy initiatives and to the efficient use of available resources. The project would improve energy security and diversify the country's energy mix, reducing the reliance on electricity imports. The potential impacts relating to pollution have been addressed as part of the Air Quality, 3rd Party Health and Safety, Groundwater and Surface Water, and Noise specialist investigations (see section 7 of this report). A Climate Change assessment was included as part of this EIA (see section 7.13 and Appendix 5).

High level description of Standards	Comments in relation to the proposed project
Performance Standard 4: Community Health, Safety and Security	
Performance Standard 4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting the health, safety, and security of the public, this Performance Standard addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups.	The 3rd Party Health and Safety Assessment covers the potential impacts relating to community health and safety (refer to Appendix 5 and sections 7.7 and 7.8 of this report). Furthermore, third party safety and security were assessed in section 7.12.6 (see Appendix 10) and relevant management and mitigation measures to avoid or minimise impacts included in the EMPs (Appendices 14 and 15).
Performance Standard 5: Land Acquisition and Involuntary Resettlement	
Performance Standard 5 recognizes that project related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project related land acquisition and/or restrictions on land use.	NamPower has purchased the land on which the proposed Power Station will be constructed (refer to section 4.2 for more details). The proposed project will not result in any physical and/or economic displacement. The potential impacts of bush thinning on land-use have been addressed as part of the socio-economic specialist investigation (refer to Appendix 10 and section 7.12.5 of this report).
Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	
Performance Standard 6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity, which defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems."	The potential impacts on biodiversity and related aspects have been addressed as part of the Biodiversity specialist investigation (refer to Appendix 6 and section 7.4 of this report). A description of the baseline environment, including biodiversity, is provided in section 6. Potential biophysical impacts have been identified and assessed in section 7. When avoidance of impacts is not possible, measures to minimise impacts have been recommended. These mitigation measures have been included in the EMPs (attached as Appendices 14 and 15).

High level description of Standards	Comments in relation to the proposed project
Performance Standard 7: Indigenous Peoples	
Performance Standard 7 recognizes that Indigenous People, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. In many cases, their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development.	Vulnerable groups within the study area have been considered and addressed as part of the socio-economic specialist investigation (refer to Appendix 10 and sections 6.12.3 and 7.12 for more details).
Performance Standard 8: Cultural Heritage	
Performance Standard 8 recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities. In addition, the requirements of this Performance Standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity.	The potential impacts on heritage within the study area have been addressed as part of the Archaeology specialist investigation (refer to sections 6.8 and 7.10 for more details). Proposed mitigation measures for the protection of heritage and cultural resources is provided in the EMPs (attached as Appendices 14 and 15).

2.1.4.4 *IFC's Environmental, Health and Safety (EHS) Guidelines*

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

2.1.4.5 *World Bank's Pollution Prevention and Abatement Handbook (PPAH)*

The Handbook promotes the concepts of sustainable development by focusing attention on the benefits, both environmental and economic, of pollution prevention, including cleaner production and good management techniques. In many cases, the guidelines provide numerical targets for reducing pollution, as well as maximum emissions levels that are normally achievable through a combination of cleaner production and end-of-pipe treatment. The guidelines are designed to protect human health, reduce mass loadings to the environment, draw on commercially proven technologies, be cost effective, follow current regulatory trends and promote good industrial practices, which offer greater productivity and increased energy efficiency.

2.1.4.6 *World Bank Operational Directives and Guidelines (ODG)*

This directive describes Bank policy and procedures on involuntary resettlement, as well as the conditions that borrowers are expected to meet in operations involving involuntary resettlement. Planning and financing resettlement components or free-standing projects are an integral part of preparation for projects that cause involuntary displacement. Any operation that involves land acquisition or is screened as a Category A or B project for environmental assessment purposes should be reviewed for potential resettlement requirements early in the project cycle.

2.1.4.7 *Equator Principles*

The Equator Principles (The Equator Principles III of June 2013: A financial industry benchmark for determining, assessing, and managing environmental and social risk in projects) is a risk management framework, adopted by financial institutions, for determining, assessing, and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision making.

Equator Principles Financial Institutions (EPFIs) have adopted the Equator Principles in order to ensure that the projects they finance and advise on are developed in a manner that is socially responsible and reflects sound environmental management practices. EPFIs recognise the importance of climate change, biodiversity, and human rights, and believe negative impacts on project-affected ecosystems, communities and the climate should be avoided where possible. If these impacts are unavoidable, they should be minimised, mitigated, and/or offset.

3 APPROACH TO THE EIA PROCESS AND PUBLIC PARTICIPATION

This chapter outlines the EIA process, including the assessment methodology and I&AP consultation process.

3.1 EIA OBJECTIVES

The EIA process has the following objectives relating to the process followed and the environmental and socio-economic issues:

3.1.1 General / process

- To provide opportunities for I&APs to be involved in the EIA process, through:
    - Ensuring effective public participation;
    - Adhering to an open and transparent consultation procedure with stakeholders at all times;
    - Ensuring that accurate and regular information is communicated to I&APs;
    - Ensure that information is communicated in a manner which is understandable and accessible to I&APs;
- To ensure potential environmental and socio-economic issues and impacts that would result from the proposed project are identified and assessed;
- Produce an EIA according to internationally recognised standards (refer to 2.1.4);
- To identify and assess feasible alternatives related to the project proposal; and
- To provide information to facilitate informed, transparent, and accountable decision making by the relevant authorities.

3.1.2 Environmental issues

- Implement measures to avoid, prevent, reduce, and if possible, offset significant adverse effects on the environment. With reference to section 1.3, a secondary (environmental related) objective/goal of the project, is to improve rangelands where the encroacher bush will be harvested;
- Determine the biodiversity footprint and baseline of the project and establish whether there are any no go areas for biomass harvesting;
- Avoid deterioration in the quality of the environment in order to achieve no net loss or a net gain of biodiversity and ecosystems;
- Protect the biophysical environment from any impacts that cannot be mitigated and will negatively impact on biodiversity on a regional scale;
- Preserve the water resources in line with the objectives of the integrated catchment management and thereby ensure that the limited available resources are utilised to the maximum benefit of the country and its inhabitants;
- Assess the impact of the proposed project on climate and its vulnerability to climate change;
- Define biomass feedstock harvesting guidelines to ensure that activities are carried out so as to aid rehabilitation;
- Ensure a safe environment for people to live in; and
- Evaluate greenhouse gases savings based on a full life-cycle analysis of the biomass feedstock.

3.1.3 Socio-Economic issues

- Enhance project benefits and minimise negative impacts through intensive consultation with stakeholders;
- Assemble adequate, accurate, appropriate, and relevant socio-economic information relating to the context of the operation;

- Ensure that recruitment strategies for the Power Station prioritises the sourcing of local labour, and share in gender equality;
- Ensure an atmosphere of equality and non-discrimination among the workforce;
- Contribute to the development of functional and literacy among employees;
- Empower the workforce to develop skills that will equip them to obtain employment in other sectors of the economy;
- Contribute to the development of a self-reliant community surrounding the area of operation;
- Ensure that decommissioning and retrenchments take place in a legally compliant and humane manner; and
- Adhere to principles of international best practice in all socio-economic activities.

3.2 EIA PROCESS

The EIA process consists of three phases, the Project Initiation and Screening (internal) Phase; the Scoping Phase; and the Impact Assessment Phase and a series of steps to ensure compliance with the EIA Regulations 2012 as set out in GN No. 30 and the objectives listed above. The process involves an open, participatory approach to ensure that all impacts are identified and that relevant information on environmental and social impacts is provided as part of the decision making process.

A flowchart illustrating the regulated EIA application (i.e. scoping and assessment phases) process is presented in Figure 3-1.

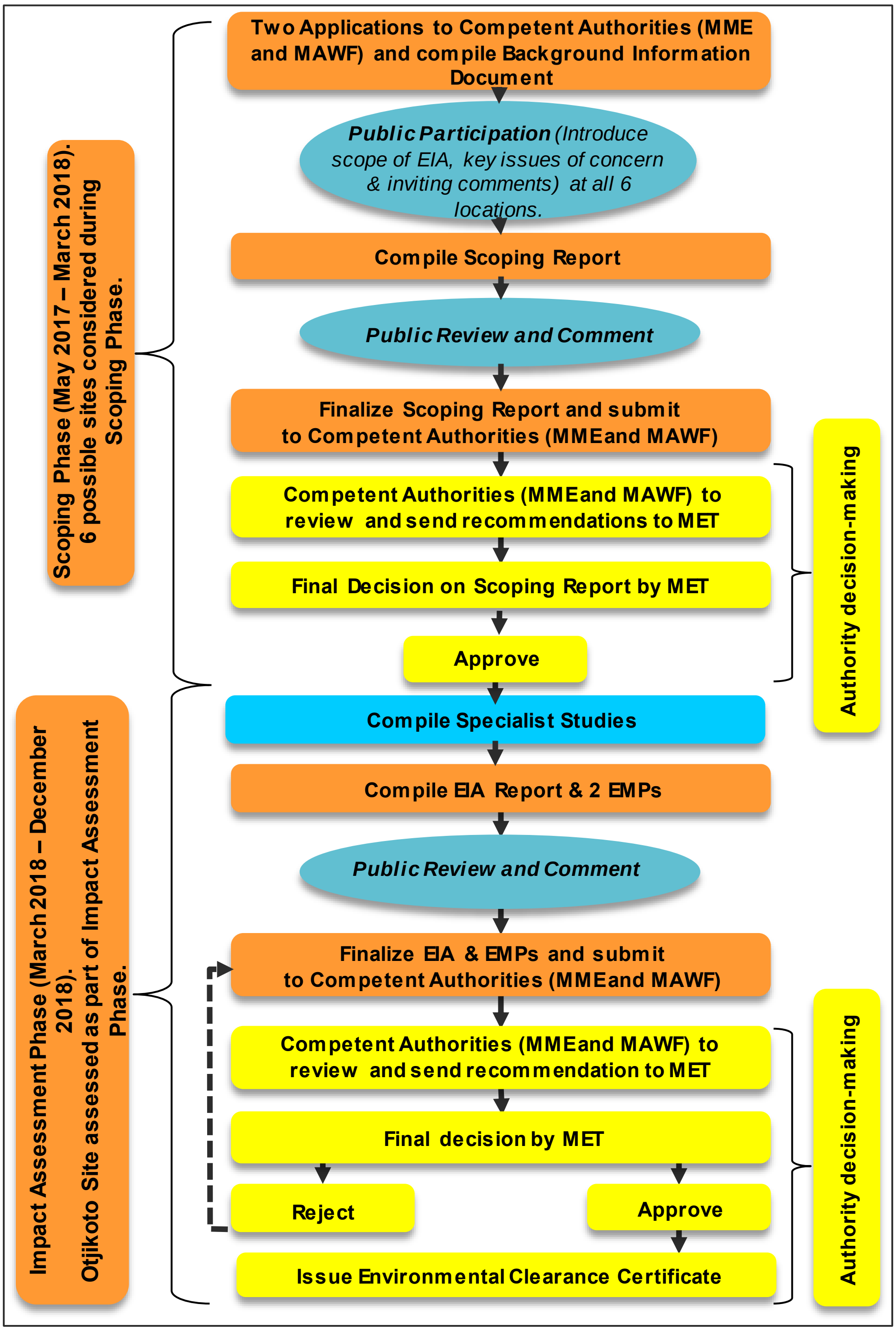


FIGURE 3-1: THE EIA APPLICATION PROCESS FOLLOWED FOR THE BIOMASS POWER PROJECT

3.2.1 Project Initiation and Screening Phase

3.2.1.1 *Project Initiation*

SLR, NamPower and the EIB held an EIA kick-off meeting on the 15th of March 2017. Subsequently, SLR prepared an internal inception report. The purpose of this meeting and Inception Report were to undertake the following:

- Confirm the approach (i.e. EIA scope and process steps) to be followed by SLR and their team of specialists to conduct the EIA;
- Identify significant environmental and social issues;
- Identify key I&APs to be involved in the process;
- Confirm the information requirements for the EIA;
- Agree to the overall objectives and the approach for the project;
- To develop a detailed programme for the completion of the activities.

During this stage of the process, NamPower and the EIB identified that the application for Environmental Clearance will only relate to the Power Station (and associated power line) and not the other project components, i.e. bush harvesting, and transportation. However, the EIA process will have to cumulatively assess all activities associated with the project, including the harvesting and associated activities.

However, during the Scoping Phase, NamPower and the EIB (with input from SLR) changed this strategy and the decision was taken to also apply for the harvesting activities as part of the same EIA process (refer to section 3.2.1.2 below).

3.2.1.2 *Authority and Application Meetings*

SLR and NamPower met separately with the MET (now MEFT) and MME on the 1st of June 2017. The purpose of these meetings was to provide notification of the commencement of the EIA process and to inform the authorities on the EIA process to be followed, as well as to obtain clarity. An Application for Environmental Clearance was submitted to MME on 1st of June 2017. This Application relates to the activities associated with the proposed Power Station and power line.

Similarly an introductory meeting was held with MAWF: Directorate of Forestry as the competent authority for the harvesting related activities. The application for Environmental Clearance was formally submitted on 9 October 2017.

3.2.2 Scoping Phase

The purpose of the Scoping Phase was to:

- Communicate the nature of the proposed project to I&APs;
- Provide baseline information and identify environmental and socio-economic aspects and potential impacts associated with all six sites that were considered for the proposed Power Station and associated harvesting activities (refer to section 1.4). Furthermore, identify any fatal flaws and key risks or opportunities relating to all six sites;
- Provide input into the “Multiple Criteria Decision-Making (MCDM) Process”, relating to the environmental and socio-economic criteria, to determine the “selected site” (i.e. the Otjikoto site), technology and capacity for the proposed Power Station;
- Identify the most significant issues for investigation and assessment and develop the terms of reference for specialist studies conducted in the Impact Assessment Phase.

The Scoping Phase involved the following:

- Notifying I&APs of the proposed project and the steps in the EIA process;
- Creating an opportunity for I&APs to interact with the EIA project team; and
- Providing adequate information for I&APs to comment on, in order to ensure that all key environmental and social issues are identified.

Steps undertaken during the Scoping Phase are summarised below.

3.2.2.1 *Scoping Public Participation Process*

The objective of the scoping public participation process was to ensure that I&APs were notified about the proposed project, given a reasonable opportunity to register on the project database and to provide comments. Steps undertaken during this phase are summarised in Box 3-1.

Box 3-1: Tasks undertaken during the scoping public participation process

1. Initial public engagement process

The initial public engagement process involved the following:

- Development of the Public Participation Process (PPP) Programme:
  - > Initiation meetings: To confirm best dates, times, venue and how to reach the people to advertise the meetings, a number of informal initiation meetings were held with the relevant Town Councils and Regional Councils at all six site locations (refer to section 1.4).
  - > Identification of I&APs: A preliminary I&AP database of authorities, Non-Governmental Organisations (NGOs), Community-based Organisations and other key stakeholders was compiled through site visits / meetings with certain key stakeholders, telephone calls and using databases from other EIAs conducted by SLR across Namibia. Additional I&APs were added to the database based on the tasks below. Table 3-1 below provides a broad list of stakeholders consulted at this point in time. A copy of the I&AP database is attached in Appendix 2.
- Notification letter and Background Information Document (BID): All I&APs on the database were notified of the application and EIA process by means of a notification letter and BID. The BID was compiled to provide introductory information on the project, to encourage people to register on the I&APs database and to provide an initial opportunity to comment. The BID was distributed for a 21 day review and comment period from 30 May to 19 June 2017.
- Advertisements, site notices and pamphlets: Repeat advertisements announcing the proposed project, the availability of the BID, public meetings and the I&AP registration / comment period were placed in *The Namibian* and the *Republikein* on the 30 May and the 6 June 2017.

  Site notices were erected at the NamPower substations at each of the six sites. Pamphlets were distributed to the immediate communities through the relevant town councils. Furthermore, the farmers in close proximity to the proposed Power Station sites (i.e. immediate neighbours) were personally informed by SLR.
- Radio announcements: Radio advertisements explaining the project and advertising the public meeting were broadcasted on the 29 of May and the 5 of June 2017 in the morning and the evening. These advertisements were announced on NBC Damara-Nama, NBC Oshiwambo, NBC Afrikaans, NBC National radio and NBC Otjiherero.

- One-on-one, focus group and public meetings: Various one-on-one, focus group and public information meetings were held between the 8 and 15 June 2017 at each of the six sites.

  At these meetings NamPower and SLR provided an overview of the project proposal and EIA process, and provided stakeholders with the opportunity to raise any issues or concerns.

2. Compilation and review of Draft Scoping Report

The preparation of the Scoping Report was informed by comments received during the initial public engagement process. Responses to all issues raised during the initial public engagement process were collated into a Comments and Responses Report (CRR), which was appended to the Scoping Report.

The Scoping Report was distributed for a 30-day review and comment period from the 5 February to 6 March 2018. Tasks undertaken included:

- Draft Scoping Report availability: Hard copies of the full report were made available at the municipalities and libraries in the towns close to each of the six sites. Electronic copies of the full report were available on the SLR website and made available on CDs on request to SLR. Electronic copies of the full report were also provided to relevant Ministries.
- I&AP notification: Notification of the Scoping Report was emailed to all I&APs (with e-mail) on the project database. The letter informed them of the release of the Report and where the Report could be reviewed. To facilitate the commenting process, a copy of the Scoping Report Executive Summary was attached to the email. Bulk text messages were sent to I&APs without emails. The availability of the report was advertised on NBC National Radio, NBC Damara-Nama, NBC Oshiwambo, NBC Otjiherero and NBC Afrikaans.

TABLE 3-1: BIOMASS POWER STATION PROJECT STAKEHOLDERS

NO.	STAKEHOLDER
1	**Authorities**
	Ministry of Mines and Energy (MME) as competent authority
	Ministry of Environment and Tourism, (MET) as regulator
	Ministry of Agriculture, Water and Forestry (MAWF) as custodian for the harvesting related activities
	Ministry of Land Reform (MLR)
	Ministry of Works and Transport (MW T)
	Ministry of Labour and Social Welfare (MLRS)
	Ministry of Health and Social Services (MHSS)
	Ministry of Industrialization, Trade and SME Development
	National Heritage Council (NHC)
	Namibian Civil Aviation Authority (NCAA), Directorate of Civil Aviation (DCA)
	Gobabis Municipality

NO.	STAKEHOLDER
	City of Windhoek
	Okahandja Municipality
	Otjiwarongo Municipality
	Otavi Town Council
	Tsumeb Municipality
	Regional Councils for the various regions
2	**Parastatals**
	The Namibia Water Corporation (NamWater)
	Roads Authority Namibia
	Telecom Namibia
3	**Environmental NGOs**
	National Botanical Research Institute
	Namibia Nature Foundation
	Namibian Chamber for the Environment
	Earthlife Namibia
	Namibian Environment and Wildlife Society
	N-Big
	GIZ Debushing Affiliation programme
4	**Farming industry**
	Omaheke Regional Farmer’s Union
	Windhoek Farmer’s Association
	Okahandja Farmer’s Association
	Otjiwarongo farmer’s Association
	Otavi Farmer’s Association
	Grootfontein, Tsumeb, Otavi Regional Agricultural Union
	Neighbouring farmers
5	**Conservancies**
	Ovitoto Conservancy
	Otjombinde Conservancy

3.2.2.2 *Compilation and approval of the Final Scoping Report*

The Final Scoping Report was prepared in compliance with Section 8 of the EIA Regulations 2012 and was informed by all comments received during the public participation process described in Box 3-1, in addition to other inputs. The key issues raised by I&APs during the scoping phase pertained to:

- Job creation, skills development, and local procurement;
- Local benefits;
- Groundwater abstraction (including water usage / losses from the plant) and pollution;
- Remuneration model;
- Harvesting practices;
- Control of sickle bush;
- Road infrastructure;
- Dust impact on surrounding people;
- Loss of wildlife especially for quota hunting (loss of income);
- Loss of biodiversity;
- Loss of tourism potential;
- After-care responsibility; and
- Process related issues.

An Issues & Responses Report is attached in Appendix 3.

All comments received from I&APs in the Scoping Report review period were included in the final report that were submitted to MME, MAWF and MET. The Scoping Report was accepted by MET (now MEFT) on 21 May 2018 (see Appendix 4). The MET acceptance stated that SLR is to '...proceed with the full EIA Report and EMP…".

3.2.3 Impact Assessment Phase

3.2.3.1 *Specialist Assessments*

The proposed terms of reference for further specialist investigations were developed as a result of the scoping phase and presented in the Scoping Report. Specialist assessments, taking these terms of reference and the baseline work conducted during the Scoping phase into consideration, were required to further inform the various impacts that the project may have on the physical, social, and economic environment and therefore were included in this report and discussed below. With reference to section 1.2, NamPower selected the "Otjikoto site", near Tsumeb as the preferred site for the proposed Power Station and the impact assessment therefore focuses on this site and the surrounding harvesting area (refer to section 4 for more details).

The following specialist assessments were conducted:

- Air Quality, Climate Change and Health Risk Assessment (Airshed, 2018) (see Appendix 5);
- Biodiversity Assessments:
  - Vertebrate and Vegetation Baseline Study, Integration of all Biodiversity Components and Biodiversity Impact Assessment (AWR, 2018) (see Appendix 6.1)
  - Avifauna Impact Assessment (ACS, 2018) (see Appendix 6.2)
  - Invertebrates Baseline Study (Biodata, 2018) (see Appendix 6.3)
- Noise Impact Assessment (SLR, 2018a) (see Appendix 7);
- Visual Impact Assessment (G. Young, 2018) (see Appendix 8);
- Archaeology Impact Assessment (SLR, 2018b) (see Appendix 9);
- Socio-Economic Impact (SLR, 2018c) (see Appendix 10);
- Groundwater and Surface Water Impact Assessment (SLR, 2018d) (see Appendix 11);
- Soil Impact Assessment (SLR, 2018e) (see Appendix 12); and
- Traffic Impact Assessment (Burmeister & Partners, 2018) (see Appendix 13).

3.2.3.2 *Impact Assessment Methodology*

The criteria used to assess the impacts and the method of determining the significance of the impacts relating to the proposed project is outlined in section 7.1. This method complies with the EIA Regulations: EMA, 2007 (Government Gazette No. 4878) and was used by all specialists to conduct their impact assessment.

3.2.3.3 *Compilation and Review of Draft EIA Report and EMPs*

This EIA Report has been prepared in compliance with Section 15(2) of the EIA Regulations 2012 (see Table 3-2). The specialist studies and other relevant information / assessments have been integrated into this report.

This report presents information in a structured format suitable for easy review by I&APs and authorities and provides further opportunity for I&APs to comment on the proposed project and findings of the EIA process (see Section 1.1 for details of how to comment and the comment period). All the project components, i.e. the Biomass Power Station, overhead power line, harvesting and associated activities) are described and assessed in this report.

Two EMPs have however been developed as follows:

- EMP for the Power Station and overhead power line (Appendix 14) and
- EMP for the harvesting and associated activities, including the transportation of the biomass to the plant (Appendix 15).

TABLE 3-2: REQUIREMENTS OF AN EIA REPORT IN TERMS OF THE EIA REGULATIONS 2012

Section 15(2)	Content of EIA Report and EMP	Completed (Y/N or NA)	Section in this report
(a)	The curriculum vitae of the EAP who compiled the report.	Y	Section 1.4, Appendix 1
(b)	A detailed description of the proposed listed activity.	Y	Section 4
(c)	A description of the environment that may be affected by the activity and the manner in which the physical, biological, social, economic, and cultural aspects of the environment may be affected by the proposed activity.	Y	Sections 6 and 7
(d)	A description of the need and desirability of the proposed listed activity and identified potential alternatives to the proposed listed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and the community that may be affected by the activity.	Y	Sections 1.3 and 5
(e)	An indication of the methodology used in determining the significance of potential effects.	Y	Section 7.1
(f)	A description and comparative assessment of all alternatives identified during the assessment process.	Y	Sections 5 and 7
(g)	A description of all environmental issues that were identified during the assessment process, an assessment of the significance of each issue and an indication of the extent to which the adoption of mitigation measures could address the issue.	Y	Section 6 and 7 and Appendices 14 and 15
(h)	An assessment of each identified potentially significant effect.	Y	Section 7
(i)	A description of any assumptions, uncertainties, and gaps in Knowledge.	Y	Section 8 and Appendices 5 to 13
(j)	An opinion as to whether the proposed listed activity must or may not be authorised, and if the opinion is that it must be authorised, any conditions that must be made in respect of that authorisation.	Y	Section 9
(k)	A non-technical summary of the information.	Y	Executive Summary

The draft EIA Report and EMPs were first reviewed by the EIB for compliance to their relevant standards as well as by the Southern African Institute for Environmental Assessments (SAEIA) to ensure IFC compliance.

Furthermore, the Environmental Compliance Consultancy, reviewed the documents to ensure alignment with the FSC Standards.

3.2.3.4 *Completion of the Impact Assessment Phase*

The following steps were conducted for the remainder of the Impact Assessment Phase:

- Notifications to I&APs of availability of EIA Report and EMPs and focus group meetings in Tsumeb:
    - The EIA Report Executive Summary was distributed to all authorities and I&APs (with e-mails) that are registered on the project's public involvement database (Appendix 2) via e-mail. Bulk text messages were sent to I&APs without emails (see email and text message wording in Appendix 16.1).
    - Electronic copies of the full report were available on the SLR website and on request to SLR (on a CD and email).
    - The availability of the report was advertised on NBC National Radio, NBC Damara-Nama, NBC Oshiwambo, NBC Otjiherero and NBC Afrikaans (see radio announcement wording in Appendix 16.1).
    - The availability of the report was advertised in the following newspapers on the 23 of October 2020: Republikein, Allgemeine Zeitung and the Sun See proof advert in Appendix 16.1).
    - Hardcopies of the Executive Summary of the main EIA Report (full report in Tsumeb and Windhoek), as well as electronic copies (CDs) of the full report, including all Appendices were available at the libraries as presented in Table 1-1.
    - Authorities and I&APs had 30 days to review the EIA Report and EMPs and submit comments in writing to SLR. The comment period ended on the 20th of November 2020.
- Information sharing meetings with focus groups and Key Stakeholders were held in Tsumeb during the review period of the EIA report and EMPs, as follows:
    - Focus group meetings with the Tsumeb Municipality representatives on 10 November 2020.
    - Focus group meeting with representative bodies of the San and other marginalised groups within the harvesting area on 8 November 2020.
    - Focus Group meeting with representative Farmers Association(s) within the area on 9 November 2020.

  The minutes of meetings, attendance registers and presentation are included in Appendices 16.2 and 16.3.

Comments and Response Report (CRR)

All comments, questions, and issues raised by the I&APs, during the review period of the EIA Report, either through written (i.e. e-mails) comments received or at the above mentioned meetings were included into a comments responses report (CRR) (see Appendix 16.5). The CRR provides responses to each of the comments, questions, and issues raised with reference to relevant sections of the EIA Report, specialists reports, EMPs, where relevant. All comments received by I&APs are included in Appendix 16.4.

Final EIA Report and review by MME and MEFT

After closure of the comment period, this draft EIA Report and EMP were finalised by incorporating all comments received on the draft report, where relevant. A CRR is appended to the Final EIA Report as Appendix 16.5. The Final EIA Report and EMPs will be submitted to MME for review, who will then forward the report with their comments to MEFT for a decision.

If the Final EIA Report and EMPs are approved, MEFT will issue two separate Environmental Clearance Certificates.

4 DESCRIPTION OF THE PROPOSED PROJECT

This chapter describes the sequence of the proposed project phases and activities, provides technical information, outlines the proposed Power Station operation; the power line specifications, the harvesting and associated activities.

4.1 PROJECT OVERVIEW

The project will consist of the following components, which are described in more detail below:

- Construction and operation of a 40 MWe Biomass Power Station[2] at the Otjikoto site;
- Harvesting and processing activities of the encroacher bush to suitable fuel specification, including all temporary storage. The approximate annual fuel requirements (i.e. wood chips, on a dry basis) for a 40 MWe biomass plant would be:
    - 175,000 at approximately 60% capacity factor
    - 200,200 at approximately 70% capacity factor
    - 220,000 at approximately 75% capacity factor
    - 245,000 at approximately 85% capacity factor
- Logistics, transportation and stockpiling of the of the wood chips; and
- Transmission substation and connection to the national grid via an overhead power line of maximum 66 kV.

The project will be implemented in three different project phases, including:

- Construction Phase, which is relevant to the Power Station and overhead power line;
- Operations Phase, which is relevant to all the project components including the harvesting activities and processing of encroacher bush, logistics, and transportation, as well as the Power Station and the overhead power line operations; and
- Decommissioning and Closure Phase; which is relevant to the Power Station and overhead power line.

4.2 PROJECT LOCATION

The location for the proposed Power Station site is approximately 7 km northwest of Tsumeb, in the Oshikoto Region, flanked by Trunk Road (TR) 1/10 (i.e. B1) on the southern side and District Road (DR) 3007 on the western side. The site, which is being purchased by NamPower, is strategically located in close proximity to NamPower's existing (Otjikoto) substation.

Refer to Figure 4-1 for the location the proposed Power Station site in relation to the existing substation and the town of Tsumeb and Figure 4-2 for the harvesting area, which covers an area of roughly 3.1 million ha surrounding the site, excluding no-go areas and other constraints in the harvesting area. These constraints and no-go areas were highlighted during the Scoping Phase of the EIA (as indicted in Figure 4-2) and include the following:

- National Parks (i.e. Etosha and Waterberg National Park);
- Slopes exceeding 12.5% gradient; and

[2] NamPower is likely to first implement a 20 MWe Biomass Power Station. However, this report and assessment of environmental and social impacts are based on a 40 MWe plant to ensure the "worst case scenario impacts" are assessed and the decision by MEFT is based on this scenario, should NamPower at a later stage decide to expand the Power Station (see section 5.3 for more details).

- Sensitive bioclimatic endemic areas.

These areas are further described and assessed in sections 6 and 7 of this report and a revised Harvesting Sensitivity map presented in Figure 6-38.

The co-ordinates of the proposed Power Station site, with a footprint of approximately 44 ha, are provided in Table 4-1. NamPower is at an advanced stage of procuring the land.

TABLE 4-1: PROPOSED POWER STATION SITE COORDINATES

Point	Latitude	Longitude
A	19˚12’19.95”S	17˚37’53.03”E
B	19˚32’32.94”S	17˚38’17.43”E
C	19˚12’53.88”S	17˚38’8.77”E
D	19˚12’48.13”S	17˚37’52.43”E

FIGURE 4-1: LOCALITY MAP FOR THE PROPOSED OTJIKOTO POWER STATION SITE

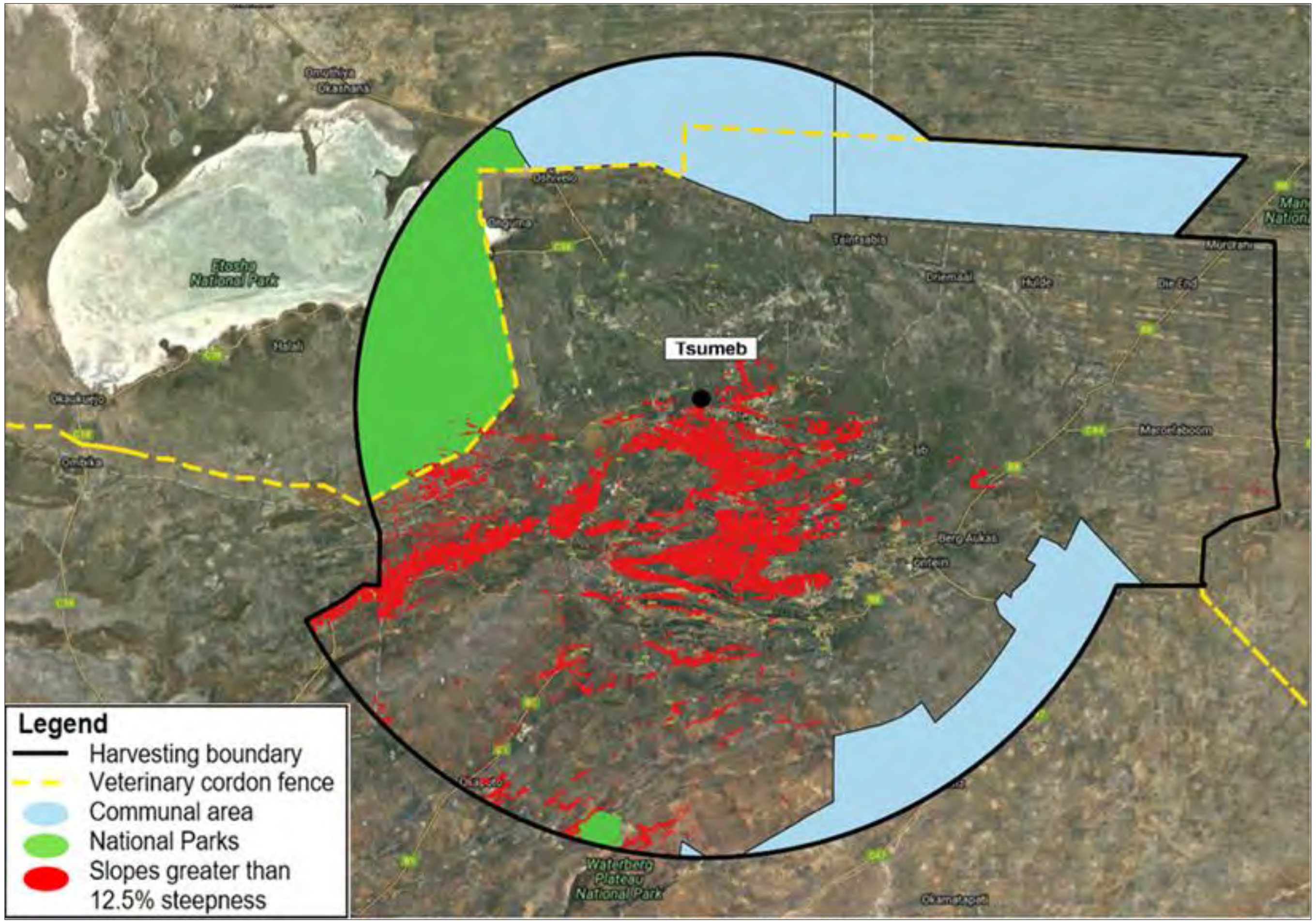


FIGURE 4-2: LOCALITY MAP FOR THE PROPOSED OTJIKOTO POWER STATION IN RELATION TO THE HARVESTING AREA[3]

[3] If part of the farm cuts the boundary that farm is considered included in the harvesting area. NamPower to conduct an assessment of the specific farms falling in and out of the area subject to approval of the ECC.

4.3 CONSTRUCTION PHASE (ASSOCIATED WITH THE POWER STATION AND THE OVERHEAD POWER LINE)

A number of construction working areas will be established on site. These work areas will either move within the footprint of the proposed site as construction progresses, or they will be located at a specific stationary site within the infrastructure footprint for the duration of the construction phase.

4.3.1 Construction Phase Facilities / Working Areas

The following facilities will be required for the construction phase of the Power Station and overhead power line:

- Contractors lay down areas;
- Workshops, maintenance areas, stores, wash bays, lay-down areas, batch plant, fuel handling and storage area, offices, change houses;
- Access road and parking areas, access to the site during construction will be from DR3007 (see Figure 4-1);
- Ablution facilities for contractors;
- Handling and storage area for construction materials (paints, solvents, oils, grease);
- Generators for temporary power supply;
- Stockpiles;
- Security provisions, i.e. perimeter fencing;
- Waste collection and storage areas; and
- Temporary power and water supply infrastructure.

These facilities would either be removed at the end of the construction phase or incorporated into the layout of the operational Power Station.

4.3.2 Construction Phase Activities

Construction activities will take place during the establishment and preparation of the site for the Power Station and the overhead power line. Significant activities which are expected to take place during construction are, but not limited to the following:

- Appointment and management of contractors, labours, etc.;
- Site preparation and enabling works, including clearing, and grubbing, levelling of area and other earth moving activities. The total area that needs to be cleared for infrastructure at the project site is approximately 44 ha;
- Drilling and pilling;
- Stockpiling topsoil and subsoil;
- Foundation excavations and hole excavation for the power line;
- Backfill of material from borrow pits;
- Opening and management of borrow pits;
- Setting up contractors' laydown areas;
- Establishing access road from the DR3007;
- Delivery of materials, storage and handling of material such as sand, rock, cement, chemical additives, etc.;
- General construction activities (i.e. foundation and substructure works and structure works) including, amongst others: mixing and pouring of concrete; steelwork erection; operation of

construction vehicles and machinery; refuelling of machinery; civil, mechanical and electrical works; painting; grinding; welding; etc.;

- Handling and storage of hazardous material;
    - Oils and lubricants,
    - Paints,
    - Gas cylinders (welding),
    - Cement,
    - Chemical additives for cement,
    - Diesel and petrol,
- Handling, storage, and disposal of hazardous waste;
    - Empty paint containers,
    - Cements bags,
    - Chemical additives (for cement) containers,
    - Contaminated PPE and other (with hydrocarbons, etc.),
    - Redundant concrete,
    - Empty oil or lubricant containers,
- Handling, storage, and disposal of non-hazardous waste;
    - Steel off-cuts,
    - Spoil material generated from earth moving activities,
    - Insulation and lagging materials,
    - Domestic waste,
    - Wood off-cuts,
    - Grinding wheels,
    - Other construction waste, i.e. plasterboard, wood containers, etc.,
    - Packaging, e.g. plastic wrapping, Styrofoam,
- Surveying and setting out of the final power line route;
    - The cleared servitude (from large trees, shrubs, bushes, etc.) must be 25 m on each side (50 m in total) with the central 12 m cleared for a maintenance access road, and
    - Pegging of the power line (a 150 m corridor will be established prior to the pegging of the power line in which the servitude can deviate if required – taking the EMP commitments into consideration).

4.3.3 Construction Vehicles and Equipment

The following vehicles and equipment are likely to be used during the construction of the Power Station and overhead power line:

- Tracked excavator;
- Lorry (unloading);
- Concrete truck mixer;
- Vibratory roller;
- Diesel generator;
- Concrete mixer truck & concrete pump;
- Dumper;
- Wheeled mobile crane;
- Mobile telescopic crane;
- Piling rig;
- Lifting platform;
- Lorry, with lifting boom;
- Poker vibrator;

- Telescopic handler;
- Compressor; and
- Tower crane.

4.3.4 Construction Workforce and Housing

The construction will be done by appointed contractors, administered by NamPower. Approximately 300 jobs would be created during the 35 month construction phase of the project. The employment of local people in close proximity to the selected site during the construction phase would be preferred, particularly for unskilled and semi-skilled labour works.

There will be no staff accommodation on site. Contractors and workers will be transported back and forth site from the nearest town, etc.

4.3.5 Construction Traffic

With reference to section 4.3.4, contractors and workers will be transported to site. The assumptions relating to construction traffic are as follows:

- Vehicle occupancy of 1.7 passengers per vehicle for skilled workers (30/1.7 = 18 trip per day);
- Vehicle occupancy of 65 passenger per bus for unskilled workers (270/65 – 4 trips per day); and
- The transport of workers to site is not the only traffic that will be generated, various supporting services will generate additional traffic during construction. An additional 10 trip per peak hour is assumed.

Furthermore, for a worst-case impacts scenario, the assessment (section 7.2) assumed 100% of workforce will be sourced from and reside in Tsumeb.

4.3.6 Construction Phase Water Supply and Management

At this stage in project planning, it is assumed that water will be abstracted from a nearby borehole(s).

4.3.7 Construction Phase Power Supply

At this stage in project planning, it is assumed that either onsite generators will be used, and / or an application will be made for a the construction of a temporary supply from the relevant distributor in the region.

4.3.8 Medical Facilities

The construction personnel will make use of the available medical facilities in Tsumeb in the event of any work related medical attention. A first aid Station will be provided on site.

4.3.9 Construction Phase Waste

4.3.9.1 *Sewage*

During the construction phase, portable toilets would be provided onsite for staff. The portable toilets will be supplied by an appropriate contractor and will be serviced on a regular basis. Sewage will be collected in trucks and disposed of at a licenced facility off-site.

4.3.9.2 *Other Waste (Hazardous and Non-Hazardous)*

The Principal contractor chosen by NamPower through the bidding process will be contractually required to develop a site specific waste management plan for the project. The general waste management principles that will apply to the construction phase are describe below.

Waste will be separated at source and temporarily stored on site in a manner that there will be no discharge to or contamination of the environment, and either recycled by suppliers, or reused by scrap dealers where possible. The remainder will be transported off site to appropriate recycling or disposal facilities (i.e. Tsumeb for general waste and Windhoek or Walvis Bay for hazardous waste). Appropriate waste management contractors will service the construction activities.

The types of waste that could be generated during the construction phase include the following:

- Hazardous and non-hazardous industrial waste;
- General waste (domestic and other non-hazardous waste); and
- Medical waste.

The waste types and specifications, as well as the management of the waste for the construction phase of the proposed Power Station and overhead power line, relating to all waste types are provided in Table 4-2.

TABLE 4-2: CONSTRUCTION PHASE WASTE

WASTE TYPE	WASTE SPECIFICS (EXAMPLE OF WASTE TYPES)	STORAGE FACILITY	END USE
Non-hazardous solid waste	General domestic waste such as food and packaging, pallets, wooden crates, cable drums and scrap metal.	Skips / bins in relevant work areas will be provided for different waste types.	Waste will be sorted, and recyclable waste will be sent to a reputable recycling company. The remainder of the waste will be transported by a waste management contractor to a permitted general landfill facility in Tsumeb for disposal.
	Waste concrete and building rubble.	Designated rubble collection points will be determined to which contractors will take rubble and concrete.	The waste management contractor will regularly remove the waste from the designated collection points to a disposal facility.
Hazardous solid waste	Printer cartridges treated timber crates, batteries, fluorescent bulbs, paint, tar, solvents, empty hazardous	Hazardous waste will be separated at source and stored in designated containers in dedicated bunded storage areas.	Hazardous waste will be disposed of at the permitted hazardous disposal site (in Windhoek or Walvis Bay) by the waste management contractor.

	material containers etc.		
	Hydrocarbons (oils, grease)	Oil and grease will be stored in drums in dedicated bunded areas. The bunds will be able to accommodate 110 % of the container contents and include a sump and oil trap. The storage area will include a concrete slab, proper bunding and an oil sump.	Used oil will be sent to a reputable recycling company for recycling.
	Hydrocarbon contaminated soil	The required steps to enable fast reaction to contain and remediate pollution incidents will be implemented. Options for treatment of contaminated soil include in situ treatment or disposal of contaminated soils as hazardous waste.	
Medical waste	Syringes, material with blood stain, bandages, etc.	Medical waste will be stored in sealed containers at the first aid station.	Medical waste will be transported by the waste management contractor to a permitted incineration facility for incineration.

4.3.10 Construction Phase Timing and Implementation of the Project

Construction commencement is subject to regulatory approval, i.e. approval of the EIA and issuing of an Environmental Clearance Certificate (ECC) by the MET. Furthermore, specific governance approval and economic considerations will dictate the start of construction.

Subject to ECC approval by MET, NamPower intends to commence with construction as soon as possible in 2020 depending on approvals from the Central Procurement Board and the Electricity Control Board. Construction is expected to take approximately 35 months to complete.

Harvesting activities may take place during the latter part of construction to initiate the working 3 months pre-commissioning stockpile.

NamPower's intention is to procure both the Power Station EPC contractor and the Fuel Suppliers via a competitive bidding process. The EMP commitments are deemed part of the Fuel Supply Price as the EMPs will be shared with prospective bidders.

Only if the Powers Station EPC price and the Fuel Price are deemed financially feasible will the project proceed.

By following the aforementioned approach NamPower will ensure that the project is both economically and environmentally sustainable.

4.4 OPERATIONAL PHASE

4.4.1 Biomass Feedstock Evaluation

4.4.1.1 *Biomass Quality*

A quality assessment was done on chipped encroacher bush wood samples, collected at different locations across the original 6 (possible) harvesting areas (refer to section 1.4), to confirm its suitability as a fuel for the proposed Biomass Power Station. Laboratory testing included the following physical and chemical properties:

- Ultimate Analysis (oxygen, carbon, hydrogen, nitrogen, sulphur and chlorine content);
- Moisture content;
- Ash content;
- Major and minor elements;
- Ash fusibility;

The laboratory analysis of the chipped encroacher bush wood samples revealed that the composition is very consistent and independent of plant species and geographical location. (COWI Biomass Source Report, 2017).

The laboratory results showed that the calorific value (CV) of Namibian biomass and more specifically the samples taken from the Otjikoto region have an average net CV of 17.7 MJ/kg on a dry basis. This value correlates with the values obtained through an independent study conducted by Namibian Biomass Industry Group (N-BiG).

4.4.1.2 *Biomass Quantity*

As part of Phase I of the Feasibility Study, the Techno-Economic Advisor, conducted a resource assessment to investigate the potential quantity of biomass woodchips fuel near the Otjikoto site. They used the “Biomass Estimates from Canopy Volume” (BECVOL) model to estimate the total wood yield. They assessed that in the planned harvesting area of the proposed Project Site on average 52.4 to 61.7 tonnes per hectare (t/ha) of total wood yield is estimated.

This assessment focused on the potential biomass woodchips supply in a 100 km harvesting radius around the proposed Project Site. The harvestable area identified after the investigation was found to be around 3.1 million hectares, which excluded protected areas, slopes greater than 12.5% and ecological sensitive areas. The potential supply restrictions and opportunities were further refined through the EIA Scoping Study (see section 3.2.2 for more details on the EIA Scoping process).

Taking the previous resource assessments into consideration, the figures provided by the Techno-Economic Advisor are considered optimistic. Based on the findings from other studies and the recommendations for safe extractable yields (without compromising the ecological systems and the bush thinning objectives (see sections 6 and 7 of this report) a conservative wood yield assumption of 12.65 t/ha will be used for the Otjikoto region and the proposed Otjikoto Power Station.

From the investigated harvestable area of 3.1 million hectares it is determined that a total of 39.215 million tonnes of biomass woodchips (dry basis) can be conservatively extracted. This is enough encroacher bush to power a 40 MWe biomass Power Station for 195 years at baseload capacity.

TABLE 4-5 (refer to section 4.4.4.3) shows the fuel requirements for a typical 40 MWe biomass Power Station operating at an 85% Capacity Factor (CF). Based on this information, a harvesting area of approximately

396 250 ha is necessary to fuel a biomass Power Station of 40 MWe over its design lifetime of 25 years. 12.8% of the investigated harvestable area (i.e. 3.1 million hectares) will therefore be harvested.

For a 40 MWe biomass Power Station, Cirrus Capital calculated that approximately 12% of the available biomass (i.e. harvestable area) will be utilized by the Biomass Power Station during the life time of 25 years, still leaving about 54% unharvested, available for possible additional users to emerge in future (refer to Figure 4-3) (Cirus Capital, 2018).

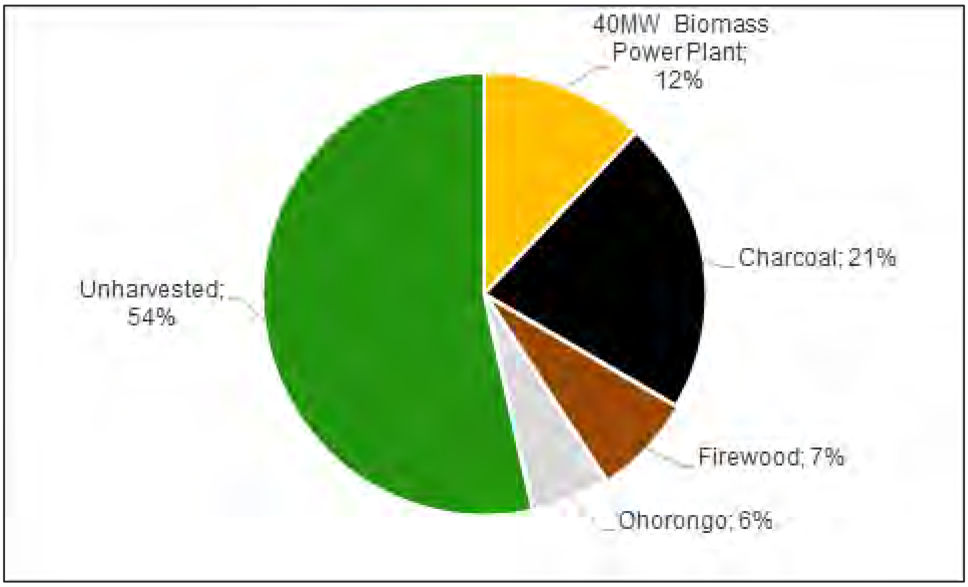


FIGURE 4-3: USERS OF BIOMASS IN THE HARVESTING AREA OVER A 25 YEAR PERIOD (SOURCE: CIRUS CAPITAL, 2018)

4.4.2 Harvesting and Processing of Biomass

Taking the quantity and quality assessments by NamPower and their Techno-Economic Advisor into account, together with the findings from the EIA Scoping Study, a harvesting area was identified surrounding the proposed Project Site. The harvesting area surrounding the proposed Power Station is illustrated in Figure 4-2.

The harvesting will be done in suitable areas around the proposed Otjikoto Biomass Power Station site. The specific harvesting areas will be determined by the harvesters, where strict adherence to the requirements included in the 'Harvesting and Associated Activities EMP' (refer to Appendix 15) will be imposed.

There are six main operations relating to the harvesting and processing component, which are described in more detail in the sections below:

- Felling;
- Stacking;
- Feeding;
- Chipping/Grinding;
- Shuttling; and
- Transferring (i.e. transportation of the biomass to the plant).

4.4.2.1 *Felling*

With reference to section 4.1, the proposed 40 MWe biomass plant would require 245,000 tonnes of wood chips per annum (on a dry basis) at approximately 85% design capacity. Harvesting, however, has to happen at a higher rate due to the fact that the wood harvested will be wet and first needs to dry, therefore losing weight. Also, assuming harvesting takes place only 9 months of the year due to rain events and other unforeseen circumstances, the assumption is that the harvesting rate should be around 750 tonnes per day. At an average yield of 12.65 t/ha, this would thin approximately 20,000 hectares of land per annum, equivalent to approximately 3 commercial farms per annum. With reference to section 1.3, the harvestable area around the proposed Biomass Power Station is approximately 3.1 million ha (excl. slopes &protected areas). Approximately 12.8% of the harvestable area will be harvested over the 25 years (NamPower, 2019).

Different felling equipment can be used to harvest bushes. The equipment varies, depending on the size of the bushes to be harvested and on the level of mechanisation of the harvesting operation. For bushes and small scale harvesting; manual (labour intensive) felling methods (FIGURE 4-4) are typically used. For larger harvesting operations; larger, fully mechanised/automated methods (FIGURE 4-5) are used to harvest. (GIZ, 2015) (Refer to section 5.1 for more details on the alternative harvesting methods).

Both methods are being considered by NamPower.

FIGURE 4-4: TROLLEY SAW (LEFT) AND BOSCUT FELLING MACHINE (RIGHT) USED IN SMALL SCALE FELLING (GIZ, 2015)

FIGURE 4-5: HYDRAULIC GRAB AND CUTTER USED IN LARGE SCALE FELLING (GIZ, 2015)

Bush will be thinned (not be cleared) during the felling activities. Practical guidelines for thinning intensities, as provided in the Forestry and Environmental Authorizations Process for Bush Harvesting Projects (Pallett & Tarr 2017), will be followed.

Also, the enormous potential woody resource compared to the supply requirements for the proposed Biomass Power Station means that re-harvesting (i.e. 'bush farming') is not required. From an biodiversity impact perspective it has been identified that that intentional bush farming may not be included as an objective by any land owners or harvesting contractor (see section 7.4.4).

For the purpose of this Project, only Namibian encroacher bush was selected as a fuel source. Namibian encroacher bush is available in abundance and is considered a renewable energy source due to its tendency to rapidly regrow and increase in numbers or coppice in their original habitat through injudicious chopping or burning. The target species to be harvested are summarised in Table 4-3 (this list may include other species as advised by the MEFT).

TABLE 4-3: TARGET SPECIES TO BE HARVESTED

Target Species		Protection status
Scientific name	Common name	
Acasia mellifera	Black-thorn acacia, swarthaak, omusaona	Not protected
Acasia reficiens	Red umbrella-thorn, rooihaak, rotrindenakazie	Not protected
Acasia luderitzii	Kalahari acacia	Not protected
Acasia erubescens	Yellow-bark acacia, omungongomwi, withaak, berkebos	Not protected
Acasia fleckii	Sandveld acacia, blade-thorn, mungamba	Not protected
Acasia nebrownii	Water-thorn, /nubib, orupunguya, slapdoring, pfannenstrauch	Not protected

Target Species		Protection status
Scientific name	**Common name**	
Dichrostachys cinerea	Sickle-bush, omutjete, sekelbos, papwielbos, farbkätzchenstrauch	Not protected
Terminalia sericea	Silver cluster-leaf, mugaro, omugolo, za'o, geelhout, vaalboom, fahlbaum, gelbholz	Not protected
Colophospermum mopane	Mopane	Protected. Thinning is only allowed in cases of high densities.[4]
Rhigozum trichotomum	Three-thorn rhigozum, //hau.b/s, okatakambindu, driedoring, dreidorn	Not protected
Prosopis	Prosopis	Not protected

4.4.2.2 *Stacking*

The expected moisture content of the delivered biomass woodchips as fuel to the biomass Power Station will vary between 45% moisture content in the rainy season to a minimum of approximately 5% in the dry winter months. Thus, the biomass Power Station has to be designed to handle a fuel source with high moisture variation in its boiler (see section 4.4.4.3).

Stacking will be done in the dry months to facilitate further processing i.e. grinding/chipping. Felled bushes will be stacked in windrows or piles to allow for the air and sun to dry the biomass (FIGURE 4-6). The Namibian climate is ideal for this drying process to be conducted naturally. However, some bush species chip easier when wet. Dry and harder wood species are often easier crushed or grinded by means of an impact action (GIZ, 2015). The specific requirements of the boiler can be met with additional drying on site and/or blending of woodchips with different moisture content.

[4] The conditions under which the *Colophospermum mopane* is classified as a protected plant is not for its population size, but due to its extent of use (EU). The species is heavily utilised by humans and animals (browse and forage) - charcoal, timber, fuel wood, construction, medicine, host to important edible caterpillar, its slow growth rate and its cultural value. (Forest Regulations 2015: Forest Act (Act. No. 12 of 2001)).

FIGURE 4-6: STACKING OPERATION (GIZ, 2015)

4.4.2.3 *Feeding*

The harvested bushes will be fed into the chipper/grinder manually or mechanically. A three-wheel logger is often used for this purpose. The proposed Power Station will most likely use 'wood chips'.

A mechanical feeder grabs the trees from the stacked windrows with a hydraulically operated 'buncher' or grab and feed the bush into the grinder. (GIZ, 2015).

4.4.2.4 *Chipping/Grinding*

The fuel specification for the proposed Biomass Power Station depends on the final specification agreed between the technology suppliers and the capability of the harvesters, but will be in wood chip format.

The bushes will be fed through a grinder, or chipper for some softer and wet woods, to produce wood chips (FIGURE 4-7). The chipping/grinding operation will have a built-in screen which could regulate the size of the chips. The wood will need to be chipped to specific size requirements.

FIGURE 4-7 shows drum chippers and grinders that are designed to pneumatically, or mechanically in the case of large grinders, convey the chips into the road trailers parked next to or behind the grinder (GIZ, 2015).


FIGURE 4-7: EXAMPLE OF A CHIPPER (LEFT) AND LARGE GRINDER INFEED CUTTER DRUM (RIGHT) (GIZ, 2015)

4.4.2.5 *Shuttling*

Wood chips will be gathered in a shuttling trailer near the point of harvesting, at the point where the grinding/chipping takes place, and transported to the collection or transferring point (GIZ, 2015).

4.4.2.6 *Transferring*

The wood chips will be stored at a central collection point prior to being loaded onto road trailers for road transport to the delivery point at the Power Station (refer to FIGURE 4-8).

FIGURE 4-8: CHIPS TRANSFERRED ONTO A ROAD TRAILER (GIZ, 2015)

4.4.2.7 *Access to the Resource*

Access to the resource is influenced mainly by the physical infrastructure (i.e. access roads and gates, bush density, harvesting equipment and topography) as well as the related commercial arrangements with the respective resource owners.

One of the critical roles associated with the fuel suppliers is to secure access to land with suitable resource for harvesting. For the execution of this Project, it is anticipated that majority of the encroacher bush will be sourced from agricultural (commercial) farmland, as the additional approvals required for harvesting on Communal Land (i.e. Communal Land Act of 2002 and the Forestry Act of 2001) may inhibit harvesting of biomass on communal or state lands at the moment. Regardless of the land classification, it is important that the fuel supplier obtains the requisite consent and rights to harvest from the correct and rightful owner(s). This consent will be provided by virtue of a harvesting agreement which will be signed by the landowner and the long term fuel supplier (in the event that they are separate entities.)

As part of the harvesting operations, the fuel suppliers and respective resource owners will need to compile and submit a verifiable Site Specific Harvesting Plan (SSHP) indicating the agreed areas for harvesting, all no-go areas, access roads and other areas to be avoided. This Site Specific Harvesting Plan will be reviewed and approved, by NamPower, in accordance with the EMP and will form part of the harvesting agreement.

4.4.2.8 *Harvesting Workforce*

The proposed Biomass Power Station will require 245,000 tonnes of dry biomass per year to achieve ±85% capacity (refer to section 4.1). NamPower is planning to contract at least 4 Long Term Fuel Suppliers which will supply at least 140,000 tonnes/annum (50%), up to 88% of the fuel requirements. To increase the spread of social and economic benefits of the power plant, NamPower plans to contract a number of Ad Hoc Fuel Suppliers to supply at least 30,000 tonnes (12% of requirements) but will consider increasing it to up to 50% of the plant’s fuel supply if the supply chain is successful.

Cirrus Capital, in consultation with NamPower, GIZ and the Namibia Biomass Industry Group (N-BiG), proposed two scenarios with a mix of operator sizes. Scenario 1 is 90% heavily mechanical with only 10% of the required woodchip production done by semi-mechanised and manual operators and this would create about 300 jobs. Scenario 2 would create approximately 1,200 harvesters to feed a 40 MWe plant, and the majority of these would be at lower skill levels (Cirrus Capital, 2018).

For the assessment, it is assumed that multiple harvesting teams will be operating at any one time. The number of weeks in a year in which biomass harvesting will take place will be 40. Please note that this may differ to actual conditions during operations, nonetheless the impacts and mitigation measures prescribed in this report and Harvesting and Associated Activities EMP will remain relevant.

4.4.2.9 *Aftercare*

Bush encroacher species, especially *Dichrostachys cinerea,* which is to be considered a dominant species in the harvesting area are extremely prone to regeneration. Therefore, if the landowners made an informed decision to improve rangelands, they will need to adopt a suitable aftercare programme to maintain the rangelands for livestock production and to realize other biodiversity improvements.

One of the benefits of the proposed Biomass Power Project is the restoration of degraded savanna through bush thinning practices. This will create the opportunity to restore ecological structure, function and composition in a way that will simultaneously improve agricultural rangeland productivity, which is a secondary objective/goal of the project (refer to section 1.3). The goal of the project is not to sustainably harvest wood for energy production, also known as ‘bush farming’. The post harvesting management of the de-bushed rangeland is the most important aspect to get right in the quest to restore rangeland ecological integrity and productivity. All the hard work of bush clearing could come undone if sound rangeland management principles are not applied.

The Biodiversity Specialists confirmed through their studies that herbaceous biomass increases after woody plant harvesting, but that aftercare is required to sustain a high herbaceous production over longer time frames.

It is important that the area harvested does not exceed the ability of landowners (or responsible third party) to do effective aftercare. Aftercare should be conducted according to the guidelines provided in the EMP. The first control to, preferably, be deployed in the first year after harvesting if stem (immediately after harvesting) or foliar arboricides are used. After three years, the situation can be assessed and an appropriate schedule for further aftercare actions planned, as per the adaptive management approach provided in the EMP. Various aftercare methods exist and are described in section the Biodiversity Specialist Report (Appendix 6) and section 5.2 of this report.

4.4.3 Transportation of Biomass to the Power Station and Ash from the Plant

Biomass transport impacts by long term fuel suppliers and ad-hoc fuel suppliers have been considered. The biomass fuel supply strategy consists of two main biomass suppliers namely i) long term fuel suppliers and ii) ad hoc fuel suppliers. Long term fuel suppliers will provide the bulk of the fuel with 30 tonne payload trucks and large annual volumes will be allocated to these suppliers. The long term suppliers will have performance obligations towards NamPower. Smaller suppliers, termed ad hoc suppliers, will also be afforded the opportunity to supply biomass to the plant. Ad hoc suppliers' truck size will be limited to a minimum 8 tonne payload. There will be at least 4 long term fuel suppliers, each assigned at least 30,000 tonnes per annum that can be ramped up to 60,000 tonnes. In total the ad hoc fuel suppliers will be allocated a maximum of 30,000 tonnes per annum.

The transport of ash is also considered although it is significantly lower at approximately 6% of the total biomass volumes. With reference to sections 4.4.4.4 and 5.5, various options are being considered for the final end use/disposal of the ash from the proposed Biomass Power Station. A possible option would be to transport the ash to Tsumeb, either to the Tsumeb smelter tailings facilities, or to the general waste facilities in Tsumeb. The volume of ash transport is only 6% of the biomass volumes resulting in approximately 2 trips per day. This is insignificant in the overall traffic impact analysis.

A 40 MWe Power Station will require 245,000 tonnes of fuel (i.e. biomass on a dry basis) per annum at approximately 85% capacity factor. The delivery of biomass would be allowed from Monday to Friday between 07h30 and 16h30 which results in a 9 hours per day or 45 hours per week. The table below calculates the truck trips for both biomass and ash transport.

TABLE 4-4 : BIOMASS AND ASH TRUCK TRIPS.

	Ton	Unit	Per Annum	Per Week	Per day	Per Hour
Long Term Suppliers	245,000 (85% CF)	Truck trips (30 ton)	8,033	154	30.9	3.4
Ad Hoc Suppliers	30,000	Truck trips (8 ton)	3,750	72	14.4	1.6
Ash*	14,700	Truck trips (30 ton)	490	9.4	1.9	0.2
TOTAL			**12,273**	**235.4**	**47.2**	**(approximately 6)**

* Based on 6% of total biomass volume.

In conclusion the biomass trips adopted for the TIA are 47 return trips per day, resulting in 47 trips in and 47 trips out or an equivalent of 94 trips additional to the average daily traffic (ADT). This may however change and is dependent on the final fuel delivery strategy to be adopted by the Otjikoto Biomass Power Station and the figures in this report are indicative only.

4.4.3.1 *Biomass Trip Distribution*

The most significant traffic contribution for the proposed project will be from the transport of the biomass. The biomass will be sourced from the project area, which covers roughly 100 km radius surrounding the plant (refer to Figure 4-2). The origin and trip distribution, of the biomass transport, is spatially discussed and presented below.

Figure 4-2 indicates the preliminary harvesting area boundary, communal areas, national parks, and slopes greater than 12.5%, where no harvesting is allowed. The slopes greater than 12.5% is indicated in red and indicates where the mountainous areas are found. The Otavi Mountain Lands are clearly visible between the triangle formed by Otavi, Tsumeb and Grootfontein. A large portion of the Otavi Mountain Lands and other areas surrounding the 12.5% slope areas will therefore not be harvested.

The Traffic Specialist divided the areas of biomass fuel origin into four regions (refer Figure 4-9) for ease of reference and by keeping the road network and topography in mind (the existing road network, etc. in these areas are discussed in more detail in section 6.3.2):

- Area 1 (North of site). 40% of biomass expected to originate from this area.
- Area 2: (West of site). 20% of biomass expected to originate from this area.
- Area 3: (South of site). Within the triangle of Tsumeb, Otavi and Grootfontein. 10% of biomass expected to originate from this area.
- Area 4 (East of Site). 30% of biomass expected to originate from this area.

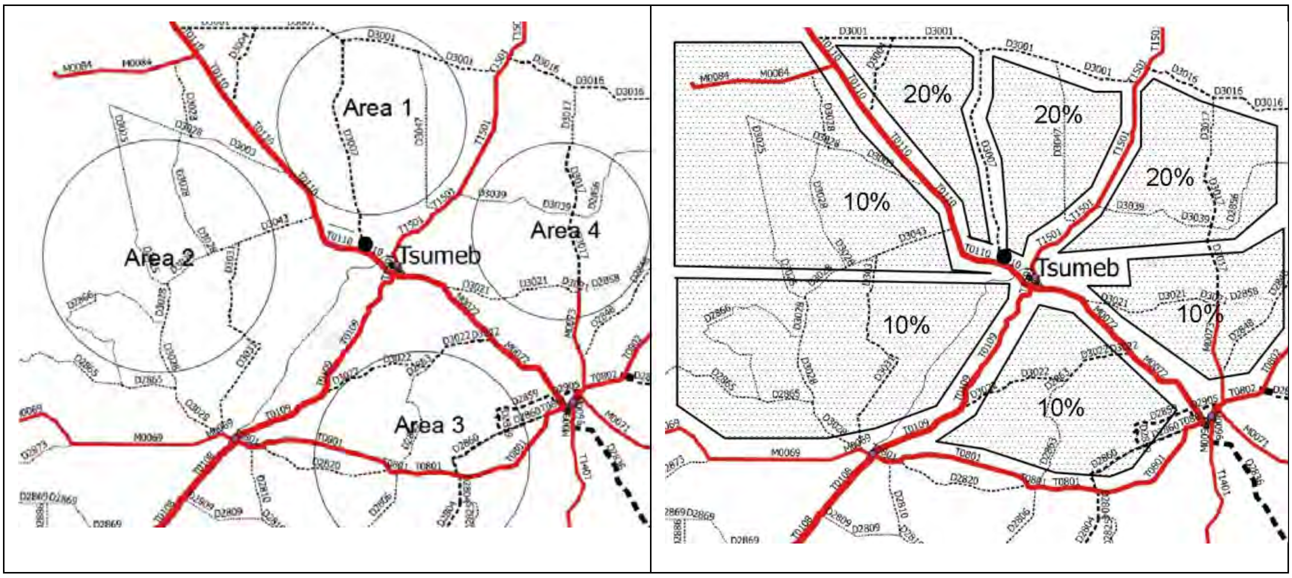


FIGURE 4-9: REGIONAL BIOMASS DISTRIBUTION (%) (BURMEISTER, 2018)

If the 90-95 average daily traffic (ADT) trips of biomass are allocated proportionally, using the above distribution, the trips allocation to specific roads (ADT, both directions) is given in Figure 4-10 below.

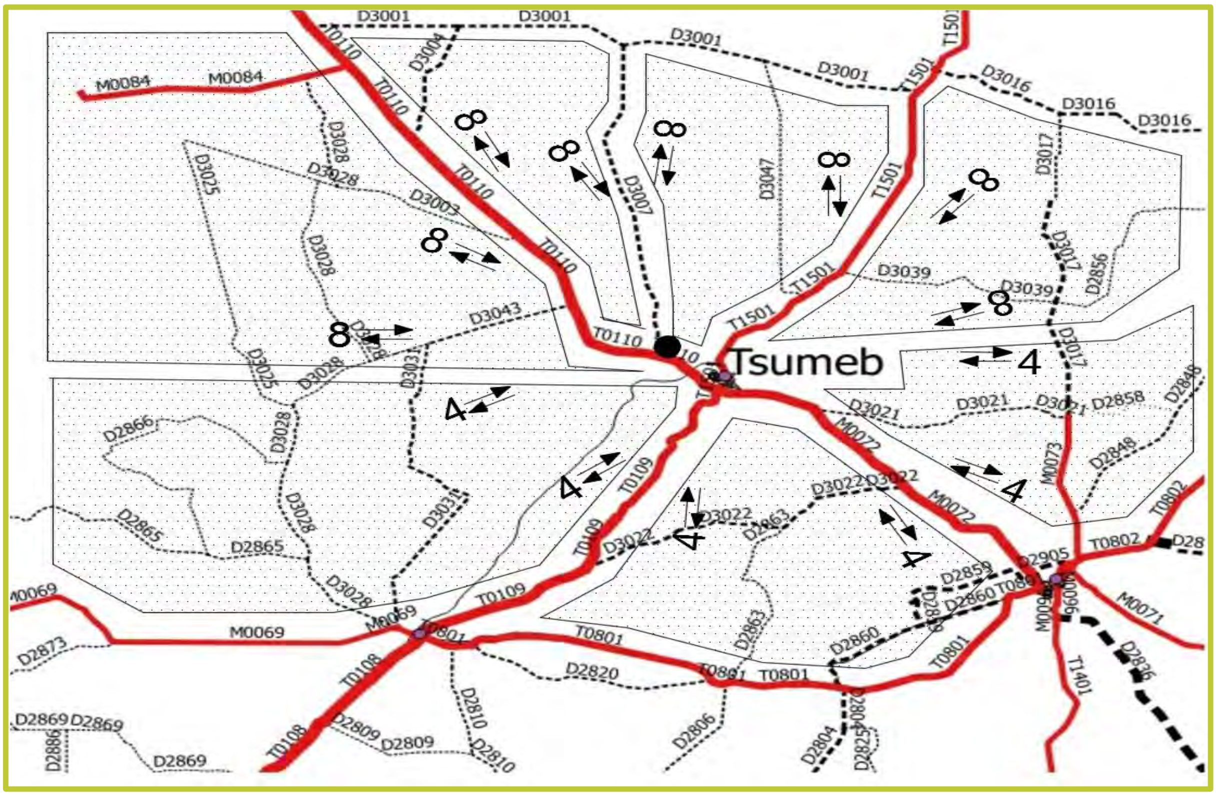


FIGURE 4-10: REGIONAL TRIP DISTRIBUTION (VPD) (BURMEISTER, 2018)

Note: the numbers in the figure includes both inbound and outbound trips

If these trips are added, the trip allocation at the site is illustrated in Figure 4-11 below.

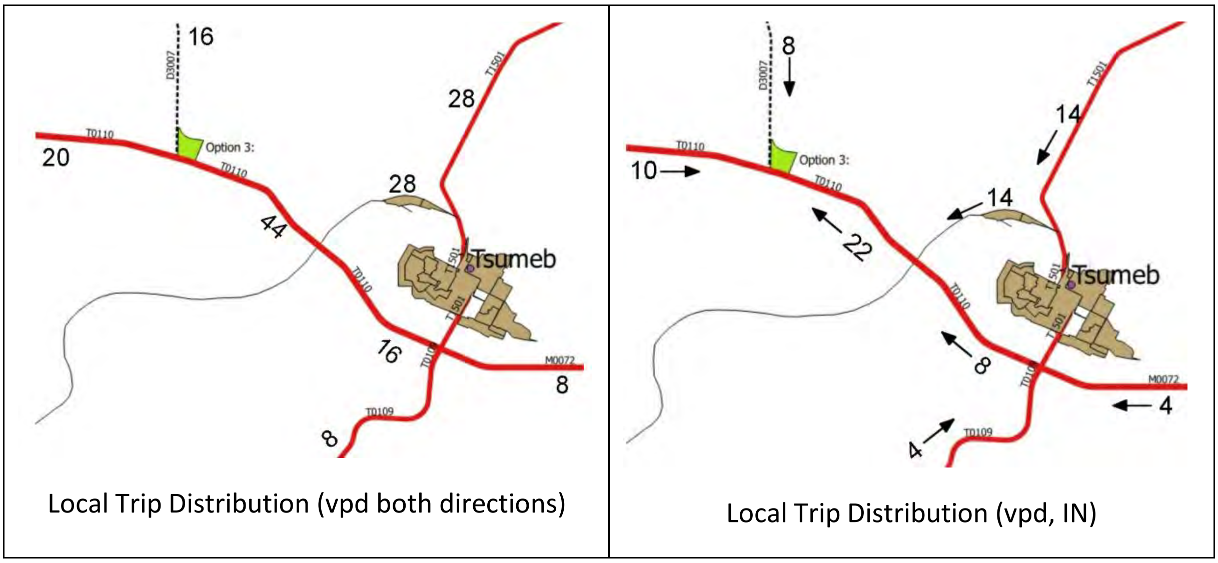


FIGURE 4-11: LOCAL TRIP DISTRIBUTION (BURMEISTER, 2018)

Taking the baseline information described in Section 6.3 into consideration, the following observations were made by the Traffic Specialist:

- Limited additional traffic on TR 1/9 (Otavi to Tsumeb) and MR72 (Grootfontein to Tsumeb);
- Most additional traffic on TR 1/10 between Tsumeb town and the Power Station site;
- 16 additional trips (both directions) expected on DR3007 (gravel road).

4.4.3.2 *Ash Trip Distribution*

Refer to section 5.5 for the proposed options for ash utilisation or disposal options. The volume of ash transport is only 6% of the biomass volumes resulting in approximately 2 trips per day. This is insignificant in the overall traffic impact analysis.

4.4.4 Power Station

The proposed Otjikoto Biomass Power Station will have a net electricity generating capacity of 40 MWe. The proposed Power Station location is described in section 4.2, Table 4-1 and indicated in Figure 4-1.

The proposed (assumed) technical description of the plant is as follows:

- Size: 40 MWe (net export capacity);
- Grate fired boiler technology (refer to section 4.4.4.1);
- Air Cooled Condensor;
- Net Electrical Efficiency at Full load approximately 28~30%;
- Capacity factor: 70~85%;
- Availability: 92%; and
- Design lifetime: 25 years, 30 years considered typical.

The assumption for the Calorific Value (CV) of the Fuel has been taken as 14.7 MJ/kg (as received 15 % Moisture and 5 % ash).

The proposed Power Station will have a footprint of 10 hectares at its maximum without ash storage. With onsite ash storage, fuel stockpiling and receiving facilities, this is expected to be approximately 25 ha. It is estimated that a 7 - 90 day stockpile will be required for the Power Station to operate at full capacity, and accommodate any interruption in the fuel supply.

The Power Station may consist, but not be limited to the following primary components (refer to Figure 4-12 for a layout of the proposed Power Station):

- Fuel handling and loading area;
- Boiler house;
- Turbine hall;
- Electrical sub-Station HV;
- Electrical switchroom & transformers;
- Compressor house;
- Ash storage;
- Air cooled condensers;
- Stack (typically up to 60 - 75 m high), filters, silos, and emission controls;
- Water treatment and sprinkler tanks;

- Effluent treatment;
- Workshops;
- Offices, welfare, and parking facilities;
- Weighbridge area;
- Wood chips unloading bay;
- Wood chips storage areas/barns;
- Internal access roads; and
- Surface water attenuation features.

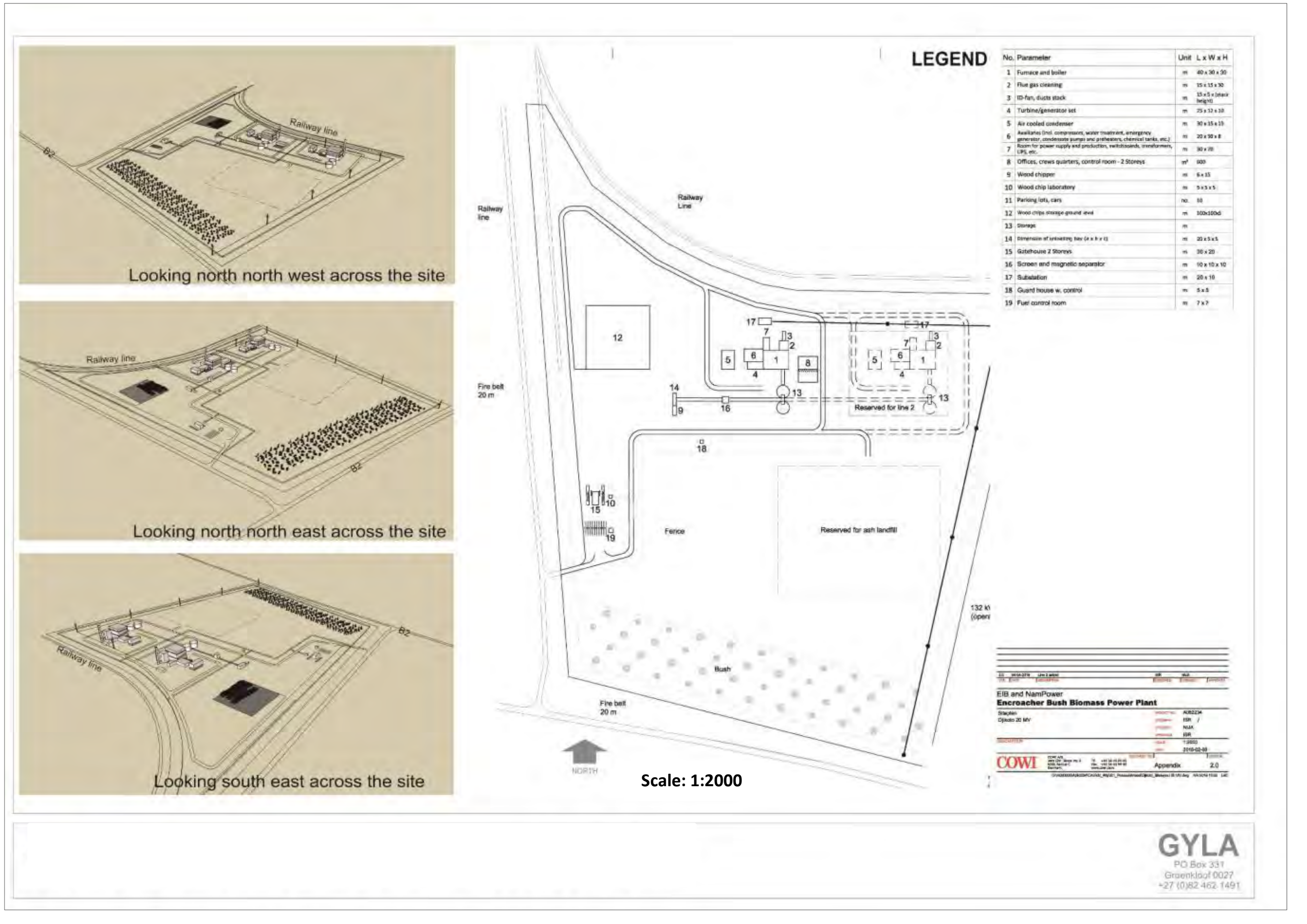


FIGURE 4-12: PROPOSED POWER STATION LAYOUT[5] (YOUNG, 2018)

[5] The exact power station layout is still subject to change, depending the detail design of the project

Figure 4-13 below shows a relatively similar Biomass Power Station, i.e. the Tilbury Green 40 MWe biomass plant currently being commissioned in London.

FIGURE 4-13: SIMILAR BIOMASS POWER STATION (TILBURY GREEN 40 MW BIOMASS PLANT IN LONDON)

The operations related to the Power Station will consist of the following key components:

- Onsite transport of raw materials to plant;
- Storage and handling;
- Combustion;
- Power generation; and
- Ash disposal activities.

The configuration of a typical biomass combustion plant is shown in Figure 4-14. The proposed operation of the plant is set out below:

- The biomass fuel reception, including quality control, will be open for receiving biomass 12 hours per day from Monday to Saturday (see section 4.4.3). The fuel trucks will haul the fuel to the unloading bay. A portion of the fuel will be dumped on the fuel yard concrete slab. Manually operated front loaders will be available for feeding fuel into the fuel receiving area.
- All fuel will be automatically transported by conveyers into a storage facility with a capacity of 7 days. The storage system operation will be managed on the principle that the first fuel that enters will be the first fuel to be fed to the boiler (first in first out).

- Grate combustion technology will be used to convert biomass to steam, and a steam turbine to produce electricity. If required, an air emissions clean-up system will be used to lower emissions to air quality standards.
- Ash will be transported by haul truck from the ash silo to an onsite ash dump facility or for other use (refer to section 4.4.4.4).

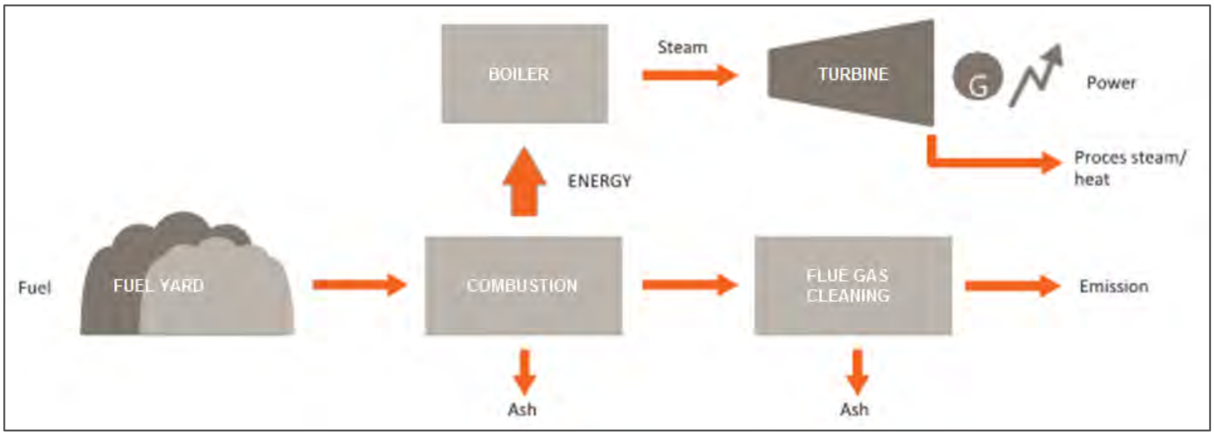


FIGURE 4-14: CONFIGURATION OF A BIOMASS COMBUSTION PLANT (COWI, 2017)

4.4.4.1 *Grate Fired Boiler Technology*

Grate Fired Boiler Technology is the preferred technology for the Biomass Power Station.

Grate Fired Boilers have traditionally dominated the biomass combustion industry due to their proven track record and lower construction and maintenance costs which can offset the possible incremental advantages from fluidised bed technology.

With the different types of grate system, such as inclined reciprocating (forward and backwards) grate, roller grate, chain grate and vibrating grate), the fuel is usually fed automatically onto the grate by a screw or ram feeder system. As the fuel bed moves from one end of the grate to the other, moisture is driven off firstly, followed by ignition and combustion and finally burn out prior to cooling or quenching of the ash before it is removed and disposed.

The air supply below the grate is often split into different sections so that the flow rates and pressures of the primary combustion air to each section can be independently controlled based on the combustion conditions in the furnace. Primary combustion air passes from below the grate underneath the burning solids and flow through the grate bed into the freeboard zone above the bed.

Those systems also require a fairly high proportion of the air supplied above the grate as secondary and tertiary air to ensure complete combustion of the combustible gas component volatilised from the solid fuel.

4.4.4.2 *Process Flow Diagram*

FIGURE 4-15 provides a simplified process flow diagram of the Power Station operations.

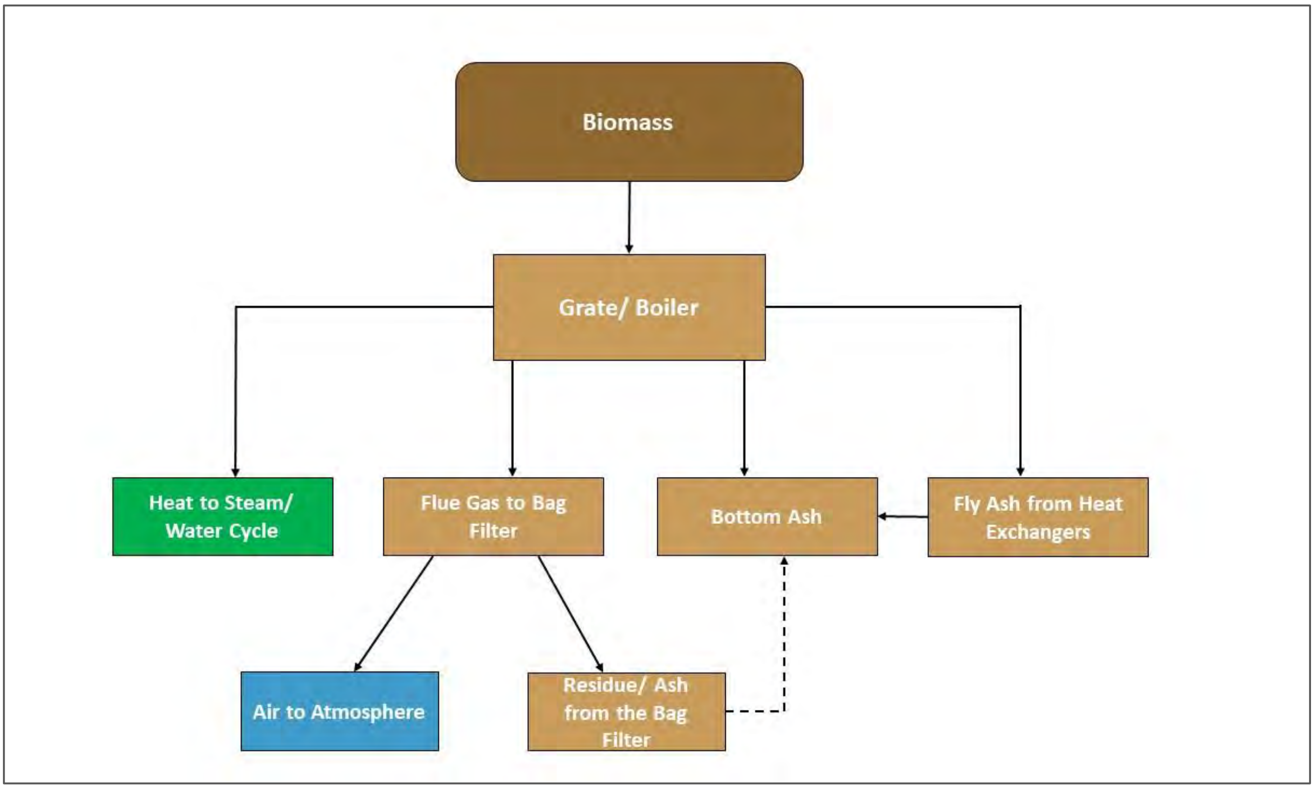


FIGURE 4-15: PROCESS FLOW DIAGRAM OF THE POWER STATION OPERATIONS

4.4.4.3 *Biomass Fuel*

A Biomass Power Station and the associated flue gas cleaning system (see section 4.4.4.5) is designed according to the specifications of the intended fuel. The proposed 40 MWe biomass plant will be fuelled by the combustion of P100 Wood Chips produced from encroacher bush harvested within a 100 km radius (Figure 4-2) of the Project Site. The Power Station would require approximately 245,000 tonnes of wood chips per annum (on a dry basis) at approximately 85% capacity factor (NamPower Business Case, 2018).

Initial investigations show that the Biomass Wood Chips can be treated as standard wood chips according to European norms with the following deviations:

- higher chlorine content;
- high silica content and
- significantly lower Moisture Content.

Thus, encroacher bush, which is the only intended fuel source for the proposed Power Station, will be harvested within the identified harvesting area surrounding the proposed Power Station.

The expected moisture content of the delivered biomass woodchips as fuel to the biomass Power Station will, however, vary between 45% moisture content in the rainy season to a minimum of approximately 5% in the dry winter months. Thus, the biomass Power Station has to be designed to handle a fuel source with high moisture variation in its boiler.

TABLE 4-5 below shows the fuel requirements (dry basis) for a typical 40 MWe biomass Power Station operating at an 85% Capacity Factor (CF).

TABLE 4-5 : TYPICAL BIOMASS POWER STATION FUEL REQUIREMENTS

Parameter	40 MWe
Hourly fuel demand (100% MW_{th})	26.89 tonnes/h
Annual fuel demand (85% CF)	245 000 tonnes/a
Effective biomass per hectare (Dry basis)	12.65 t/ha
Calorific Value of Fuel (Dry Basis)	approximately 14.7 to 16.7 MJ/kg
Harvested area required p.a.	Approximately 20 000 ha/a

The Fuel Specification (i.e. P100) will be according to EN ISO 17225, with the properties presented in Table 4-6.

TABLE 4-6: FUEL SPECIFICATIONS

Physical Properties	Unit	Design	Max
Bulk Density	Kg/m^3	250	350
PSD (P_{100}), main fraction	mm	100	350
Max allowable fraction after screening	mm	100	350
Lower Calorific Value (wet basis)	GJ/ton	14.7	16.7
Moisture Content	%	15	35
Ash Content	%	NA	6

4.4.4.4 *Ash*

During the combustion process, two different types of ash with different physical and chemical characteristics will be produced. The fuel analysis completed during the feasibility phase, show that ash represents approximately 6% of the biomass fuel which ends up as either fly ash or bottom ash (refer to FIGURE 4-15). Fly ash is the fine ash that is suspended in the flue gas and adheres to the surfaces of heat exchangers and is also captured in the particulate filtration system (i.e. cleaning system), while bottom ash is the ash that exits the grate into the discharging system. Depending on how the plant will be configured some of the fly ash that adheres to heat exchanger surfaces can be mixed with bottom ash via conveyor system and ash discharger, or can be mixed externally.

Composition of the ash streams

The ash is the inorganic incombustible part of the fuel left after complete combustion and contains the bulk of the mineral fraction of the original biomass (encroacher bush in this case) (Khan et al., 2009). The fuel composition and installation type are the primary factors that influence the ash quality (Pels et al., 2005).

The bottom ash material is a courser material that exits the grate and ash discharger and will have higher moisture content (25-30%) as it is likely to have been passed through a quenching system as part of the ash discharging system. The fly ash is a finer material. The fly ash is pulled through the boiler flue gas path and part of the fly ash adheres to the surface of heat exchangers. This material will have low levels of moisture and are typically removed with internal cleaning systems and transported via mechanical or pneumatic conveyor systems. The remaining fly ash will be captured in the filtration system before the flue gas exists through the stack. This fly ash will be removed from the filtration system via a mechanical or pneumatic conveying system and will form a separate waste stream. For grate boiler systems the production amounts of bottom ash are generally four (4) to five (5) times higher than the produced amounts of fly ash. Approximately 20% of the total ash content will be fly ash and the remainder (approximately 80% bottom ash).

The partitioning of trace metals between fly and bottom ash was described by Saqib and Backstrom (2014) (Dahl *et al.*, 2010). For their research it was evident that the trace metal concentrations of As, Cd, Hg, Cr, Pb, Zn, Sb and Co in the fly ash exceeded the concentration in the bottom ash. The Cu concentrations in all the samples were higher in the bottom ash. The partitioning fate of trace elements in ash is a function of several factors including the following (Zhang *et al*., 2008, 2012; Chang *et al*., 2009; Astrup *et al*., 2011):

- Incineration temperature;
- Waste composition;
- Feed chlorine content;
- Combustion conditions i.e. CO & O^2 levels – operating regime of the boiler; and
- Flue gas treatment process.

Ash Analysis and classification

Both bottom ash and fly ash are classified as non-hazardous, by adopting the following international criteria:

- Relevant United Kingdom (UK) Regulations relating to how a biomass plant in the UK using virgin wood as feedstock would be regulated and the resulting classification and codes applied to the ash residues; and
- EU Standards ("Notices from European Union Institutions, Bodies, Offices and Agencies European Commission: Commission notice on technical guidance on the classification of waste)[6].

Refer to Appendix 12 for more details.

The potential use of ash is influenced by the chemical and physical characteristics of the ash material. Virgin wood contains chemical components, which become concentration upon combustion (James et al., 2012). The major and minor elements in biomass, in decreasing order of abundance, are commonly C, O, H, N, Ca, K, Si, Mg, Al, S, Fe, P, Cl, N and Mn, Ti and other trace metals. The major and minor elements in plant ashes are commonly O, Ca, K, Si, Mg, Al, Fe, P, Na, S, Mn, Ti, Cl, C, H and some trace metals. Trace metals are

[6] Ref: Official Journal of the European Union (2018/C 124/01)

typically concentrated in fly ash but are also present in bottom ash. During incineration, highly volatile elements such as Hg and Cd are mostly found in the fly ash. Partially volatile elements such as Pb and Zn, generally distribute equally between fly and bottom ash or more to fly ash. Elements with a low volatility such as Fe and Cu generally end up in the bottom ash.

Ash samples from a similar project within Namibia were taken and analysed for total concentrations and particle grading, as well as water soluble content. Another ash sample from a bushfire were taken and analysed for the same parameters. The laboratory test results are presented in Appendix 12.

From the results the following observations were made:

- More than 50% of both ash samples are composed of CaO. This is a valuable resource and can be used as a liming agent. Hydrolysis with water can be used as a binding agent in the building industry.
- Due to the high oxide content the pH is also very high and well above 9 also indicating the liming potential of the material.
- of the trace elements the influence of As, Cr6+, Be and B on the selected use should be considered during further evaluation.
- The particle grading indicates that the fly ash is finer than the bottom ash with 91% being <38µm in the Fly Ash, while 2.5% is larger than 4.75mm in the Bottom Ash.
- Although the ash has a high pH the properties of the material can be utilised beneficially for specific downstream uses.
- The high pH is again noted in the soluble extracts indicating the potential to use as liming material.
- High total phosphate (1-2%) and potassium (5-12%) provides an opportunity for the material to be used as a fertiliser together with its uses as a liming material. Some Boron and Molybdenum can also be an advantage when using as a fertiliser.
- The fly ash has the highest contents of most constituents, but values are very comparable to bushfire ash indicating the natural origin of the material.

Ash handling / disposal

Refer to section 5.5 for the proposed options for ash utilisation or disposal options.

4.4.4.5 *Power Station Stack Parameters and Flue Gas Cleaning*

During combustion, various kinds of impurities are generated some of which are found in the flue gas, i.e. the exhaust gas coming from the boiler. Most of these are related to the composition of the biomass and among other things are, particles from ash, NOx from nitrogen, SO_2 from sulphur, carbon monoxide (CO), and greenhouse gases (GHG) such as CO_2, methane (CH_4), and nitrous oxide (N_2O). etc. (refer to section 7.13 for more details on the greenhouse gases and the climate change evaluation).

Particulates are the main pollutant of concern from wood boilers.

The plant design parameters, based on 6% oxygen, are provide in Table 4-7 below.

TABLE 4-7*: POWER STATION STACK PARAMETERS*

Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exhaust Vol.-Flow (m^3/s)	Exit Temp (°C)
60 - 75	1.75	15	36.08	125

An optimum stack height was calculated as part of the plant design (see the Air Quality, Climate Change and Health Risk Assessment report included in Appendix 5). This was based on Good Engineering Practice (GEP). Dispersion simulations were conducted to demonstrate the reduction in ground level concentrations (GLCs) as a result of a GEP stack design.

With reference to section 7.7 (and the Air Quality Specialist report in Appendix 5), a cleaning system, such as bag house filters or electrostatic precipitators, will be installed for the removal of particulate matter (PM).

If future emission values require further flue gas cleaning (based on the monitoring requirements (refer to Power Station EMP in Appendix 14), NOx emissions can be reduced by retrofitting a selective non-catalytic reduction (SNCR) system in the combustion chamber of the boiler or utilising flue gas recirculation.

The Power Station will be equipped to accommodate an Emission Measurement System should a dedicated measurement campaign be required. Periodic testing of air emission and quality will be done to adjust the required air flows and fuel rates to maintain the operating environmental conditions.

4.4.4.6 *Water Requirements*

The water demand for the proposed Power Station is determined by the project design and is directly linked to the size and selected technology. The demand for the 40 MWe Power Station option is summarised in TABLE 4-8 (COWI Water Study Report, 2017). The figures below are based on the assumption of using dry cooling. The majority of the water is used as make-up water for the steam cycle for replacing boiler blow down and ash quenching requirements.

TABLE 4-8 : POWER STATION WATER REQUIREMENTS

TECHNOLOGY TYPE	PLANT POWER (MW)	PLANT WATER CONSUMPTION (M^3/HR)	WASTE WATER DISCHARGE (M^3/HR)
Grate	40	6	2.2 ~5

Additional water requirements are expected for domestic use, such as the onsite office facilities including the kitchen and sanitation facilities, as well as sub activities, which may include irrigation, dust suppression, firefighting system etc. According to the COWI Water Study Report, 2017, these demands are expected to be insignificant in proportion to the Power Station water consumption.

Waste water streams from one process will be recycled and the recycled water used in other processes applications as far as possible. Boiler blow-down water can be used for ash cooling. Part of the boiler make-up water will be used for quenching ash from the grate. Waste streams from ash quenching and from the demin plant can be potentially used for dust suppression or for landscaping. The final detailed design of the water cycle of the Power Station will depend on the chemical composition of the raw water supply from the boreholes. It is envisioned however that only waste streams from domestic water use and the initial water polishing will have to be discharged into either evaporation ponds or reinjected into the boiler.

A simplified water balance is presented in FIGURE 4-16 (COWI, 2017).

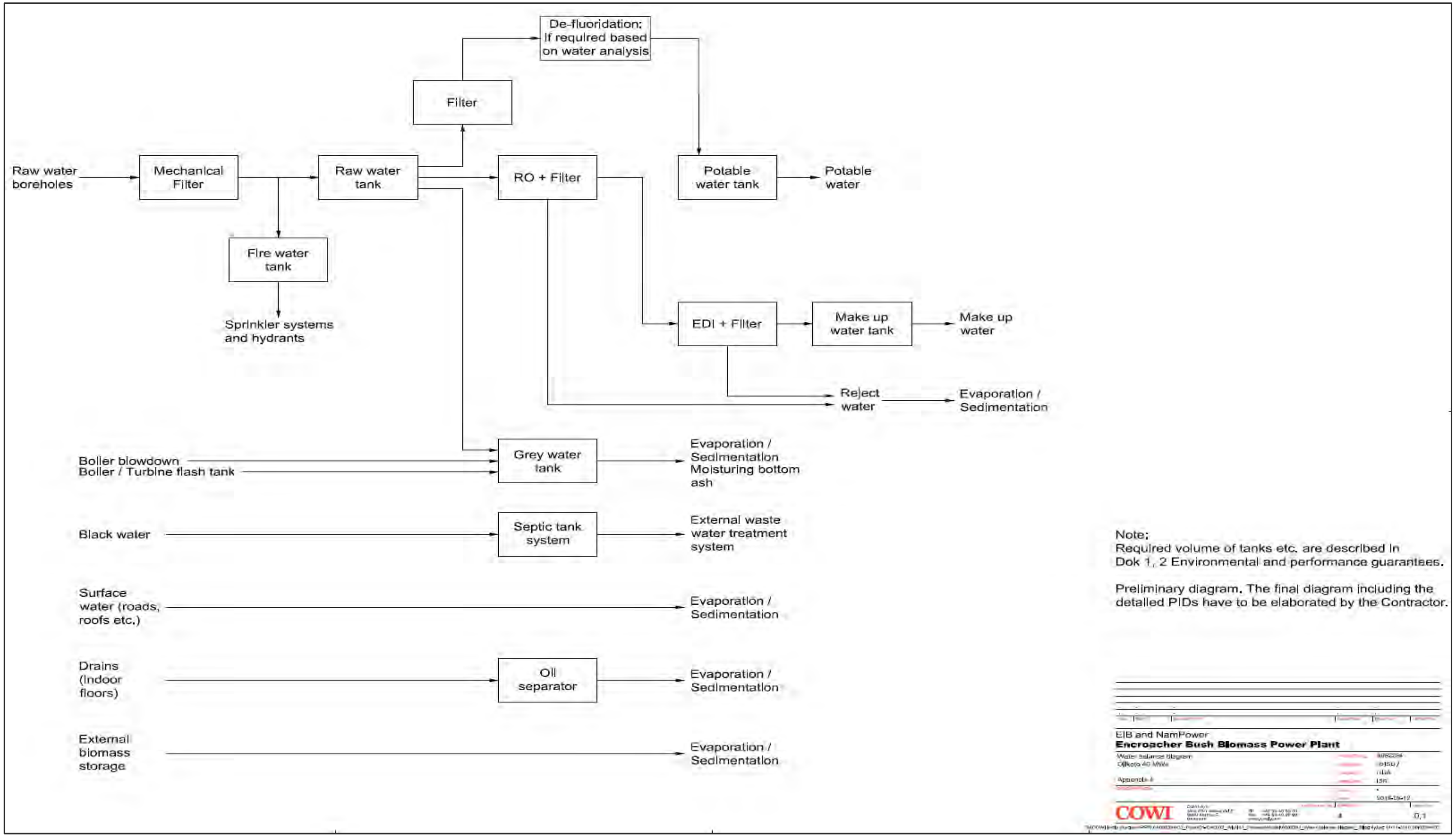


FIGURE 4-16: SIMPLIFIED WATER BALANCE (COWI, 2017)

4.4.4.7 *Water Treatment and Chemicals*

To maintain boilers and turbines at a high level of availability and efficiency the water in the steam cycle needs to be treated. The chemical control of water and steam purity is aimed at the prevention of the following:

- Corrosion of feed, boiler, and steam systems;
- Scale and deposit formation on heat transfer surfaces; and
- Disposition and corrosion of turbines.

The purpose of the water treatment plant is to condition the water prior to being fed into the deaerator, which is part for the condensate circuit and is standard equipment for any steam raising boilers as the condensate having been converted back to water from the steam is fed to the deaerator prior to feeding back up to the boiler via the economizer. The purpose of water treatment is to remove all contaminants like particulate matter and deionizing through filtration, Reverse Osmosis (RO) membranes or Capacitive Deionization (CDI)/ continuous electro-deionization (CEDI). CDI is a form of batch processing of the feed water to deionize the water and is a form of water treatment.

There is also a need to remove oxygen from the water via the deaerator by stripping it out with steam and a final chemical dosing to polish the remaining oxygen. The deaerator should reduce the dissolved oxygen content to about 12 to 7 parts per billion (ppb) and the remaining oxygen is removed via chemical addition.

The chosen water treatment and boiler dosing technology will determine the appropriate water treatment based on the required boiler water parameters and the resulting steam quality dictated by the turbine provider.

The section below provides examples of typical chemicals associated with the water treatment in the plant:

<u>Raw (feed) water</u>

To minimise corrosion on the components of the water-steam circuit the feed water is maintained at an alkaline pH by the addition of ammonia and by removing dissolved oxygen down to very low concentrations. Furthermore, sodium hydroxide is added to the boiler water to neutralise acid species appearing in the boiler water (COWI Water Study Report, 2017).

The bicarbonate level in the raw water, pH, and temperature will dictate the carbon dioxide (CO_2) content. As a gas, CO_2 will not be removed by the RO. Adding caustic to the softened water will convert the CO_2 to bicarbonate, which will then be effectively removed by the RO. RO is one of several water treatments methods and this can also include carbon filtration of incoming raw water and ion exchange and depending on the chosen technology there will be chemicals or resins used.

Effective control of chlorine is critical for CDI, (and to some extent the RO's), to prevent oxidative attack. The industrial 'norm' is generally to add three times the concentration of chlorine, as bisulphite, to ensure an excess. Providing there is sufficient mixing and contact time, this will remove the residual chlorine.

Boiler dosing

To ensure that the correct pH levels in the boiler are maintained, phosphate is added. Oxygen scavenger (hydrazine or amine) is added to remove residual oxygen after the deaerator.

Effluent discharge

Prior to the discharge of effluent, caustic or acid is added to control the pH levels.

4.4.4.8 *Workforce and Housing*

During operations, NamPower anticipates that approximately 62 employees will be required to run a 40 MWe Power Station. The employment will be made up of 35 operational/maintenance staff and 27 service staff; the majority of the power plant staff will be skilled and semi-skilled workers.

As Tsumeb is a mining and processing hub, it is likely that some skilled, semi-skilled and unskilled personnel maybe sourced locally for operations.

Should there be a need for highly skilled personnel which cannot be recruited locally, they will be sourced regionally or nationally. A training plan will ensure local skill development throughout planning, construction, and operational phases.

On site housing facilities are not planned for the employees during the operational phase. Staff will reside in nearby towns or villages and transported to and from site.

4.4.5 Power Lines

The proposed Otjikoto Biomass Power Station will be connected to the national grid at the existing Otjikoto Substation via a new transmission line operated at 66 kV, approximately 3 km in length. The tie-in at the Otjikoto Substation will be on an existing space in the feeder bay section in the 66 kV yard. On the Otjikoto Biomass Power Station side there will be a new substation to step up the voltage from 11 kV to 66 kV. This substation will be close to the generator building of the Otjikoto Biomass Power Station.

The length of the new transmission line will be a maximum of 3 km from the Biomass Power Station to the existing Otjikoto Substation. The power line servitude will be 150 m in width, although the cleared corridor will be less than 30 m (maximum).

An existing 132 kV transmission line with lattice tower structure crosses the proposed plant site; this line will need to be moved. There are also other powerlines that will need to be relocated in collaboration with Cenored. It will be re-routed to the north and east of the plant site, and will then run parallel to the new transmission line (refer to Figure 4-12 and Figure 4-17).

FIGURE 4-17: PROPOSED POWER STATION SITE NEAR THE OTJIKOTO SUB-STATION AND EXISTING POWER LINES IN THE AREA (YELLOW, BLUE AND RED LINES) (ACS, 2018)
(Note: the blue line needs to be relocated)

4.5 DECOMMISSIONING AND CLOSURE OF THE POWER STATION AND OVERHEAD POWER LINE

NamPower must ensure that adequate rehabilitation and closure of the proposed Power Station and overhead power line takes place following the end of life of the proposed project. Socio-economic aspects relating to job losses, etc. also need to be considered at closure. At a conceptual level, decommissioning can be considered a reverse of the construction phase with the demolition and removal of the majority of infrastructure and activities very similar to those described with respect to the construction phase. However, at this stage it is unknown whether the plant will continue to operate after the design life of 25 years as refurbishment may be economically considered at that stage.

The closure phase occurs after the cessation of all decommissioning activities. Relevant closure activities are those related to the aftercare and maintenance of remaining structures, if any structures remain.

4.5.1 Closure Objectives

The planning stage for decommissioning and closure has not yet commenced but in broad terms the main objective will be to remove as much infrastructure as possible and rehabilitate what remains to resemble the pre-project land state as closely as possible.

The following broader objectives will be applied:

- Disturbed areas will be returned to as close to their original state as practicable.

- Contamination beyond the site by wind or surface runoff will be prevented through appropriate containment bunds and air pollution prevention measures.
- Linear infrastructure comprising roads, railways, pipelines, power lines and related components will be removed, and the disturbed land rehabilitated to blend with the surrounding natural environment, unless an alternative end-use is identified.
- Socio-economic impacts (including the loss of employment) will be minimised through careful planning and preparation for closure beginning three to five years before closure takes place.

The above principles and concepts will be refined as part of ongoing detailed closure planning and costing during the life of the operations and in consultation with relevant stakeholders.

5 ALTERNATIVES

This chapter describes the various project alternatives that were considered and provides a comparison in terms of advantages and disadvantages that the proposed alternatives may have had on the environment and affected communities.

5.1 ALTERNATIVE HARVESTING METHODS

With reference to section 4.4.2.1, different felling equipment can be used to harvest bushes and varies, depending on the size of the bushes to be harvested and on the level of mechanisation of the harvesting operation. For bushes and small-scale harvesting; manual (labour intensive) felling methods are typically used. These manual and semi-mechanised biomass harvesting methods involve the use of one or more of the following equipment in combination (GIZ, 2015):

- Axe, panga / machete, pruning and pruning shears, hand saws;
- Trolley with power driven saw type cutters or bit type circular cutters;
- Tractor drawn slasher (‘Power take-off (PTO) driven);
- Multi-circular saw PTO driven (limited application); and
- Hand held chain saws (limited application, mainly because of the bush shape and high abrasive de-bushing conditions in Namibia).

For larger harvesting operations larger, fully mechanised methods are used to harvest. These fully mechanised biomass harvesting methods involve the use of one or more of the following equipment in combination (GIZ, 2015):

- Skidsteer harvester equipped with horizontal rotary cutter or circular sawblade;
- Three wheel loader equipment with buncher and hydraulic cutter;
- Hydraulic grab and or buncher with blade cutter;
- Hydraulic grab and tree puller/bush lifter (for soft, wet sandy soils and riverbed clearing); and
- Bush combined harvester and grinder plant on tracks with shuttle bucket.

Although all methodologies were considered in the impact assessment, the fully mechanised process is foreseen to be implemented to provide the bulk of the fuel required, due to the fact that volumes required for the Otjikoto Biomass Power Station may not be reliably met with only the manual harvesting processes.

The type of equipment and harvesting method to be used will be dictated by the requirements in the EMP and Harvesting Guidelines (SAIEA, 2017) relating to bush thinning, avoiding sensitive species and habitats, avoiding large trees, etc.

5.2 ALTERNATIVE AFTERCARE METHODS

With reference to sections 4.4.2.1 and 7.4, intentional ‘bush farming’[7] activities will not be allowed as a biomass source to supply fuel to the Power Station. To ensure regrowth of harvested bush is prevented

7 “Bush farming” means: Re-harvesting regrowth within the project's lifespan from areas where aftercare was not applied. Aftercare must be implemented after harvesting (refer to section 7.4). Intentional bush farming will therefore not be encouraged. However, “special cases / harvested areas” could be evaluated, if reasonable aftercare measures were implemented.

and the opportunity is created to restore ecological structure, function and composition in a way that will simultaneously improve agricultural rangeland productivity, the harvested areas should be managed.

The Biodiversity Specialists, in their report (Appendix 6), provide the following background to various aftercare methods, referring to various references in literature.

In harvested areas, rapid regrowth of harvested woody plants and woody seedling establishment are to be expected, which need to be controlled to maintain the thinned, stable state and associated ecosystem benefits. The majority of savanna woody species are able to coppice (regrow from the collar region of the plant) after removal of stems. In addition, the release from tree-on-tree competition often results in a wave of woody reproduction (seedling establishment and probably also root suckers). An effective aftercare programme is therefore deemed essential to keep woody plant densities in harvested areas in check. This is especially true for the higher rainfall parts of the study area.

How the harvesting is conducted, and the harvesting area is managed after harvesting will impact on the effort required to maintain an open woody state. Important natural allies in preventing a resurgence of undesirable woody plants include harvesting in such a way that a good stand of large trees and bushes are retained to help suppress the growth of young woody plants, as well as suppressing the establishment of recruits close to large trees and bushes. Selective thinning where large trees and bushes are retained, evenly spread over the harvested area, is therefore seen as a crucial component of the harvesting operation. Second, the competitiveness of the herbaceous layer should be encouraged through an effective grazing management system aiming to increase the vigour and competitiveness of perennial grasses. Managing for a competitive herbaceous layer may take several seasons and will depend on the level of degradation (e.g. perennial grass cover loss), as well as current climatic conditions. Even in the best of cases will these actions not be enough to maintain an open savanna state indefinitely but will result in both fewer woody recruits to be dealt with and will reduce the growth rate of surviving plants in the aftercare programme. Third, the season when harvesting is conducted appears to affect the subsequent growth and mortality rate of cut woody plants. Cutting Namibian encroacher species during the rainy season (i.e. January to April) significantly decreased coppice growth rates and also increased the mortality rate of five encroacher species, although the mortality rate of *Dichrostachys cinerea* and *Terminalia sericea* remained low in this experiment, even in the second year of the trial. All three factors mentioned above may slow down the re-infestation rate of the harvested areas but does not negate the necessity of controlling coppice growth and reproducing woody plants years after the initial harvest event.

Aftercare in the current context deals mainly with the coppice (resprouts) of harvested plants, existing saplings of encroacher species not harvested and emerging woody recruits. It is important that aftercare is not seen as a once off operation. These undesirable woody plants can be controlled in several ways, which include mechanical, chemical and biological approaches or combinations of these.

5.2.1 Mechanical bush control

In mechanical bush control, plants are either physically removed or damaged to such an extent that these plants eventually die. Seedlings and saplings can be removed manually. Physically removing larger coppiced plants is, however, labour intensive as many encroacher species have to be removed to a depth of at least 20cm below ground. Slashing the aboveground parts is usually ineffective, except when done repeatedly in a single season i.e. 4 times/annum, and perhaps also in the case of seedlings, which are more vulnerable to physical damage. The use of heavy machinery in aftercare operations is not recommended due to the high soil disturbance and soil compaction expected. One exception might be where the young new growth is cut or mulched and used as roughage in animal feeds (bush-to-feed). In this case it should be kept in mind that the removal of the plants, especially the foliage, will drain the ecosystem of nutrients in the long run (browsing animals, on the other hand, recycle nutrients through dung and urine).

5.2.2 Arboricides (i.e. 'pesticides' according to FSC)

Various chemical herbicides developed to kill shrubs and trees (arboricides) are registered in Namibia for the purpose of controlling encroacher species. Arboricides, however, differ with regards to the mode of application, safety of use and potential environmental impacts. Essentially three application modes can be distinguished. First, soil applied arboricides where the chemical is applied to the soil surface within the root range of target plants. These arboricides dissolve in rain water and are transported to the roots of plants as it infiltrates the soil. The use of soil applied arboricides is generally not recommended in aftercare programmes due to their non-selective nature arboricides may affect desirable plants and the risk of leaching from the target area. Soil applied arboricides are also not suitable for treating harvested bushes and the long-term residual effects of soil applied arboricides has not been well studied in a Namibian context.

Second, stem applied arboricides are applied to the freshly cut/sheared surface of harvested plants as soon as possible after harvesting i.e. within hours. Failure of applying the arboricide according to the specified time can result in poor control of woody plants. Stem applications have the advantage that it is selective, as only the treated plants are controlled. A disadvantage of stem applications is that a percentage of harvested plants would probably die naturally after being harvested; therefore some arboricide will be unintentionally wasted. A Namibian study showed that on average about half of *Senegalia mellifera, Vachellia reficiens* and *Terminalia pruniodes* did not coppice after being cut close to the ground (stem diameter 75-118mm). *Dichrostachys cinerea*, however, coppiced prodigiously, especially on soils with a high clay content.

Third, the foliage of target plants can be sprayed with a registered arboricide. Foliar control is effective where stem treatment is not feasible, e.g. where stems are broken of i.e. rolling operations, rather than cut or sheared. To effectively control coppiced plants, the regrowth should be allowed to grow out after harvesting e.g. 2-10 months; knee to hip height, and the foliage should be green and mostly mature to ensure good arboricide action. Foliar applied arboricides has the advantage that it is also selective and that saplings and seedlings can be effectively controlled. Unselective spraying using for example tractor boom sprayers will negate the selective advantage and a substantial amount of arboricide may reach the soil surface, therefore should be discouraged. A disadvantage of foliar control is that it is susceptible to drift in windy conditions, thereby potentially harming desirable plants. Therefore, it is essential that spraying is only undertaken during suitable weather conditions.

A list of arboricides suitable for controlling regrowth of Namibian encroacher species are provided in Van Oudshoorn (2015). However, new developments are underway and new arboricides may replace or complement the existing registered chemicals in future. The FSC also developed a list of 'highly hazardous' pesticides to be considered in this project.

5.2.3 Other methods

Other approaches to aftercare include the use of periodic fire and/or browsers such as goats. Nevertheless, fire needs thorough planning, preparations and fire-fighting equipment, approval from neighbours and carries the risk that it may spread. Also, to be effective, the fire interval in the harvesting area will probably be every 3-4 years, depending on the rainfall and fuel accumulation. Fire generally kills only seedlings and larger saplings and coppiced plants are only top killed (will coppice again). To minimize damage to desirable larger shrubs and trees, fires for aftercare purposes should be managed to be of intermediate intensity (therefore not hot fires prescribed for bush control. This can be achieved by burning only during the cool time of the day, when fuel loads are < 1500kg DM/ha and when the wind is calm. It is always best to burn as far as possible with the wind (some back fires are necessary to contain the fire on the downwind side of the burned area). Burning where *Dichrostachys cinerea* are present should be avoided, because scarification of hard-scaled seeds of species such as *D. cinerea* by fire can facilitate mass germination of dormant seeds. It is possible that fire may have the same effect on other encroacher species with long-lived seeds. The effect of fire can be drastically enhanced if combined with foliar spraying of re-sprouting (coppicing) plants (regrowth must be at least knee high) and seedlings, as well as in combination with intensive browsing, e.g. with goats and/or browsing game.

Using goats to control post-fire bush may suppress benign woody species more than spinescent encroacher species such as Vachellia/Senegalia (*Acacia)* species and *Dichrostachys cinerea*. A sufficiently high browsing stocking rate is also required to keep re-sprouting bush under control. In Botswana a stocking rate of 1 goat/hectare was estimated too lightly stocked to control bush indefinitely. In those parts of the harvesting area that receive relatively higher rainfall, higher stocking rates applied over an extensive period would be required. The benefit of incorporating browsers in the aftercare programme is that it is a source of additional income for the landowner but will require considerable management inputs. Browsing game will also benefit from the available browse, but it is more difficult to control stocking rates and their impact on the woody component, therefore should not be relied on as the primary aftercare method.

Encroacher species have different traits that affect the effort required to control regrowth and recruitment. Especially harvested areas where *Dichrostachys cinerea* (sickle bush) was dominant may be difficult to control and should be properly planned for in advance. This species is widely distributed in Namibia and at least 19% of those quarter-degree grid squares in which it has been recorded as common to abundant in the Tree Atlas project occur within the harvesting area for the proposed Biomass Power Project. Traits that make *D. cinerea* control challenging include the ability to rapidly regrow from disturbed roots and stems, the persistent and long-lived seed bank of this species and effective dispersal of seeds by animals. *D. cinerea* also tend to be more resistant to soil-applied arboricides than other encroacher species, requiring a higher dose to control. Fortunately, *D. cinerea* is sensitive to current stem and foliar applied arboricides.

5.3 ALTERNATIVE POWER STATION LOCATIONS AND SIZE

The EIA scoping process and the "Multiple Decision Making" (MCDM) process, NamPower selected the Otjikoto site (Tsumeb) to develop the Biomass Power Project, to be assessed in the impact assessment phase of this EIA. The MCDM model was used to accumulate inputs and interpret results from multiple work streams and relevant stakeholders to assist the decision-making process and enable a wide spread stakeholder engagement to provide a level of comfort in the decision making process and end results. The MCDM process was conducted to find the most preferred combination, in terms of site, size and technology (see section 5.4 for the technology options considered), from a set of variable options, alternatives or scenarios for the definition of the Biomass to Power Project.

The site selection process, including consideration of the advantages and disadvantages of key decision areas i.e. technical; infrastructure; fuel supply / sourcing; financing; deliverability; environmental; and socio-economic considerations, were presented in the Scoping Report and will not be repeated here.

With reference to Figure 5-1, three site locations for the selected Power Station site at Otjikoto were considered by NamPower:

- Site option 1: North-East of Otjikoto substation (opposite the B1 Road)
- Site option 2: South-West of Otjikoto substation (next to the substation)
- Site option 3: North-West of Otjikoto substation (opposite the B1 Road)

The Environmental Team found no fatal flaws from an environmental or socio-economic perspective relating to either one of the three sites. Similar environmental issues were identified for each of the three sites and potential impacts could all the avoided or mitigated with the implementation of relevant management and mitigation measures. The decision was therefore made by NamPower, based on technical, financial and economical considerations.

Option 1 is already subdivided into smaller plots. Access to option 3 is easier via the DR3007 road on the western border. Power line routing for option 3 is simpler than option 1, without the need to crossing other transmission lines.

Option 2, being close to the existing substation, with existing and planned powerlines crossing this area, and insufficient space to relocate or plan for alternative routes (congestion), proofed that this site would not be feasible for NamPower to further consider.

Site 3 was selected as the preferred site by NamPower and they are in the process of purchasing the land.

FIGURE 5-1: OTJIKOTO SITE OPTIONS FOR THE POWER STATION

In line with the initial feasibility study outcomes, the MCDM process concluded that the most economical and affordable capacity of the Power Station should be sized at a net capacity of 20 MWe. The 20 MWe option emerged as the most preferable size. A large driver for the smaller capacity compared to the 40 MWe option, was the maturity of the harvesting and fuel supply industry and the significant ramp-up effort required to serve the bigger capacity plant.

NamPower will therefore likely first implement a 20 MWe Biomass Power Station. However, this report and assessment of environmental and social impacts are based on a 40 MWe plant to ensure the worst case scenario impacts are assessed and the decision by MEFT is based on this scenario, should NamPower at a later stage decide to expand the Power Station.

5.4 ALTERNATIVE POWER STATION TECHNOLOGIES

NamPower originally considered implementing either one of the following two possible Biomass Power Station technologies, i.e.:

- Fluidised Bed Boiler Technology
- Grate Fired Boiler Technology (see section 4.4.4.1)

From an environmental impacts perspective, the only aspects that could be influenced by the choice of technology i.e. potential difference in impacts, are atmopspheric emissions, noise, water use, effluent discharge, and visual impacts. These aspects are discussed below:

- Atmospheric emissions. The two technology options mainly differ in the type of Control Options available for each design with relatively similar achievable emission rates.
- Noise. Neither one of the two technical options will have a significant advantage over the other from a noise impact point of view as both options will have a similar equipment being utilised throughout the plant.
- Water use and effluent discharge. Neither one of the two technical options will have a significant advantage over the other from a water usage or effluent discharge perspective as both options will utilise similar water treatment equipment and will have similar water demand for the plant.
- Visual. Neither one of the two technical options will have a significant advantage over the other from a visual impact point of view as both options will have a similar scale and massing of structures.

It can therefore be concluded that although a preferred technology has been chosen, there is very little advantage of either technologies from an environmental impacts perspective.

With reference to section 5.3 NamPower conducted a “Multiple Decision Making” (MCDM) process. This process also considered the two technology options.

The study suggested that grate technology is preferred. The feedstock pre-treatment was one of the highest weighted sub criteria in the MCDM process. This was one of the driving factors for the technology option. The grate technology emerged more preferable to the fluidized bed option owing to the simplicity of the process and pre-treatment from bush to fuel specification. The margin between grate and fluidized bed technology was significant enough to exclude the fluidized bed technology from the next stage of procurement.

NamPower has therefore considered the grate fired boiler as the preferred technology, as opposed to the fluidised bed boiler technology. The EIA Application therefore relates to the grate fired boiler technology.

5.5 PROPOSED OPTIONS FOR ASH UTILISATION

With reference to section 4.4.4.4, both bottom ash and fly ash are classified as non-hazardous. The analysis of ash samples from a similar project within Namibia, were also discussed in section 4.4.4.4 and are taken into consideration regarding the section below.

5.5.1 Agriculture

Fly ash from wood combustion contains macro and micronutrients that plants need in the correct proportions. Since nitrogen (N) is released to the atmosphere during the combustion process, ash contains little to no nitrogen (James et al., 2012). Biomass ash can be used directly as a fertiliser or soil improver or may be used as a raw material in the production of mineral fertiliser (Pels et al., 2005). The application of fly ash can decrease soil acidity, increase the base saturation and the total amount of nutrients (except for N) in the surface layer of the soil. The ash may be utilised as a neutralising and liming agent (James et al., 2012).

The application of ash may also lead to an increase in the total reserve of trace metals in the soil. The impact of ash fertilisation on trace metal concentration of the soil will depend on both the trace metal concentration in the ash as well as the amount of ash applied. In Finland guidelines for trace element concentrations in ash generated from the combustion of wood are regulated by the Fertiliser Product Act (539/2006) and related decrees (Ministry of Agriculture and Forestry Decrees 24/11 and 11/12) which specify the permitted minimum concentrations for phosphorus (P), potassium (K) and calcium (Ca) and maximum concentrations for some trace metals. The guideline applies to wood ash by-product which does not include material that has undergone flue gas treatment. In Canada the use of wood ash as a soil amendment is also regulated by provincial and territorial jurisdictions, thus it varies significantly across the country. For example, in Alberta, the use of wood ash as a soil amendment has become relatively standard practice. In some provinces guidelines have been developed to facilitate the appropriate use of other residual materials as soil amendments which also apply to the use of wood ash (Hannam et al., 2016; Canadian Council of Ministers of the Environment, 2005; Canadian Food Inspection Agency., 1997; Sylvis Environmental, 2008; Nova Scotia Environment; 2010; Hebert, 2008).

Research shows that bottom ash has significantly lower concentrations of trace metals than fly ash, and as such, a mixture of fly and bottom ash may be suitable for application as a soil ameliorant (James et al., 2012). Mixtures of fly ash and bottom ash may be useful to achieve optimum nutrient delivery within limits for trace metal concentrations (Gomez-Barea et al., 2009).

Pels et al., (2005) suggest that returning the ashes to the locations where the biomass was harvested is presented as the most sustainable option to pursue as it returns nutrients to the original soils. The soil pH and fly ash should be assessed on a case-by-case basis in order to determine the appropriate application rate for a given soil, as is practice for general agricultural lime requirement.

5.5.2 Fuel

The presence of carbon in ash limits its application as it decreases its binding properties in construction material (James et al., 2012). According to Demirbas (2005), fly ash from biomass fired grate boilers may contain high levels of unburned carbon. The presence of this carbon indicates inefficient fuel use. The carbon content may be recycled to the boiler or furnace to improve energy output (James et al., 2012). The minimum carbon content for the re-use as fuel is 35%. If ash is burned again, the conditions under which it softens, and melts needs to be known since this may cause severe negative impacts on the combustion equipment leading to corrosion (James et al., 2012).

5.5.3 Construction

The use of biomass ashes as building material or as raw material in the manufacture of building products can be regarded as a sustainable form of utilisation (Pels et al., 2005). Bottom ash is more easily applied in construction compared to fly ash. Fly ash can be utilised in the construction industry as a cement replacement in concrete, soil stabilization, road base and synthetic aggregate (Gomez-Barea et al., 2009). Compared to coal fly ash the use of biomass fly ash in these scenarios is often not possible due to problematic components such as chlorine and phosphates, which may have a negative effect on the quality of the concrete. (Pels et al., 2005). Bottom ashes can be used as building material generally replacing sand, gravel and granulates in road construction and landscaping. Other applications include the capping of mine waste (SEPA, 1996b, Saqib and Backstrom, 2014). Besides technical requirements, there are also environmental specifications for building materials (Pels et al., 2005).

5.5.4 Options for the Final End Use or Disposal of the Ash

Table 5-1 summarises the various options being considered for the final end use or disposal of the ash from the proposed Biomass Power Station, taking the interpretations from the laboratory test results (section 4.4.4.4) into account.

The bottom ash and fly ash mostly differ in its particle grading with the bottom ash having much coarser fractions and the fly ash being very fine. The chemical properties are very similar. When deciding to the use of the ash the impact of this on the proposed use will have to be considered. Most potential uses would require a fine product and the coarse ash may have to be ground finer to be able to be used effectively.

TABLE 5-1: OPTIONS FOR THE FINAL END USE/DISPOSAL OF ASH

End use / disposal option	Pros	Cons	Comments
Utilising the Ash ("Resource Material"):			
Irrigation farms in the nearby area (i.e. use as fertilizer)	Can be used as liming material and contributes to phosphorus, potassium and micronutrient fertilisation. The fly ash is fine which is required for use as lime	Depends on the soil requirements for liming. If soil pH is not low this will not be required.	This could be a feasible option but needs agreements between NamPower and the farm owner(s). Also, irrigation farms own EMP commitments, which need to be taken into consideration and amended, where required.
Taking the ash back to the farms or areas where the bush was harvested (i.e. use as fertilizer)	Completing the cycle and reapplying the nutrients to the area which it originated from is a sound principle.	The pH of the area is already above 6.5 and would not require liming.	This could be a feasible option, depending on agreements with the land owners. Refer to assessment in section 7.
Cover the tailings storage facilities at the DPMT (Tsumeb) Smelter	Can be used to mitigate low pH effects of waste disposal facilities.	The pH of the waste will have to be low.	This could be a feasible option but needs agreement between NamPower and DPMT. Also, DPMT's EMP commitments need to be taken into consideration and amended, where required.
Cover waste at the waste facility of the smelter	Can be used to mitigate low pH effects.	The pH of the waste will have to be low.	
Cover waste at general waste facilities (landfill sites – Tsumeb, Grootfontein or Otavi)	Often facilities use lime as mitigation of vector attraction at facilities and the ash would be effective for this.	The requirement and transport cost would have to be considered	This could be a feasible option but needs agreement between NamPower and the Town Council managing the landfill site (e.g. Tsumeb Town Council). Also, the landfill site's EMP commitments

End use / disposal option	Pros	Cons	Comments
			need to be taken into consideration and amended, where required.
Brick making	Has been shown to be effective for this purpose.	There will have to be a market for bricks in the area.	This could be a feasible option for some of the ash volumes. However, further investigations on the practicality of this will have to be done by NamPower and the potential interested parties identified and consulted.
Cement manufacturing	It has been shown to be useful in this process.	Proximity of a cement manufacturer will have to be investigated.	
Road construction	Has been shown to be able to be utilised for this purpose.	There needs to be development and upgrading of roads in the area.	
Disposal Options ("Waste Material"):			
Dispose as waste at a new facility at the Power Station site	Not causing damage to the environment as the area would already be disturbed.	The ash is still not disposed; it will still be an eye sore.	This option should be weighed against the beneficial use of the material. Potential groundwater and surface water impacts (refer to section 7.5 and 7.6)
Dispose in the old quarry next to the proposed Biomass Power Station site. This could assist with rehabilitation of the old quarry – i.e. backfilling of the hole.	Rehabilitation of the area would be required.	Dumping in one site might lead to the accumulation of metal concentration to levels above acceptable standards, during rainy seasons this may be a problem	Not a preferred option due to the potential groundwater impacts.
Dispose as waste on general landfill site.	The ash will be beneficial for the landfill site in the management of vector attraction and stability of the site.	Based on the UK LoW coding, the ash is non-hazardous.	See above comments relating to cover waste at landfill sites – Tsumeb, Grootfontein or Otavi.
Dispose as waste at hazardous waste facility i.e. Walvis Bay or Windhoek.	Could be of benefit to the waste facility as a liming material.	Based on the UK LoW coding, the ash is non-hazardous.	Not a preferred option as finding a beneficial use should be priority. Also, the ash is classified as non-hazardous.

5.6 NO-GO (PROJECT) OPTION

The assessment of this option requires a comparison between the options of proceeding with the project with that of not proceeding with the project.

The proposed project would assist with grid stability by delivering renewable base load capacity and provide a portion of ancillary support services associated with a thermal Power Station, with the proposed Otjikoto site located close to a significant load centre within the Namibian electricity network.

Proceeding with the proposed project will also result in significant positive economic impacts such as increased employment (i.e. direct job creation and skills transfer nationally and locally), investment and procurement of goods and services. If the management and mitigation measures in the EMP are effectively implemented, the project would furthermore have a positive impact from the harvesting of the fuel source i.e. encroacher bush, thereby contributing to combatting bush encroachment and the restoration of rangeland, potentially benefitting the country, society, and surrounding communities both directly and indirectly. Not proceeding with the project leaves the status quo (refer to Section 6).

The challenge facing NamPower (and their contractors) is its contribution towards achieving these benefits while at the same time preventing and/or mitigating potential negative social and environmental impacts. Even though this project will present a number of potential negative environmental and social impacts which are discussed in detail in Section 8 of this report, it can be concluded that proceeding with this proposed project will also present potential social, economic as well as environmental benefits if well implemented and managed, which outweigh these negative impacts.

6 ENVIRONMENTAL BASELINE

An understanding of the environmental and social context and sensitivity within which the proposed project activities are being located is important to understanding the potential impacts. This chapter provides a general overview of the current baseline conditions associated with the proposed Biomass Power Project. For this EIA, the receiving environment is defined as: the geophysical system; the biophysical system, which includes flora, vertebrates and invertebrates and the general ecosystem dynamics; the social environment, including farms, settlements and relevant towns; and the economic environment, including livelihoods and commercial activities. This chapter provides a description of the attributes of the geophysical, biophysical, and socio-economic receiving environment of the area of interest, i.e. the proposed Power Station site and the associated harvesting area.

This section was compiled using the following sources of information:

- The Scoping Report for the Biomass Power Project (SLR, 2018);
- Visual observations during site visits by SLR;
- Input from the subcontracted environmental specialists, as described in section 1.4.1 (the Specialist Studies are attached to this report as Appendices 5 to 13).
- Atlas of Namibia; and
- Google Earth.

During the Scoping Phase, the EIA Project Team conducted baseline studies and site visits at each of the six possible Power Station locations and at a high level, the associated harvesting areas relating to each site. During this stage of the EIA process, the baseline environment was further described by referring to relevant assessment reports in the respective areas and other literature. This baseline description was conducted to allow for a better understanding of the local environment associated with each of the six site locations considered during the Scoping Phase (refer to section 3.2.2).

For the EIA Phase the Environmental Team updated their baseline studies of the Otjikoto site and associated harvesting area, which is the subject of this report (see section 4.2).

The description of the current environment therefore encompasses the Otjikoto Site i.e. proposed biomass Power Station site (refer to Figure 4-1) as well as the harvesting area surrounding the site (refer to Figure 4-2).

6.1 CLIMATE BASELINE

Information from this section was sourced from the Air Quality and Health Risk Assessment Report (Airshed, 2018) included in Appendix 5 as well as the Groundwater and Surface Water Specialist Report (SLR, 2018B) included in Appendix 11.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment (see section 7.7). Airshed used modelled MM5 data for the project site for the period 2014 to 2016. Measured data from the closest weather Station at the Tsumeb Copper Smelter (approximately 8 km to the east) was compared to the modelled data to assess its representativeness.

6.1.1 Link to anticipated impacts

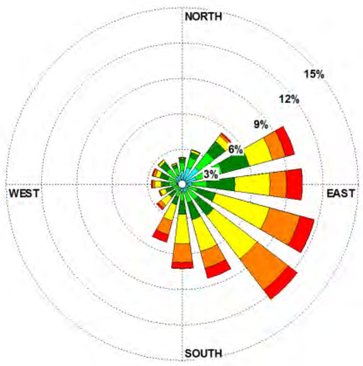
The various aspects of the climate that are discussed influence the potential for environmental impacts and related project design. Specific issues are listed below:

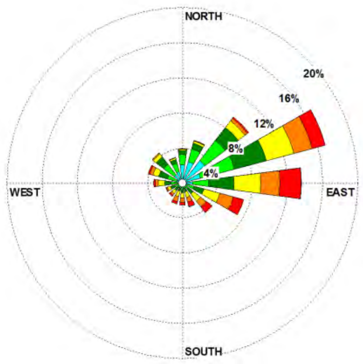
- The wind direction, and the variability in wind direction, determines the dispersion of potential atmospheric pollutants i.e. the general path air pollutants will follow and the extent of crosswind spreading. Wind could also influence erosion.
- Temperature could influence air dispersion through impacts on atmospheric stability and mixing layers, vegetation growth, and evaporation which could influence aftercare, rehabilitation planning, etc. Temperature affects gas phase vapour pressure, and therefore, the volatility.
- Rainfall could influence erosion, evaporation, vegetation growth, aftercare and rehabilitation planning, and groundwater and surface water management planning. Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials.

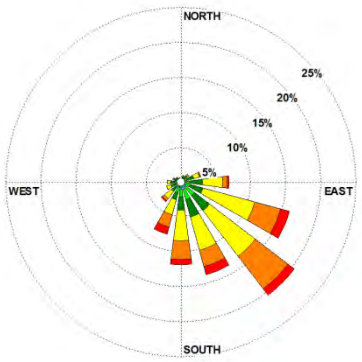
6.1.2 Surface Wind Field

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

Period, day-time and night-time wind roses for the study area, based on modelled MM5 Hourly Data for the period 2014 to 2016 are depicted in Figure 6-1.







Period	Day-time	Night-time
Calms: 9.47%	Calms: 12.72%	Calms: 6.23%

1 m/s	2 m/s	3 m/s	4 m/s	5 m/s	>=6 m/s

FIGURE 6-1: PERIOD, DAY- AND NIGHT-TIME WIND ROSES BASED ON MODELLED MMS DATA FOR THE STUDY SITE (JAN-14-DEC-16)

The wind field for the 2014 to 2016 period has a large component from the east and southeast. Calm conditions prevailed 9.47% with a period average wind speed of 3.45 m/s. During day-time the wind field is mostly characterised by wind from the east and northeast, an average wind speed of 3.07 m/s and

12.72% calm conditions. The average wind speed was 3.84 m/s during night-time hours and blew mostly from the southeast with 6.23% calm conditions.

For comparison purposes, wind roses based on measured data at the Tsumeb copper smelter for the period Jan 2013 to Oct 2016 are shown in Figure 6-2. It should be noted that the data availability during the two-and-a-half-year period is 52.9%, which is below what is typically considered acceptable internationally.

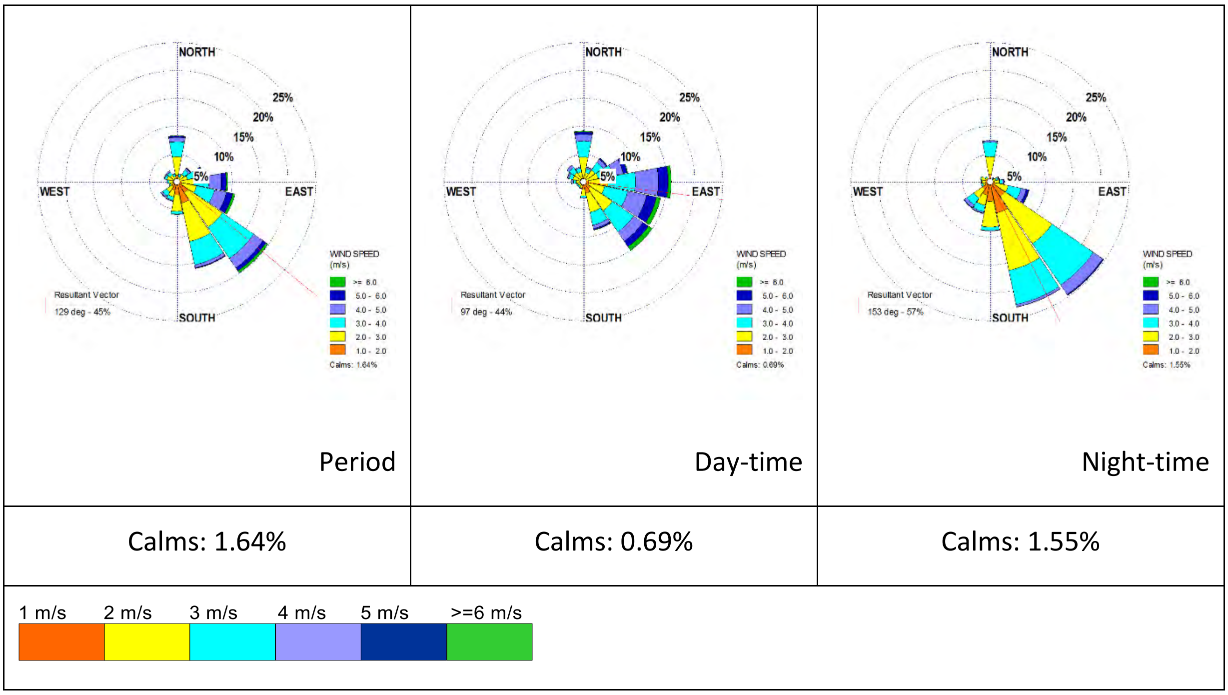


FIGURE 6-2: PERIOD AVERAGE WIND ROSES (AVERAGE, DAY TIME AND NIGHT TIME) (TSUMEB SMELTER DATA, JAN-13 TO OCT-16)

The period wind rose based on measured data is similar to Figure 6-1 and shows a uniform wind field with frequent south-easterly winds. There are also occasionally winds from the north. Calm conditions prevailed 1.6% during the recording period with a period average wind speed of 2.8 m/s. The daytime wind rose is dissimilar to the corresponding wind rose in Figure 6-1 with a much smaller component from the northeast. The measured day-time wind field is characterised by wind from the east southeast, an average wind speed of 3.1 m/s and 0.7% calm conditions. The night-time wind rose shows similarity with the wind rose based on modelled MM5 data. The average wind speed decreased to 2.5 m/s during night-time hours and blew mostly from the south-southeast with 1.6% calm conditions.

6.1.3 Temperature

Average daily maximum temperatures for the Otjikoto site range from 29°C in January to 19°C in July, with daily minima ranging from 22°C in December to 9°C in June. The average day-time temperature is given as 24°C, whereas the average night-time temperature is given as 20°C. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperatures decrease to reach a minimum at around 07:00 i.e. just before sunrise.

According to the Atlas of Namibia, the maximum temperatures for the regional (wider harvesting) area may be up to 34˚C but on average temperatures are between 20 to 22˚C. (Mendelsohn, 2002).

6.1.4 Atmospheric Stability

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the predominance of an unstable layer. In unstable conditions, ground level pollution is readily dispersed thereby reducing ground level concentrations. Elevated emissions, however, such as those released from a chimney (such as the Biomass Power Station stack), are returned more readily to ground level, leading to higher ground level concentrations.

Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and less dilution potential. During windy and/or cloudy conditions, the atmosphere is normally neutral. Neutral conditions disperse the plume equally in both the vertical and horizontal planes and the plume shape is referred to as coning. For low level releases (such as biomass harvesting), the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 6-1.

TABLE 6-1: ATMOSPHERIC STABILITY CLASSES (AIRSHED, 2018)

Designation	Stability Class	Atmospheric Condition
A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Unstable	moderate wind slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind slightly overcast night-time conditions
F	Very stable	low winds, clear skies, cold night-time conditions

Airshed used an in-house meteorological pre-processing program to estimate stability classes for the study area, using the modelled MM5 Data for the period 2014-2016 as input. Estimations indicate that atmospheric conditions are mostly very unstable (27%), with the second most prevalent atmospheric stability class indicated as stable (26%), followed by neutral (18%). The percentages of moderately unstable and very stable conditions were lower at 15% and 10% respectively, whereas unstable conditions were estimated to be 5% (Figure 6-3).

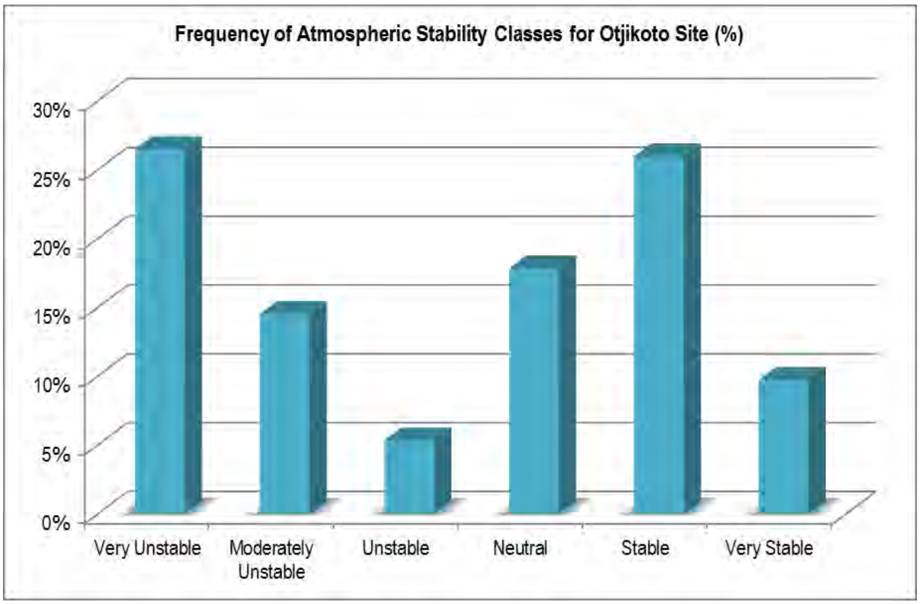


FIGURE 6-3: FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR OTJIKOTO SITE (IN %) (BASED ON MM5 DATA FOR THE PERIOD 2014-2016) (AIRSHED, 2018)

From the MM5 data the average day-time stability class for the study site may be characterised mostly as very unstable, whereas night-times are characterized mostly by stable conditions (Figure 6-4).

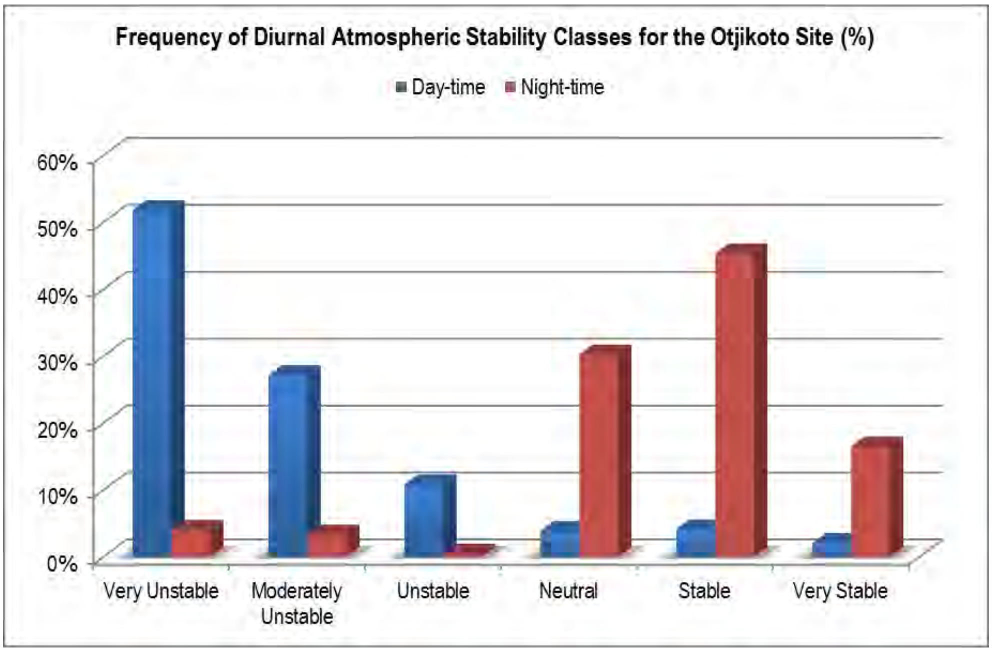


FIGURE 6-4: FREQUENCY OF DIURNAL ATMOSPHERIC STABILITY CLASSES FOR OTJIKOTO SITE (IN %) (BASED ON MM5 DATA FOR THE PERIOD 2014-2016) (AIRSHED, 2018)

6.1.5 Precipitation

The nearest long and reliable rainfall record significant to the Otjikoto site is from Tsumeb Meteorological Station, which is approximately 9 km south-east of the site.

Tsumeb has a Meteorological Office rainfall record of approximately 90 years commencing from 1913/14 with some data gaps in between (see Appendix 11 for more details), which provides a fairly accurate long-term average. Rainfall data has been analysed for the hydrological year, which runs from 1 October to 30 September, hence years are shown as 1913/14, being data for October 1913 through to September 1914. The average monthly rainfall values are shown in Table 6-2 and Figure 6-5 which shows that the majority of rainfall (88 %) falls between November and March. The Mean Annual Precipitation (MAP) is 508 mm and there are two months of average rainfall greater than 100 mm (January and February), with the highest monthly rainfall being 370.6 mm recorded in February 1944. The highest annual rainfall was 1,006 mm recorded in 1943/44 and there have been ten years when the annual rainfall was over 700 mm. Annual rainfall data recorded at Tsumeb is shown graphically in Figure 6-6.

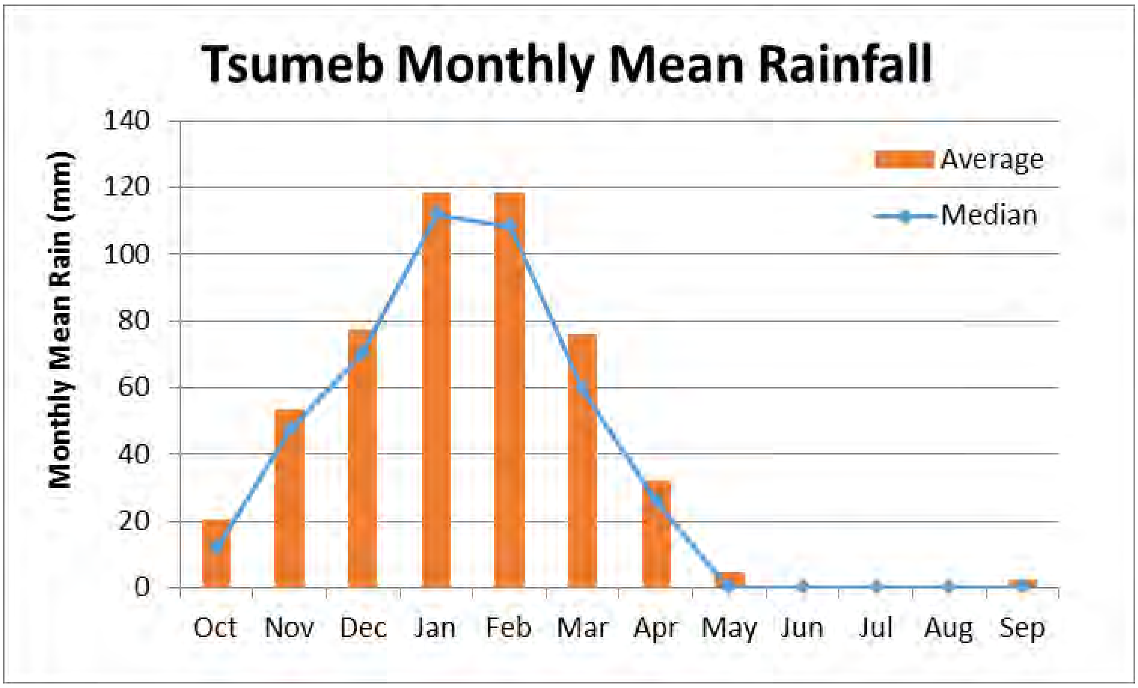


FIGURE 6-5: TSUMEB MONTHLY MEAN RAINFALL DISTRIBUTION

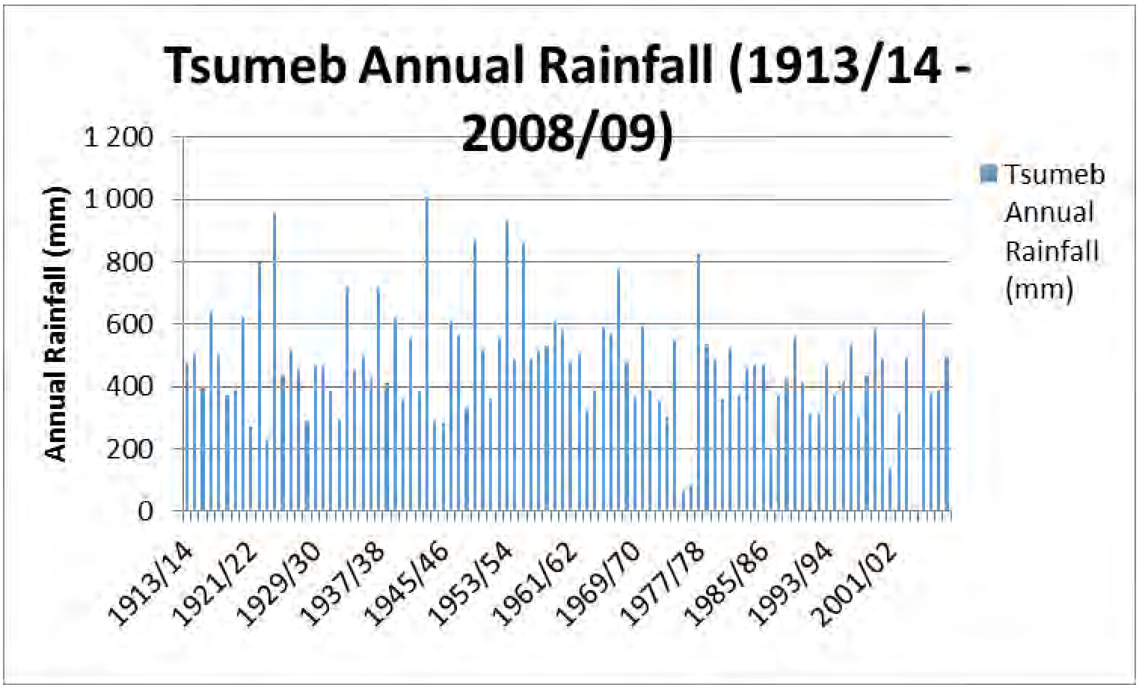


FIGURE 6-6: TSUMEB ANNUAL RAINFALL

The rainfall data (1913/14 to 2008/09) for the Tsumeb Met Office rain gauge was analysed for exceedance (see Appendix 11 for more details). From this it was established that in Tsumeb there is an 80 % probability that the annual rainfall will be approximately 370 mm, a 50 % probability that the annual rainfall will be approximately 480 mm and a 20% probability that the annual rainfall will be approximately 590 mm.

Rainfall is generally from storms producing short cloud-bursts of low to high intensity, but as the site is located in the karst area where infiltration rate is relatively high, reduced surface runoff volumes should be expected.

According to the Atlas of Namibia, the Average Mean Annual Precipitation (MAP) for the regional (wider harvesting) area ranges between 550 mm in the central area, decreasing to 500 mm in an almost circular circumference around the Otavi Mountain Land. The lowest MAP can be expected at 350 mm to the south east of the area (Mendelsohn, 2002).

6.1.6 Evaporation

Calculated from Namibian Meteorological Office (Met. Office) Class-A evaporation pan data, the following evaporation data was taken from the Department of Water Affairs Evaporation Map Report (DWA, 1988).

The A-pan evaporation values for Tsumeb were then converted to open water values (evaporation from a Class-A evaporation pan is higher than from an open body of water) to compile an estimated evaporation distribution for the Tsumeb area. The estimated open water evaporation values are shown in Table 6-2 and in Figure 6-7.

TABLE 6-2: TSUMEB AREA MONTHLY RAINFALL AND EVAPORATION DATA

Tsumeb Mean Annual Evaporation	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Monthly Percentage	11.9	11.2	11.8	10.7	8.0	7.3	6.2	5.5	4.9	5.4	7.3	9.8	100
A-Pan Evaporation (mm)	249.2	234.5	247.1	224.1	167.5	152.9	129.8	115.2	102.6	113.1	152.9	205.2	2094
Open Water Evaporation (mm)	174	164	173	179	134	122	104	92	82	90	122	164	1602
Tsumeb Mean Monthly Rain (mm)	20.4	53.4	77.3	118.3	118.6	76.2	32.1	4.5	0.4	0.0	0.1	2.5	504

These figures show that the monthly evaporation for all months is higher than the rainfall, indicating that the Tsumeb area is a water negative area, meaning that there is an overall deficit in the available water, especially during the months from April to November, when there is little or no rainfall. However, from Figure 6-7 it can be seen that in January and February the mean monthly rainfall and evaporation are much closer, suggesting that the area becomes more of a water neutral area, where rainfall nearly matches evaporation.

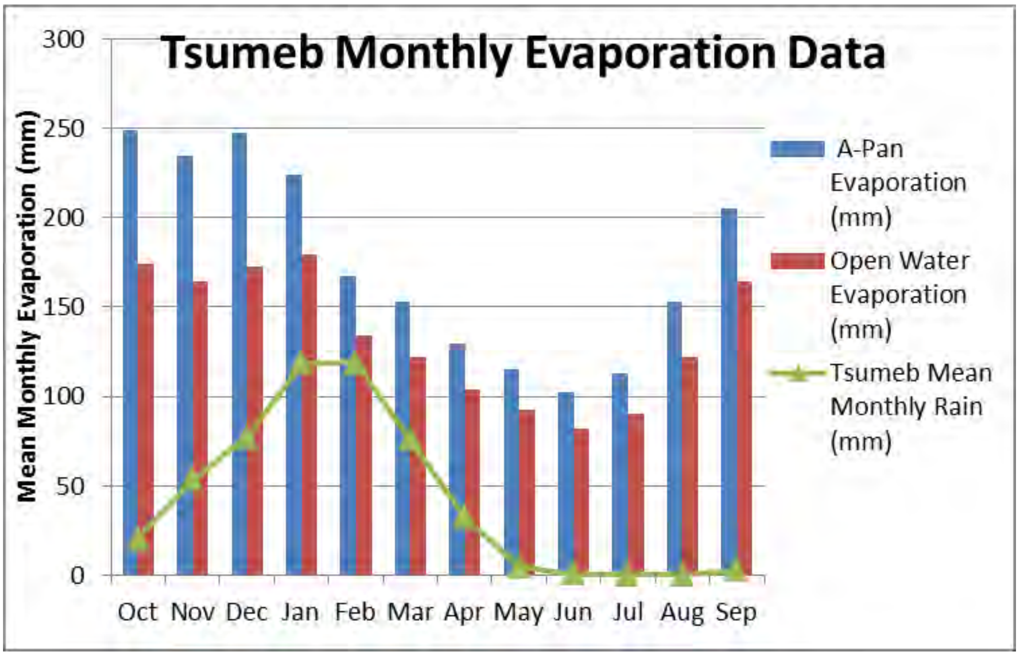


FIGURE 6-7: MEAN MONTHLY EVAPORATION AND RAINFALL FOR TSUMEB AREA

According to the Atlas of Namibia, the evaporation in the regional (wider harvesting) area is estimated to be between 1900 and 2200 mm/year. (Mendelsohn, 2002).

6.2 TOPOGRAPHY BASELINE

Information was sourced from the Groundwater and Surface Water Specialist Report included in Appendix 11 and the Biodiversity Impact Assessment included in Appendix 6.1.

6.2.1 Link to Anticipated Impacts

The topography of a particular area will determine the following factors:

- The flow of surface water, and in many cases, also groundwater.
- The depth of soils and the potential for soil erosion, for example, in the case of steep slopes.
- The type of land use.
- The aesthetic appearance of the area.
- Topography can also influence climatic factors such as wind speeds and direction, for example, wind will be channelled in between mountains along the valley.

Changes in the topography caused by the project infrastructure could potentially alter all of the above-mentioned aspects of the environment.

This section provides an understanding of the topographical features relevant to the Otjikoto project site and surrounding area, as well as the bigger harvesting area from which to measure potential change.

6.2.2 Proposed Otjikoto Biomass Power Station Site

The Otjikoto site is located approximately 7 km northwest of Tsumeb on the main B1 i.e. TR 1/10, tar road to Ondangwa and covers an area of approximately 44 ha within the Tsumeb-Otavi-Grootfontein Subterranean Water Control Area (see section 4.2).

The relief of the area is gently sloping northward. The elevation of the Otjikoto site is approximately at 1,200 mamsl. The proposed site is located on relatively flat ground, with some calcrete outcrops and mostly sand and gravel cover. No ephemeral rivers or any other surface water features are in the vicinity. The area is surrounded by some commercial and resettlement farms. An old quarry which is currently not operational exists to the west of the site, and a crusher exists south of the site. The topography within a 10 km radius of the study site is illustrated in Figure 6-8.

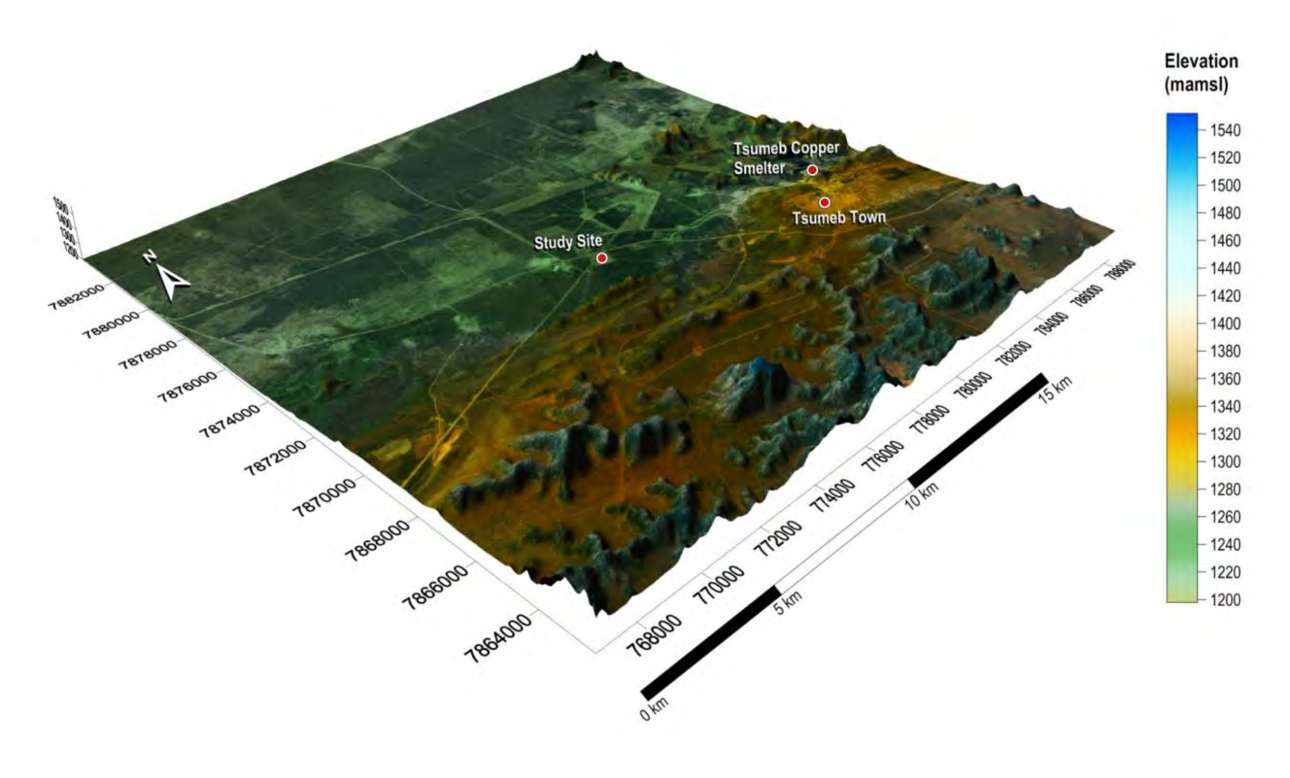


FIGURE 6-8: TOPOGRAPHY WITHIN A 10 KM RADIUS OF THE OTJIKOTO STUDY SITE (AIRSHED, 2018)

6.2.3 Harvesting Area

Topographically the harvesting area is essentially a plain interrupted by the prominent limestone Otavi Mountains in the centre, which taper out in a spur that stretches for about 150 km to the southwest. In the south, the area overlaps the sandstone Waterberg massif, but only partially so. (Refer to Figure 6-9).

The altitude ranges from 1000 m amsl to the outskirts of the harvest area increasing in elevations to 1800 m amsl around the Otavi Mountainland. Kalahari Sands cover the north-west, north and east of the area, with lower altitudes. Surface water is limited, with only the Omatako Ephemeral River draining to the north-east of the country towards the Okavango River and the Omuramba Owambo Ephemeral River located to the north of the site, which drains towards the Etosha Pan (refer to Figure 6-14 for the location of these rivers).

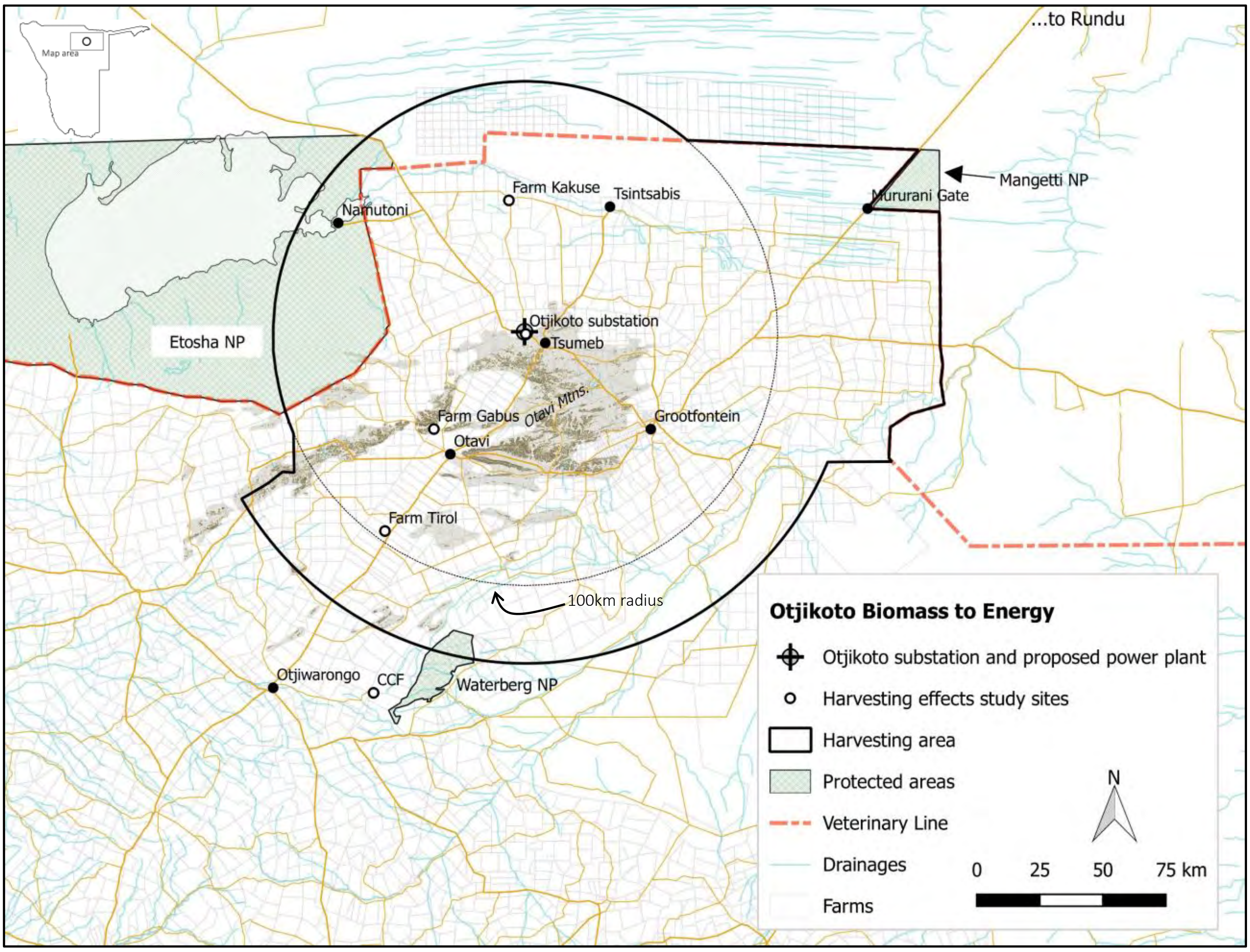


FIGURE 6-9: THE STUDY AREA INCLUDING THE PROPOSED HARVESTING AREA AND POWER STATION IN RELATION TO THE OTAVI MOUNTAINS, AND SOME BASIC ORIENTATION POINTS (AWR, 2018)

Note: the Veterinary Line is s a pest-exclusion fence separating northern Namibia from the central and southern parts of the country

6.3 TRAFFIC BASELINE

Information in this section was sourced from the Traffic Impact Assessment Report included in Appendix 14.

6.3.1 Link to anticipated impacts

Understanding the nature, use and conditions of existing transport systems relevant to the proposed project provides a basis for understanding a change as a result of project contributions, specifically relating to:

- The construction traffic for the Power Station and the overhead powerline (see section 4.3.5);
- The transport of the fuel, i.e. woodchips from the harvesting areas to the plant (see section 4.4.3); and
- The possible transport of the ash from the plant (see section 4.4.3).

This section therefore provides an overview of the regional and local road context.

6.3.2 Regional & Local Road Context

Figure 6-10 below indicates the trunk, main and district roads in the harvesting area, in the vicinity of the proposed Power Station. The roads within the immediate vicinity of the proposed Power Station are depicted in Figure 6-11 below.

The roads of concern are:

- Trunk Road 1/10 (TR110) which forms the main commercial road artery between the central areas of Namibia and the north, also known as the Trans-Kunene Highway Corridor; and
- District Road 3007 (DR3007) which connects with TR110 and is from where the main access to the plant will be situated.

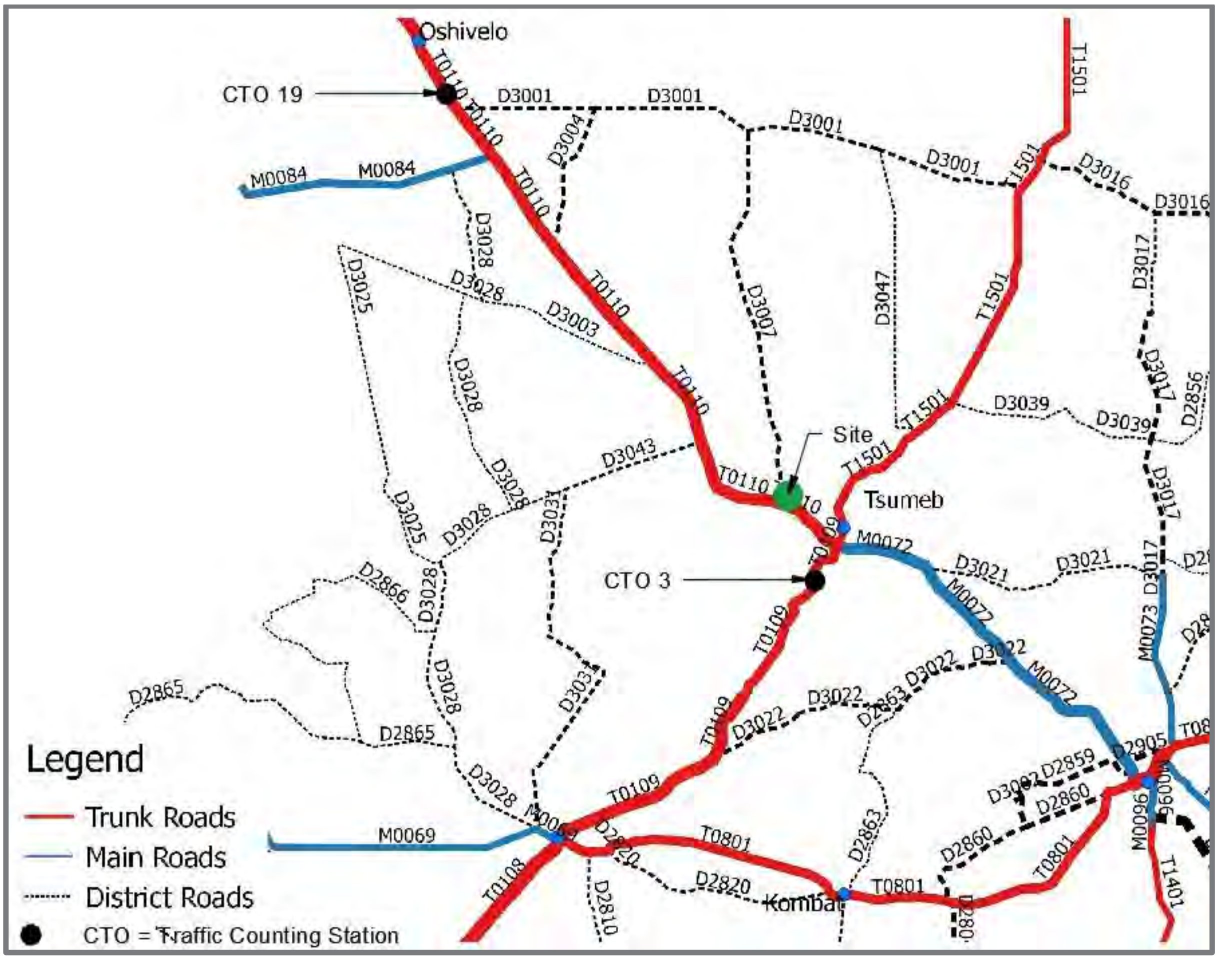


FIGURE 6-10: REGIONAL ROAD NETWORK

The Roads Authority has traffic counting Stations or Comprehensive Traffic Observation (CTO) Stations positioned all over the Namibia road network. CTO Stations 3 and 19 are indicated in Figure 6-10. CTO 28 is positioned between Tsumeb and Grootfontein. Some general information at these Stations, for 2015, is given in Table 6-3 below and limited information for 2012 for CTO 19.

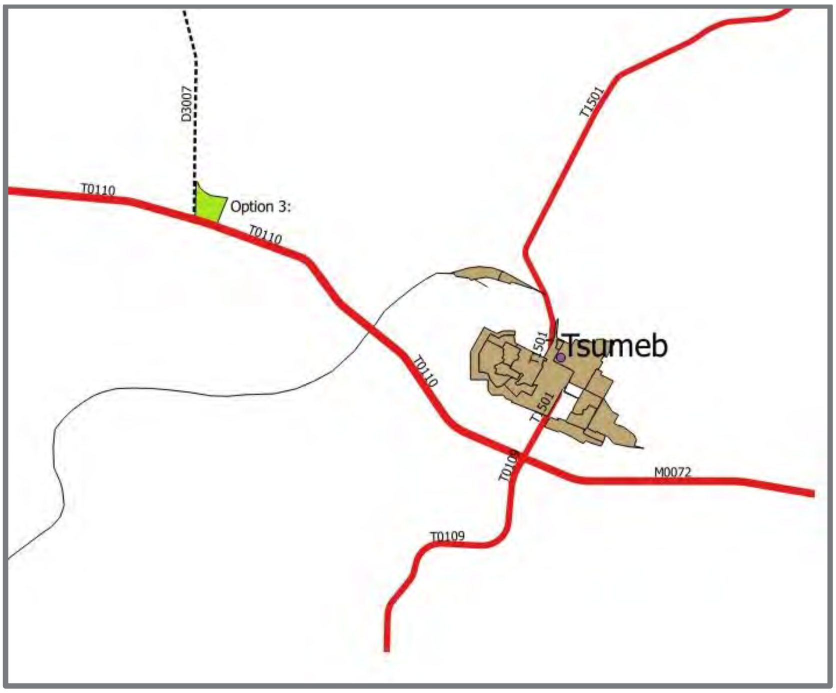


FIGURE 6-11: ROADS WITHIN VICINITY OF THE PROJECT

TABLE 6-3: CTO TRAFFIC DATA ON BITUMEN ROADS

Description	CT0 3	CTO 19		CTO 28
Year	2015	2012	2015	2015
Average daily traffic (ADT) (light) & [traffic growth]	1293	837	987 [5.6%]	652
ADT (heavy) & [traffic growth]	668	525	610 [5.1%]	109
ADT (total) & [traffic growth]	1961	1363	1597 [5.4%]	761
Directional Split	51:49		50:50	48:52
% Heavy vehicles	34%		38%	14.3%
Average light vehicle speed (km/h)	100		120	120
Average heavy vehicle speed	57		99	97
Typical peak vehicles per hour (vph) (one-direction)				
Sunday				

Light vehicles	70		70	
Heavy vehicles	30		30	
Total	120		110	
Monday – Friday				
Light vehicles	40		40	
Heavy vehicles	20		20	
Total	60		60	
Saturday				
Light vehicles	45		30	
Heavy vehicles	15		15	
Total	60		45	

The growth between the 2012 and 2015 is calculated at approximately 5%. Average Daily Traffic (ADT) volumes are normally given as a combination of both directions. Typical hourly volumes for different days of the week were obtained and are included in Appendix 13. An extract is depicted below.

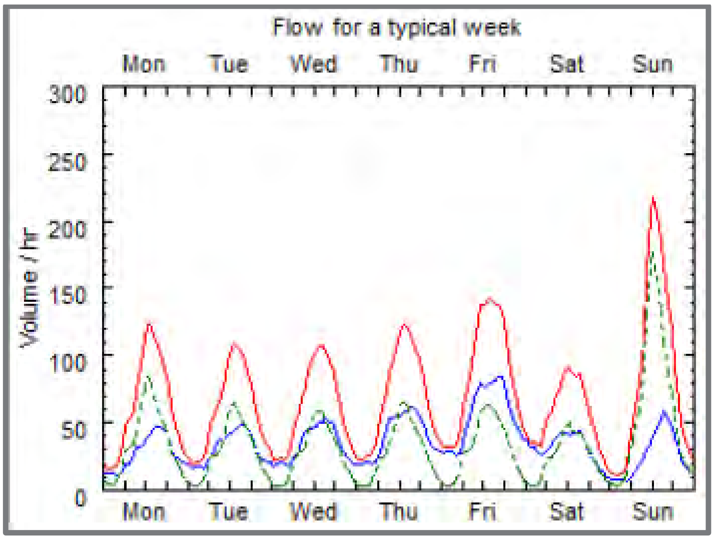


FIGURE 6-12: TYPICAL HOURLY VOLUMES AT CTO 19 (BOTH DIRECTIONS)

The peak during Sundays (approximately 200 vph) is noticeable and approximately double of the other days.

There are no CTO Stations on gravel roads in the vicinity of the project. The Road Management System (RMS) division of the Roads Authority does have estimated traffic volumes on all the roads. The RMS periodically conducts visual assessments of all the roads as part of their management system. The relevant information, from a couple of gravel roads in the vicinity of the proposed Power Station and within the harvesting area, is summarized below (see Figure 6-10 for the location of the roads).

TABLE 6-4: GRAVEL ROAD DATA

Road No.	Current light vehicles	Current heavy vehicles	Current Annual average daily traffic (AADT)	2016 Visual Assessment	
				Gravel Thickness	Roughness: International roughness index (IRI) – m/km
D3007	20	5	25	80	5.03
D3043	10	5	15	80	5.03
D3047	5	2	7	76	4.83
D3003	5	1	6	76	4.83
D3004	5	1	6	76	4.83
D3028	10	2	12	26	5.07
D3001	20	3	23	-	-
D3039	10	5	15	-	-
D3021	10	2	12	-	-
D3022	20	5	25	-	-
D3031	15	5	20	-	-
D3028	10	2	12	-	-
D2863	5	2	7	-	-
D2809	4	1	5	-	-
D2810	10	1	11	-	-
Average for District	**11**	**3**	**14**	**-**	**-**
MR72	650	115	765	n/a	3.07
MR69	50	10	60	-	-

Table 6-5 provides an approximate correlation between comfortable speed and IRI on gravel roads. The recommended level of service (LOS)[8] is 60 km/h for an IRI off less than 10.

[8] ***Level of service (LOS)*** is a qualitative measure used to relate the quality of motor vehicle traffic service. LOS is used to analyze roadways and intersections by categorizing traffic flow and assigning quality levels of traffic based on performance measure like vehicle speed, density, congestion, etc. LOS is measured differently for intersections and roadways but the aim is always to have a LOS of C which is deemed acceptable. LOS is defined between A and F:

TABLE 6-5: GRAVEL ROAD IRI CORRELATION

Comfortable Speed	IRI
100 km/h	< 5
80 – 100km/h	5 – 7.5
60 – 80km/h	7.5 – 10
45 – 60km/h	10 – 12.5
< 35 km/h	15

The average daily traffic (ADT) for the bitumen and gravel roads differ substantially. The ADT on TR 1/9 (Otavi to Tsumeb) and TR 1/10 (Tsumeb to Oshivelo) ranges from 1,600 to 2,000 vehicles per day. The average of the gravel roads, in the vicinity of the project is 14 vehicles per day. Impacts or changes to traffic on gravel roads, although it might be small changes, will be observed and experienced by local farmers.

With reference to section 4.4.3.1, the Traffic Specialist divided the areas of biomass fuel origin into four regions (refer to Figure 4-9). The road network and topography relating to each of the areas are described below:

- Area 1 (North of Power Station site).
    - The area has a good district and trunk road network which will give direct and quick access to the site.
    - The overall topography of the area is flat with the majority of the area assumed harvestable.
- Area 2: (West of Power Station site).
    - The area has a good district and trunk road network which will give quick access to the site.
    - The overall topography of the north western area is flat with the majority of the area assumed harvestable.
    - The south western area has several slopes greater than 12.5% and only a portion is assumed to be harvestable.
- Area 3: (South of Power Station site).
    - The access to the site is limited to TR 1/9 from Otavi via Tsumeb. The road network is therefore not considered optimal.
    - The overall topography of the area directly south of the site is mountainous (Otavi Mountain Lands) with a small portion considered harvestable.

- LOS of A: Free flow. Motorists have a high level of physical and psychological comfort.
- LOS of B: Reasonably free flow. Motorists still have a high level of physical and psychological comfort.
- LOS of C: Stable flow, at or near free flow. Most experienced drivers are comfortable, roads remain safely below but efficiently close to capacity. This is the target LOS for some urban and most rural highways.
- LOS of D: Approaching unstable flow. Minor incidents are expected to create delays.
- LOS of E: Unstable flow, operating at capacity. Any incident will create serious delays. Drivers' level of comfort become is poor.
- LOS of F: Forced or breakdown flow. Travel time cannot be predicted.

- The areas further south of the Otavi Mountain Lands is flatter but at a greater distance from the site.
- Area 4 (East of Power Station site). 30% of biomass expected to originate from this area.
    - The area has a good district and trunk road network although direct access to the site is only via TR 1/15 which will make access slightly longer than Area 1.
    - The overall topography of the north eastern side is flat with the majority of the area assumed harvestable.

6.3.3 Current Road Safety and Condition

6.3.3.1 *TR1/10 and DR3007*

The Power Station site is flanked by TR 1/10 on the southern side and DR3007 on the western side. Access to the plant will be from DR3007. The current TR1/10 & DR3007 intersection has no deceleration, acceleration or passing lanes.

The Roads Authority of Namibia has conducted a comprehensive road safety audit on the Trans-Kunene Highway corridor. Crashes with animals were the most dominant incident.

The crash statistics was used by the Traffic Specialist to calculate the crash rate which is an expression of the number of crashes per million vehicle kilometres. The crash rate gives an indication of the relative safety of a section of road compared to other similar sections. The highest three crash rates on the corridor were:

- Omaruru – Otjiwarongo = 1.79
- Karibib – Omaruru = 1.39
- Tsumeb – Oshivelo = 1.3

The crash rates were compared to similar freeways in South Africa and it was found that a crash rate above 1 is considered high. The crash rate on TR 1/10 is therefore considered high but not abnormal for Namibian road conditions.

The geometry of a road plays an important role in the safety of a road. The recovery area is one such design feature affecting the road safety as well as alignment of the road. The recovery area along TR 1/10 was found to be the best along the entire Trans-Kunene corridor.

6.3.3.2 *Gravel Roads*

Traffic on gravel roads causes gravel loss and ravelling which is the generation of loose material. Ravelling also poses safety problems. Gravel losses for roads with ADT of less than 50 vehicles per day (vpd) are less than 10 mm/year. The current traffic on D3007 is estimated at 25 vpd (ADT) or 12.5 vpd per lane. The DR 3007 road currently has a gravel thickness in the order of 70 mm. The current gravel loss is between approximately 3.1 mm and 7.8 mm per annum (see Appendix 13) for more details.

6.4 SURFACE WATER BASELINE

The information in this section was sourced from the Groundwater and Surface Water Specialist Report included in Appendix 11.

6.4.1 Link to anticipated impacts

Surface water resources include drainage lines and paths of preferential flow of stormwater runoff. Project-related activities have the potential to alter the drainage of surface water through the establishment of infrastructure and support facilities and/or result in the contamination of the surface water resources through seepage and/or spillage of potentially polluting materials, and waste (general and hazardous). Key to understanding the hydrology of the site is the climatic conditions of the site (refer to section 6.1).

As a baseline, this section provides an understanding of the hydrological catchments that could be affected by the project (both the Power Station and the harvesting and associated activities) and the status of surface water resources in the project area.

6.4.2 Surface water baseline relating the Otjikoto Power Station Site

The study area is in the Omuramba Owambo sub-catchment of the Etosha Basin drainage system, with the general drainage direction in a northerly direction. There are no significant rivers in the surrounding area and most drainage is towards the Etosha Pan. The Tsumeb area is described as karst area, which means that there is a limited and fractured drainage pattern, with fountains and sink holes providing sites for water to appear and disappear from the surface over much of the area.

SRTM (Shuttle Radar Topography Mission) data from National Aeronautics and Space Administration (NASA) was used to compile a ground elevation map for the study area in conjunction with the local 1:250 000 topographical map (Map 1916 Tsumeb). From this elevation data combined with satellite images, the local catchment was identified. There is a small northward flowing drainage line to the south-west of the proposed Power Station site and a small northward flowing drainage network to the south-east of the site, both of which will only have ephemeral flow occurring after significant rainfall events (Figure 6-13). These two drainage lines do not appear to cross the B1 (i.e. TR 1/10) road and will therefore not have any impact on the drainage at the site. The relief of the area shows the highest ground located to the south of the Otjikoto site, with an overall slope northward over most of the area (refer to section 6.2.2 for the topography of the area).

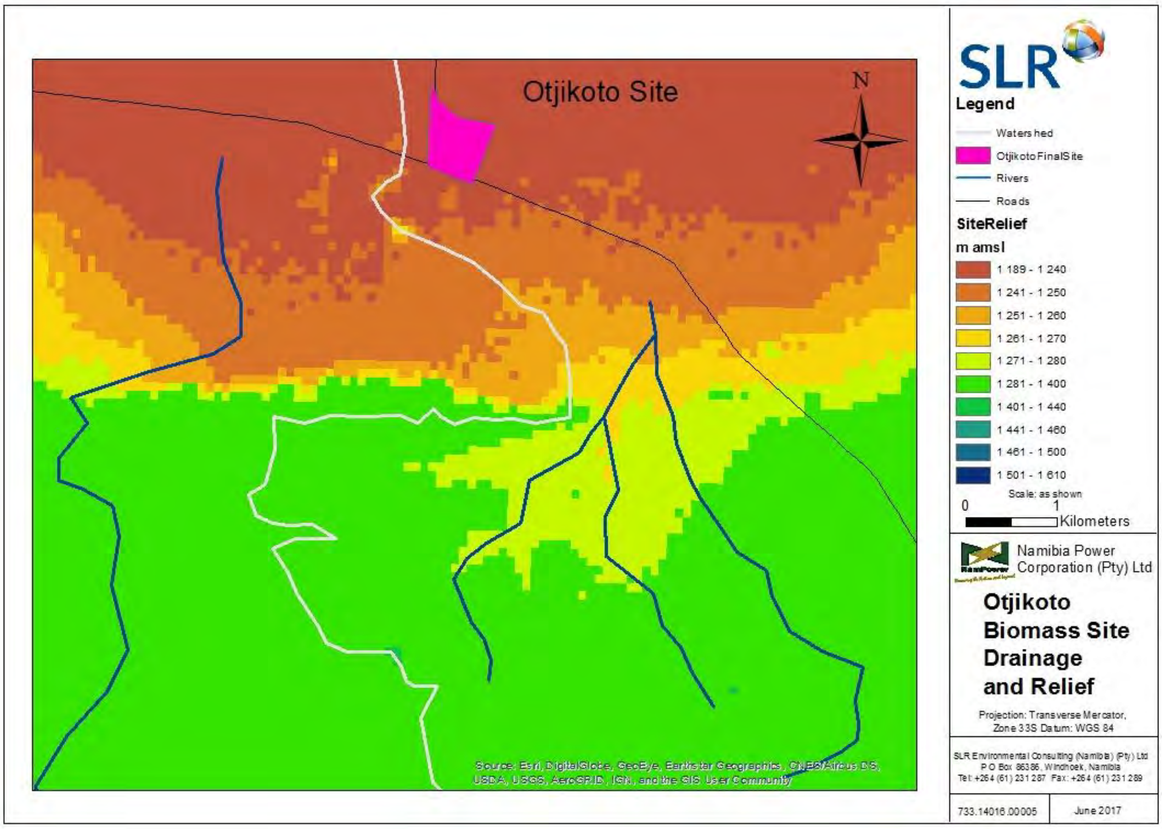


FIGURE 6-13: OTJIKOTO SITE GENERAL DRAINAGE AND RELIEF

6.4.2.1 *Peak Flow Estimation for Local Runoff and Design Storm Estimation*

The following sections summarise the calculation of peak flows for the local area. Once more detailed surveys are undertaken for the site, flood-line calculations can be carried out to ensure that the planned infrastructure will not be at significant risk from extreme flooding events.

Table 6-6 shows the catchment characteristics that were calculated and input to the calculation of peak flows (refer to Appendix 11 for more details).

Results from these calculations gave peak flow values for the catchment as shown in Table 6-7. This shows that the 1:100 year peak flow will be 3.54 m^3/s (taking the average of the RM and ARM values) and the 1:50 year peak flow 2.82 m^3/s. This indicates that there will not be a significant flood generated in the small upstream catchment area, which confirms the information from the catchment area, which has no significant drainage lines due to the karstic nature of the area.

TABLE 6-6: OTJIKOTO BIOMASS SITE CATCHMENT; MODEL INPUTS FOR RM AND ARM

Area of catchment	= 2.92 km²						
Dolomitic area	= 85 %						
Length of longest watercourse	= 2 km						
Flow of water	= surface flow						
Height difference along 10-85 slope	= 16 m						
Rainfall region	= Inland						
Area distribution	= Rural: 100%, Urban: 0%, Lakes: 0%						
Surface slopes (%)		**Permeability (%)**		**Vegetation (%)**			
Lakes and pans	10	Very permeable	30	Thick bush & forest	0		
Flat area	70	Permeable	60	Light bush & cult. land	70		
Hilly	20	Semi-permeable	10	Grasslands	20		
Steep areas	0	Impermeable	0	Bare	0		
Days on which thunder was heard	= 40 days/year						
Meteorological Office Station number	= 105 5374						
Meteorological Office Station location	= Tsumeb, 54 years data						
Mean annual precipitation	= 526 mm						
Duration	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year	200 Year
1 day	37	53	66	80	101	119	140
2 days	47	70	89	109	140	167	197
3 days	55	83	106	132	172	207	246
7 days	74	122	163	209	282	347	421

TABLE 6-7: CALCULATED PEAK FLOW VALUES

Return Period	1:2	1:5	1:10	1:20	1:50	1:100
Method	Peak Flow (m^3/s)					
Rational Method	0.84	1.22	1.64	2.15	2.94	3.81
Alternative Rational Method	0.62	1.12	1.55	2.03	2.69	3.26
Average	0.73	1.17	1.60	2.09	2.82	3.54

The results of the surface water study should be used as input to future storm water management planning, to be included in the calculations for a flood-line study (if required) and to assist with the correct sizing of required containment and protection structures once detailed design has been carried out.

6.4.2.2 *Surface Water Quality*

No surface water has been identified on the site. However, it is recommended that water samples should be collected from the main site if there is a significant rainfall event and analysed to build up a baseline data set for site surface water quality, and also to provide information on the likely quality of runoff water at the site. No potential pollution sources have been identified close to the site.

6.4.3 Surface water baseline relating to the Harvesting Area

There are two main surface drainages in the harvesting area, the Omuramba Omatako, south east of the site, draining to the north-east into the Okavango River and the Omuramba Owambo located to the north of the harvesting area, which drains towards the Etosha Pan in the west. Both these omiramba have episodic flows (less than 75% of the year) and are linked to high rainfall events during summer months. Omiramba are the Namibian term for ancient riverbeds. The main water divide between these two rivers will be in the Otavi Mountain Lands (OML) between Otavi and Tsumeb. Any surface water south of the OML will flow towards the Omuramba Omatako while surface water north of the OML will flow towards the Omuramba Owambo. No perennial rivers exist in the harvesting area with most of the area being relatively flat and with some minor flow pathways from the higher laying areas. Flood events generated by the upstream catchment areas which contribute runoff during extreme rainfall events will have fairly small volumes and durations of peak flows.

Two of the most prominent lakes, Otjikoto Lake and Guinas Lake, are found within the harvesting area boundary. These lakes are sinholes formed by collapsing karst caves and are therefore groundwater fed. Before the project commences, background and baseline surface water chemistry from these ephemeral rivers and the two lakes should be conducted, the ephemeral rivers and the two lakes can be viewed in Figure 6-14.

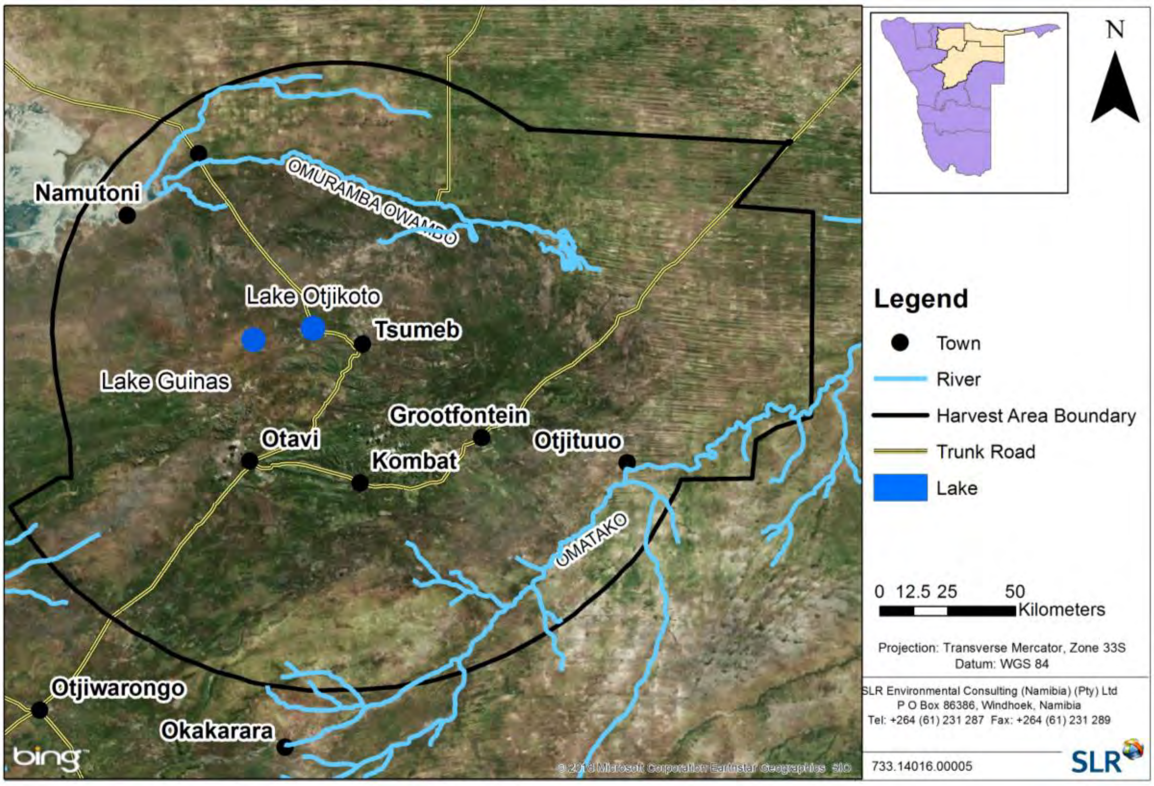


FIGURE 6-14: SURFACE WATER IN THE BUSH HARVESTING AREA

6.5 GROUNDWATER BASELINE

The information in this section was sourced from the Groundwater and Surface Water Specialist Report included in Appendix 11.

6.5.1 Link to anticipated impacts

Groundwater is a valuable resource and is defined as water which is located beneath the ground surface in rock pore spaces and in the fractures of lithologic formations. Understanding the geology of the area provides a basis from which to understand the occurrence of groundwater resources. Project-related activities such as the handling and storage of materials and wastes have the potential to result in the contamination of groundwater resources, which could impact on the environment and third party users. This section provides an understanding of the current groundwater conditions and the potential for pollution to occur as a result of project-related activities.

6.5.2 Groundwater baseline relating to the Otjikoto Power Station Site and Surroundings

6.5.2.1 *Hydrocensus*

The outcome of the hydrocensus conducted is that there are variable borehole depths in the hydrocensus area with the rest water level (RWL) not more than 50 m below ground level (bgl). In June 2019 three production boreholes were drilled on the proposed Biomass Power Station site as part of the geotechnical, geohydrological and topographical survey carried out by Burmeister and sub-consultants

(Burmeister, 2019). The three boreholes intersected fractured and partly karstified dolomite of the Elandshoek Formation at depth.

6.5.2.2 *Depth to Groundwater*

The depth to groundwater in the immediate surrounding of the site is between 15-30 mbgl but is deeper towards the south and south east (see Figure 6-15). The depth to groundwater is considered moderately shallow.

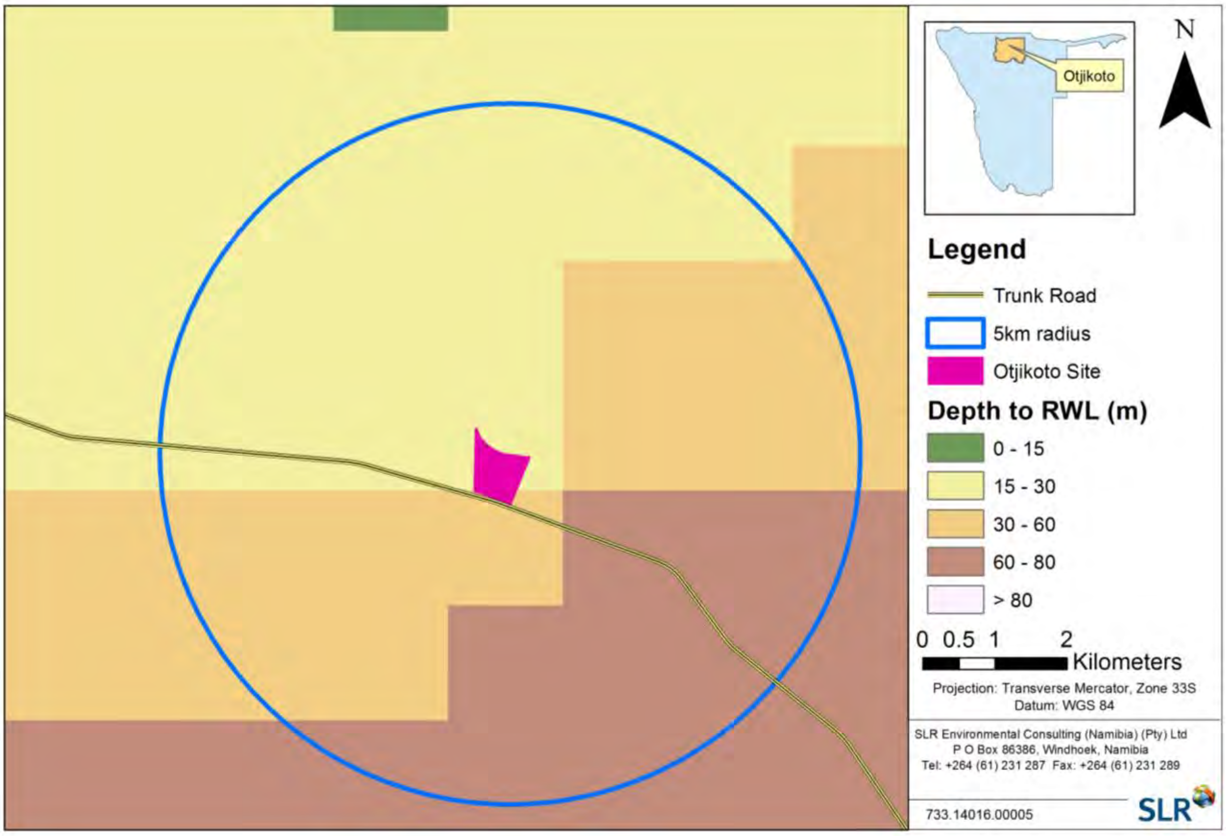


FIGURE 6-15: MAP DEPICTING DEPTH TO GROUNDWATER LEVEL WITHIN 5KM RADIUS OF PROPOSED PLANT (SOURCE: GROWAS 2009)

6.5.2.3 *Hydrogeology and Groundwater Potential*

The composition of rocks in the north of Namibia resulted in the formation of strategically important aquifers with high to moderate groundwater potential. The proposed Power Station area falls into one of two OML karstic aquifers, namely the Tsumeb Karst Aquifer (TKA). It is also reported that the OML aquifers have no primary porosity or permeability; hence groundwater flow and storage are restricted to structural elements (fractures and fissures) and dissolution features that enhance secondary porosity and permeability. Christelis & Struckmeier (2001) report that the Karoo dyke system in the Tsumeb area provides vertical conduits where bulk water supply for the town is sourced. Unconfined carbonaceous Kalahari aquifers are present to the north of Tsumeb (GKW; 2003).

A site walk over of the proposed Power Station site by the SLR Water Specialist Team revealed that the underlying rock beneath the surface soil cover is mostly calcrete (refer to section 6.6.3.1 or more details). The calcrete cover bears relevance as it is a rock resulting from the conglomeration of calcium carbonate rocks and other materials held together by calcareous cement. Due to its cementation, the rock may act as a pollution buffer and retard potential spread of pollution. The calcrete is underlain by dolomite of the Elandshoek Formation (see Figure 6-17). Water supply boreholes intersect the fractured dolomite rocks at depth, which form the main aquifer at the Otjikoto Power Station site.

In a 5 km radius of the site, the aquifer is fractured, or karstified and has a high groundwater potential (Figure 6-16). There are several boreholes with yields > 5 m^3/h where the blue circle represents a 5 km radius from the site. Should independent water sources be sought, the aquifer has high potential, which increases the chance for successful boreholes. Additionally, there were two boreholes located on the existing NamPower substation, located across the road from the proposed Biomass Power Station site.

One borehole located to the south of the substation has a reported yield of 14 m^3/h, which would be sufficient for the required demand of both, the 20 MW and the 40 MW Power Station, with additional infrastructure such as pipelines. The borehole would have to be pump tested to confirm the sustainable pumping rate and yield of the borehole and an accompanying abstraction permit is required. This is because the proposed Biomass Power Station site is within the Subterranean Water Control Area and therefore a permit to abstract water would be required from Department of Water Affairs and Forestry (DWAF). The second borehole on the premises of the existing NamPower substation, found during the site walk over, is decommissioned, as reported by COWI (2017).

The Tsumeb Municipal Water Supply Scheme is 8 km south-east of the existing substation and hosts eleven boreholes of variable, but high yields of up to 120 m^3/h. The borehole depths are also variable and are up to 200 m bgl.

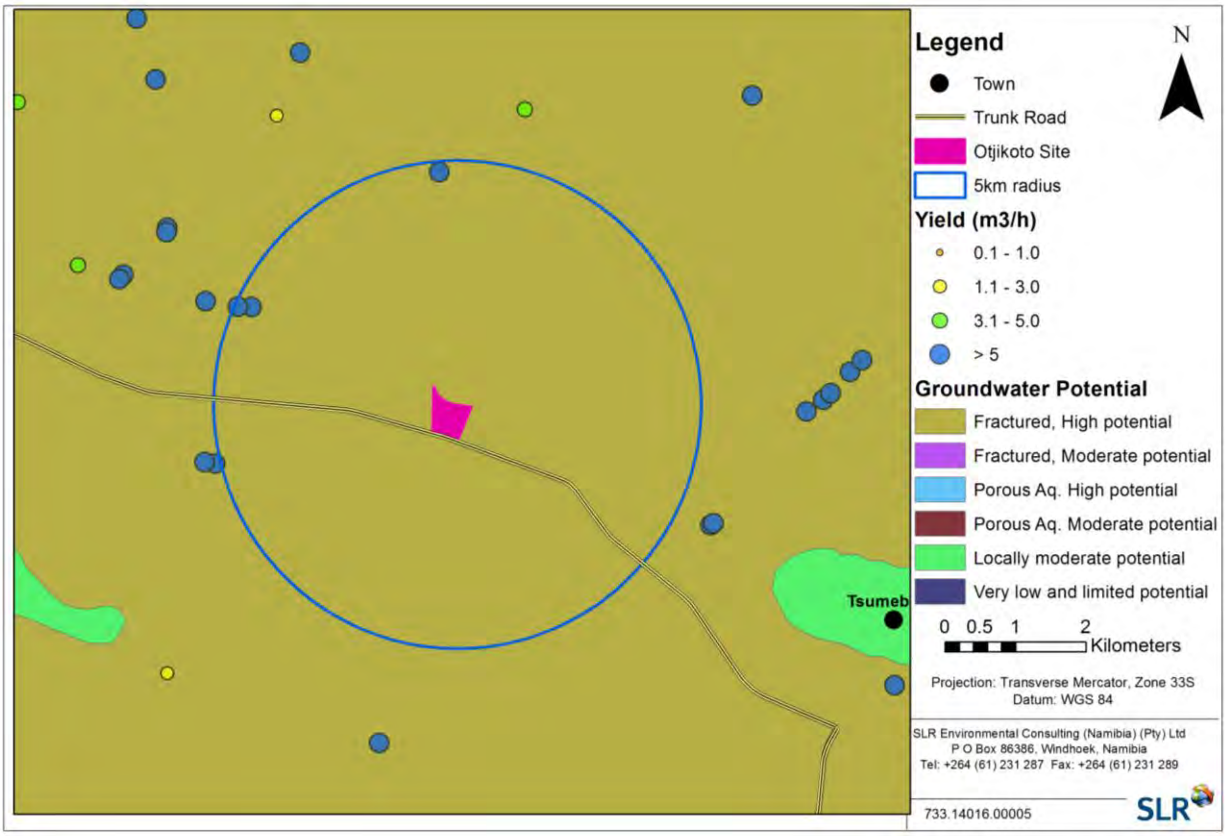


FIGURE 6-16: OTJIKOTO BIOMASS POWER STATION SITE: GROUNDWATER POTENTIAL WITHIN 5 KM RADIUS (SOURCE: CHRISTELIS & STRUCKMEIER, 2001 AND GROWAS, 2009)

6.5.2.4 *Groundwater Quality*

Water quality based on the Total Dissolved Solids (TDS) within the radius of 5 km is reported to be below 1,000 mg/l, (see Figure 6-17), which is classified as Ideal Standard in line with the Namibian Drinking water guidelines, National Water Resources Management Act, No 11 of 2013 and of Class A based on the Namibian Drinking Water Guideline of 1991. Locally, water quality may vary, but the planned water treatment plant will ensure the desired quality. A borehole water sample analysis from the Tsumeb Water Supply Scheme dated March 2016 shows Group B water quality due to elevated total hardness.

Water samples collected from nearby boreholes by the SLR Water Specialist Team (see Appendix 11) confirm that water is of Class B due to total hardness. This includes water from one of the boreholes at the NamPower substation. The results are given in Appendix 11. The lab results also show that the nitrate concentrations from the surrounding boreholes was of Class A, <10 mg/l. This validates that water quality based on TDS and nitrate is of very good quality.

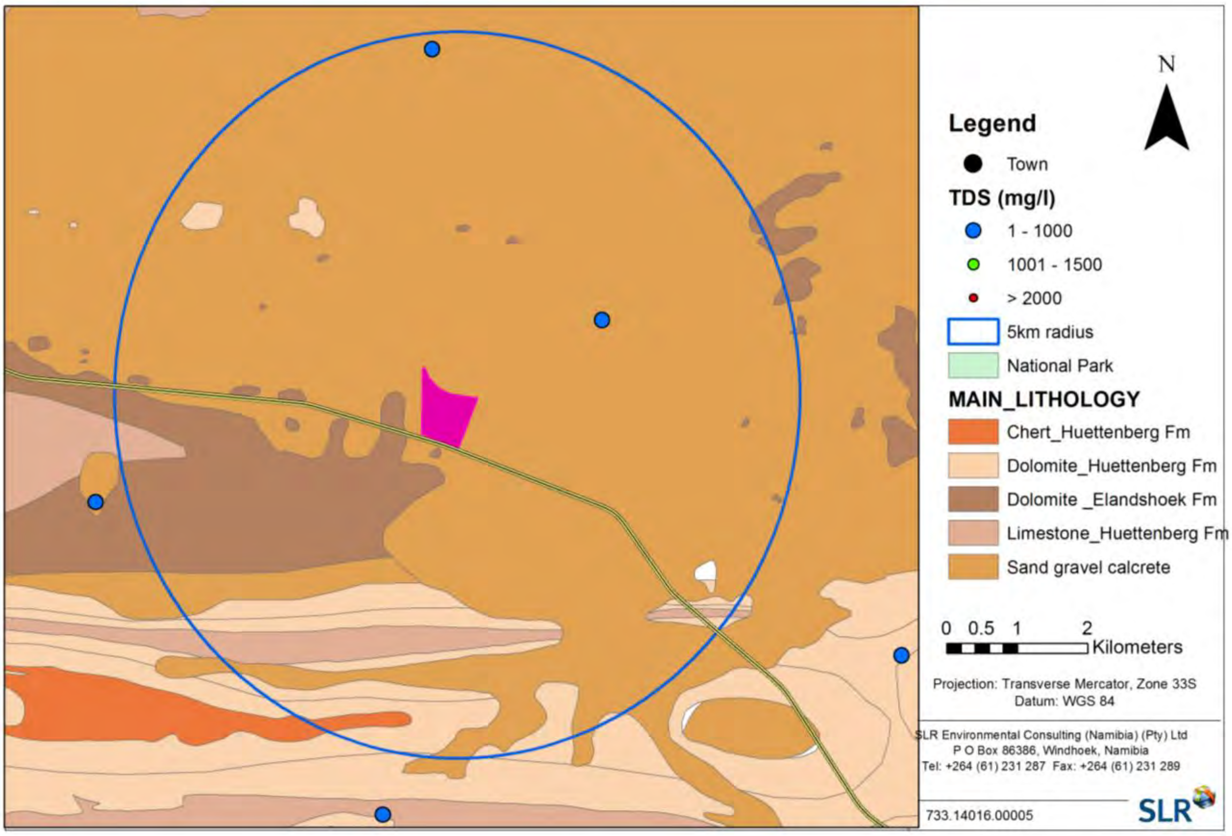


FIGURE 6-17: TOTAL DISSOLVED SOLIDS WITHIN A RADIUS OF 5KM FROM THE PROPOSED PLANT (SOURCE: CHRISTELIS & STRUCKMEIER, 2001 AND GROWAS, 2009)

6.5.3 Groundwater Baseline Relating to the Harvesting Area

6.5.3.1 *Groundwater Use Across the Harvest Area*

The major users are given in Figure 6-18 below. These include the Tsumeb municipality with 11 production boreholes (which is located approximately in the centre of the harvesting perimeter) and the Tsumeb smelter that abstracts water from the mine shaft 1. A few mines are found within the harvest boundary as indicated on the map. Mostly commercial farms are supplied by boreholes in the east of harvesting area. To the south-east and south the main towns/settlement are Grootfontein, Otjituuo and Kombat which are supplied through the water canal and the Waterberg pipeline. Land in the south to south west is still dominated by commercial farms which use groundwater as a main water supply source. The harvesting activities, as explained in the earlier section 4.4.2, is not expected to consume water and therefore there is no threat of competition with other existing water users outlined in Figure 6-18.

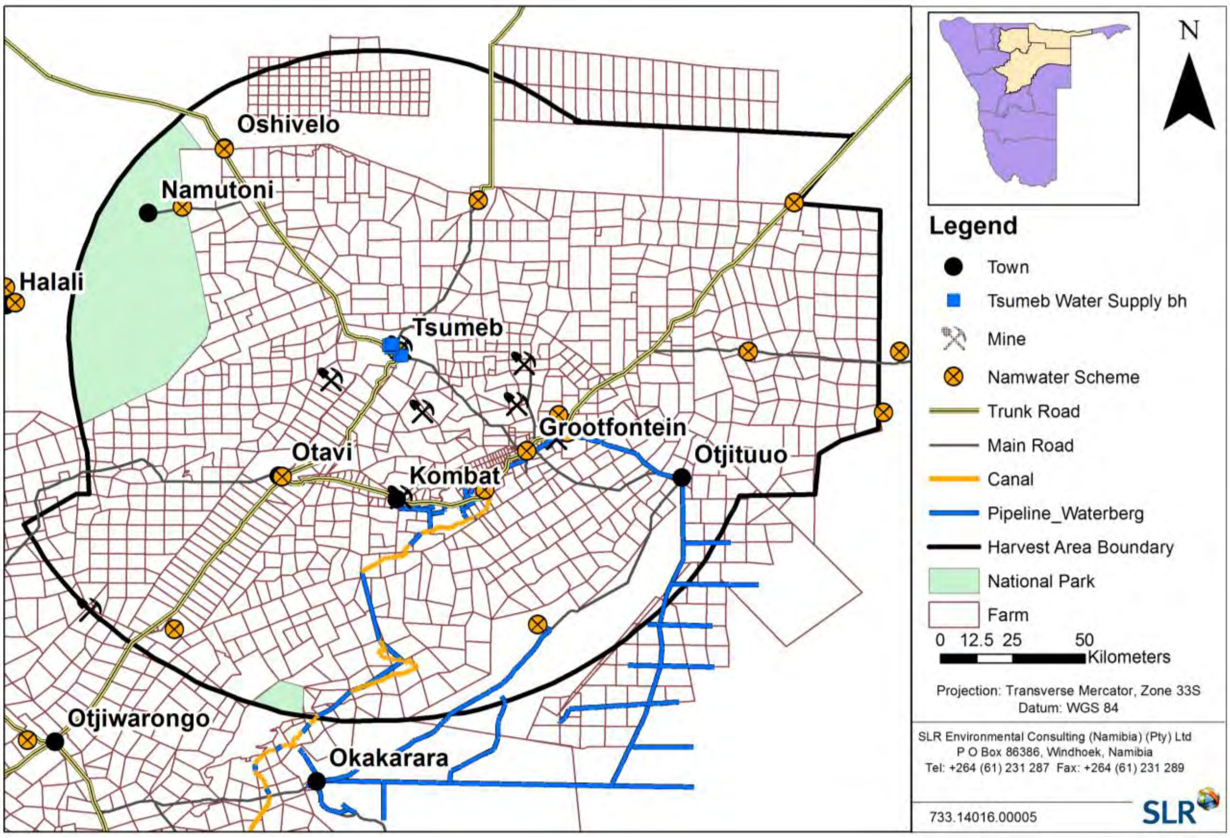


FIGURE 6-18: WATER USERS IN THE BUSH HARVESTING AREA (SOURCE: GROWAS, 2001)

6.5.3.2 *Hydrogeology and Groundwater Potential*

Tsumeb is part of what is known as the Otavi Mountain Land (OML). It is the northern platform for the Damara Orogenic Belt. Rocks found in the area are generally of the Otavi Group and Tsumeb Subgroup. The youngest rocks are those of the Kalahari Sequence which form surficial cover, thickening towards the north and north-west of Tsumeb, (SLR, 2016). The GKW & BICON (2001) study observed the Tsumeb dykes and SW-NE striking lineaments in the Tsumeb area covered by Kalahari sediments. Further N-S striking faults extending between 50 to 100 km, SE-NW striking faults with length of mostly 10 to 20 km in the OML, E-W faults with varying length of 10 to 80 km, while circular structures indicating karst appearances were found. These structures can be important water-bearing structures.

Across the harvesting area, the areas with high groundwater potential are mapped in the northern, central and south-west regions of the harvesting area (see Figure 6-19). The SLR Water Specialist Team observed the following:

- The northern end covering the settlement of Oshivelo and north-west of the harvest area is characterised by porous and fractured aquifers.
- The central region, around Tsumeb as well as the south and south-west of the study area, comprises moderate to high potential fractured and karstified aquifers. Some localised high potential karstified and fractured rocks are also represented to the south.
- Areas with moderate groundwater potential are found to the north-east, south-east and west of the harvesting area. The north-east is made up of porous aquifers; the west by fractured and fissured aquifers and the south-east is made up of rock bodies with locally moderate potential.
- The low groundwater potential is mapped to the south of the investigation area.

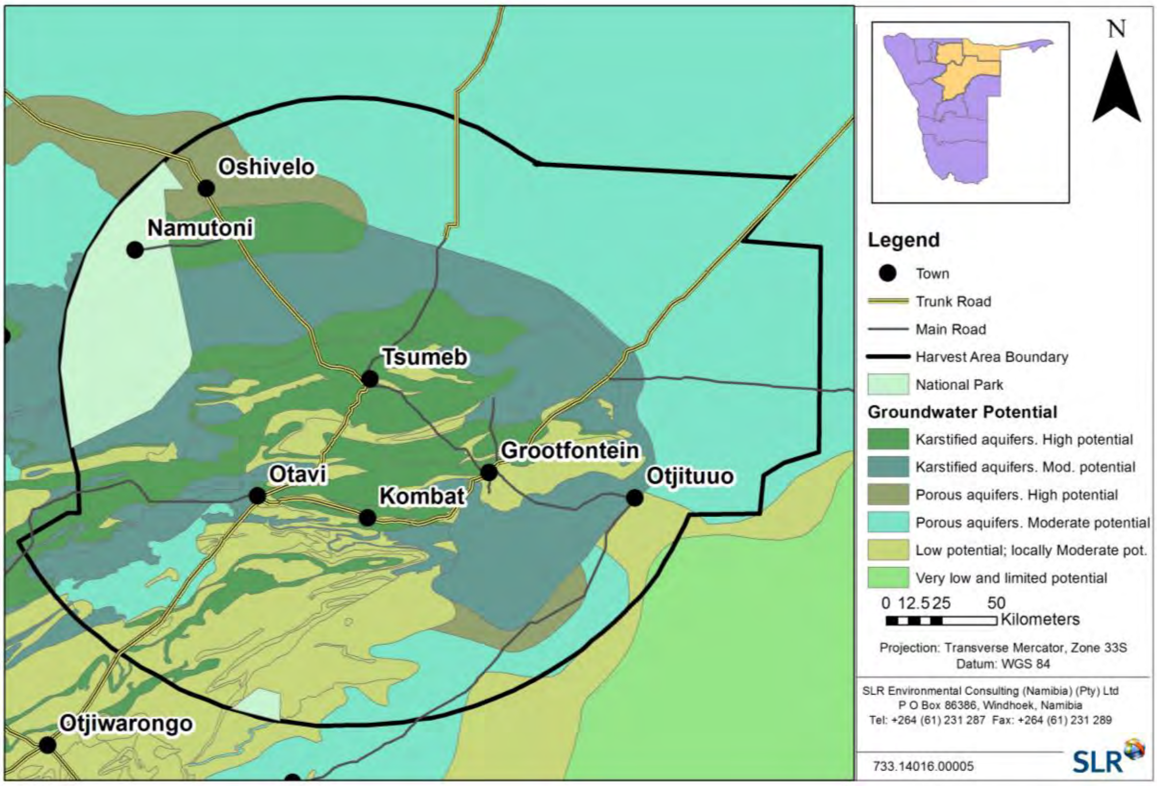


FIGURE 6-19: GROUNDWATER POTENTIAL MAP (SOURCE: HYMNAM 2001)

6.5.3.3 *Depth to Groundwater*

The root systems of the trees and bush, including the encroacher bush to be harvested, keep the groundwater levels down and the salt content low in the soil. Without these plants, the groundwater levels would rise along with the salt, in areas where the natural groundwater salinity is high. This in turn could affect the health of nearby streams, and ultimately affect the drinking water of animal and human populations.

The areas to the north of Tsumeb, extending into the Mangetti area, is mostly commercial farmland (refer to the green and light-yellow areas indicated in Figure 6-20 below. In these areas, the depth to groundwater is between approximated 0-30 mbgl. A similar trend may be expected in the areas of Grootfontein and Otjituuo to the south-east of the study area where the Rest Water Level (RWL) does not exceed 30 mbgl. The central part of the area, extending from Tsumeb to Kombat, has the deepest groundwater, with levels deeper than 80 mbgl, mostly due to the geological setup and high elevation of the highly permeable dolomite rocks, outcropping in that area, as seen in Figure 6-20. The map below shows extrapolated values. Some isolated figures may be found to differ on the ground.

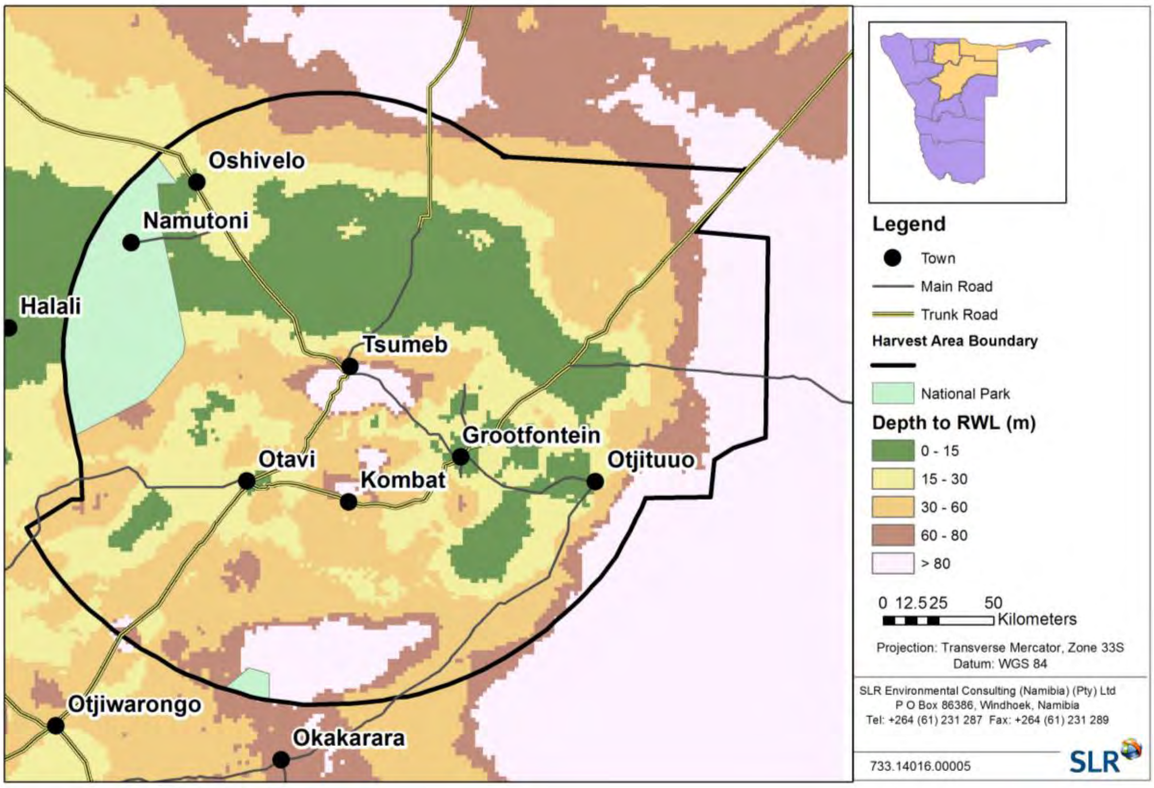


FIGURE 6-20: OTJIKOTO SITE: DEPTH TO GROUNDWATER (SOURCE: GROWAS, 2001)

6.5.3.4 *Borehole Yield*

The expected yield is illustrated in the Figure 6-21 below, reiterating that the area is of high groundwater potential. Many more boreholes are recorded to supply above 5m^3/h than those with lower yields. This further illustrates the yield required for the proposed Power Station has good potential to be met.

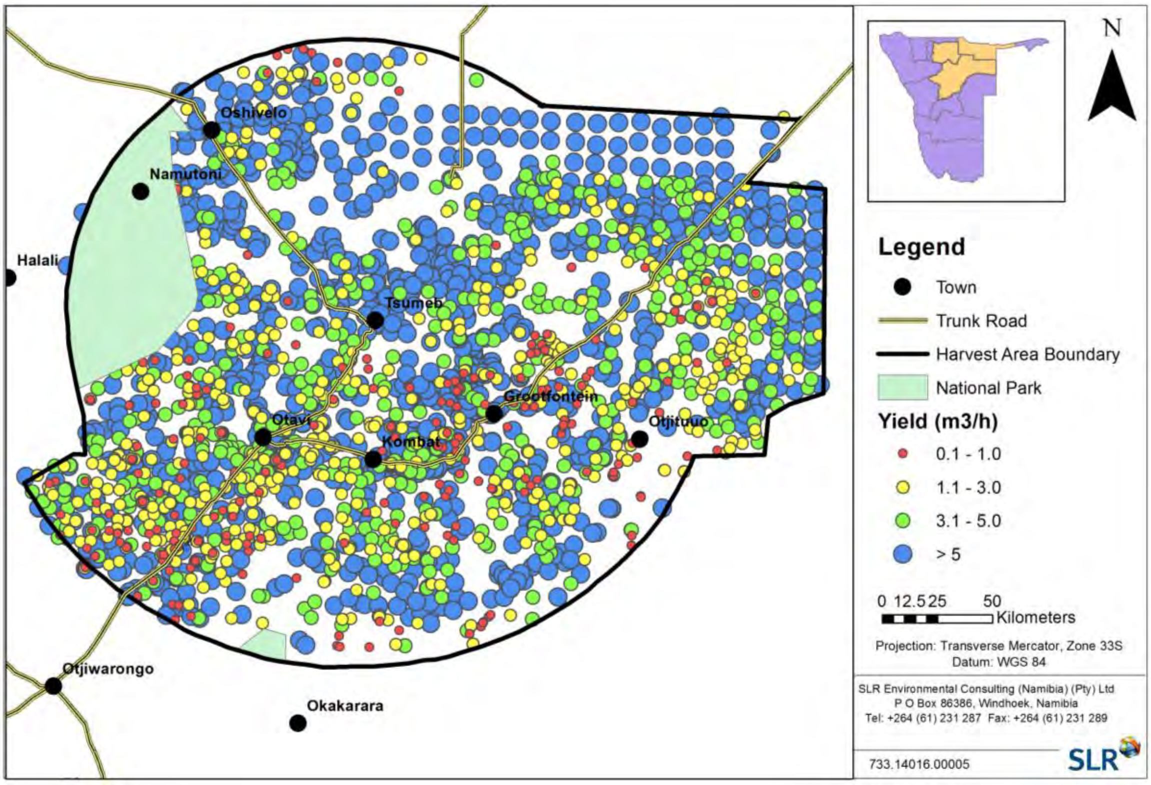


FIGURE 6-21: YIELD ACROSS THE HARVEST AREA (SOURCE: GROWAS, 2001)

6.5.3.5 *Groundwater Quality*

Within the harvesting area, the Total Dissolved Solids (TDS) on the largest scale is of acceptable and good water quality standards, as per Namibian Drinking Water Guideline of 1991. It is classified as good water quality fit for human consumption and livestock watering. A few locations however, have elevated, undesirable concentrations, e.g. the area east of Namutoni (see Figure 6-22 below).

The other concerning water quality parameter is the nitrate concentration. In the harvesting area, the Nitrate concentration, as per same guideline, is to a large extent within very good drinking water quality standards, with some isolated locations with elevated nitrate concentrations see Figure 6-23.

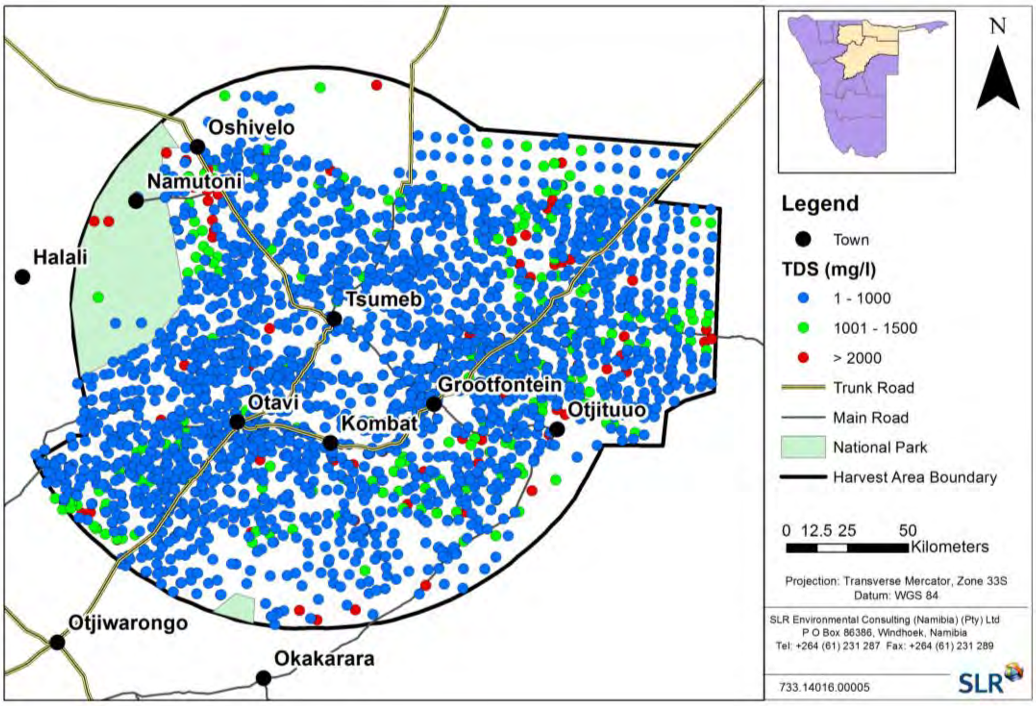


FIGURE 6-22: TOTAL DISSOLVED SOLIDS ACROSS THE HARVEST AREA (SOURCE: GROWAS, 2011)

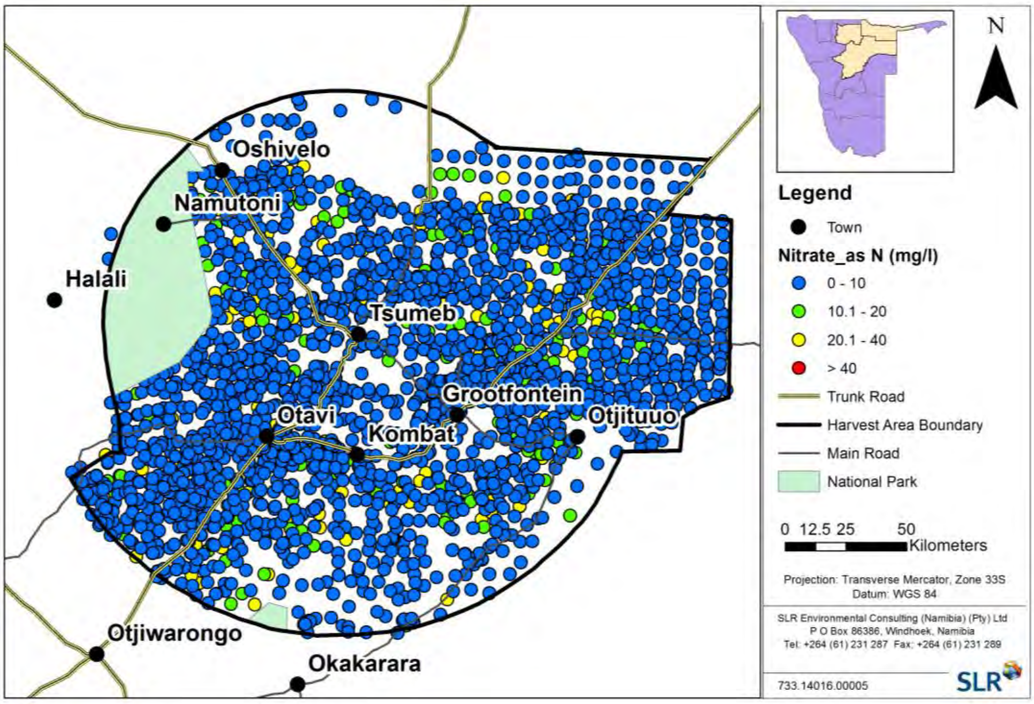


FIGURE 6-23: NITRATE CONCENTRATION ACROSS THE HARVEST AREA (SOURCE: GROWAS, 2011)

6.5.3.6 *Areas Sensitive to Groundwater Pollution by Harvesting Activities*

Combining the areas of high Nitrate (as N) and high TDS with the shallow depth to groundwater, the zones of sensitivity could be mapped. These areas are highlighted in Figure 6-24 below with maroon outlines. This is vital to indicate because bush harvesting in areas with shallow brackish groundwater is potentially at increasing the risk for soil salinization and increased nitrate concentrations in groundwater. The processes leading to potential groundwater and soils salinization due to bush harvesting are described in detail in the sections below.

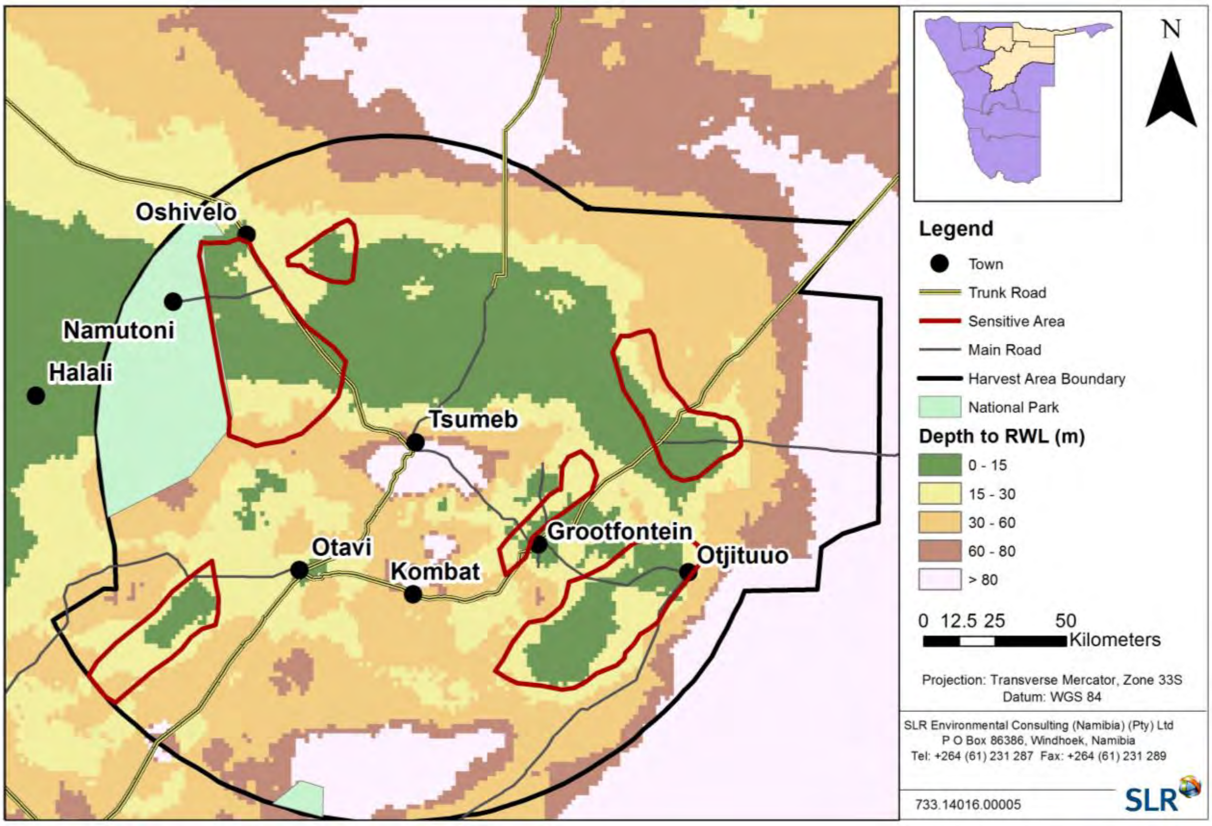


FIGURE 6-24: DEMARCATION OF AREAS OF SENSITIVITY BASED ON DEPTH TO GROUNDWATER, NITRATE AND TDS CONCENTRATIONS

6.6 SOIL BASELINE

The information in this section was sourced from the Soil Impact Assessment report (SLR, 2018C) included in Appendix 12.

6.6.1 Link to Anticipated Impacts

Potential impacts on the soils at the proposed plant site at Otjikoto and in potential harvesting areas are considered to include compaction and soil erosion and impacts on soil fertility. The severity of impacts is expected to depend on the soil properties of the area. This section provides a baseline assessment of chemical and physical soil properties within the areas climatic context and determine the pre-development agricultural potential and land capability.

6.6.2 Geology and Terrain

The Project area is largely underlain by Kalahari Group sands and calcrete-petrocalcic horizons in World Reference Base (WRB) terminology, Otavi limestones and dolomites as well as Damara Supergroup and Gariep Complex schists and dolomites (refer to Figure 6-25).

Three main sets of parent materials gave rise to present-day soils including the following:

- Kalahari sands, giving rise to present day Arenosols and Luvisols;
- Planed-down dolomite, limestone and schist (often capped by Petrocalcic material) of the plains landscapes, giving rise to the present day shallow Calcisols and Leptosols;
- The Otavi Mountains giving rise to deep or moderately deep red loams, the Cambisols, on the pediments and in valleys between the mountains and hills; and
- Fluvisols are found along the margins and flood plains of larger river courses.

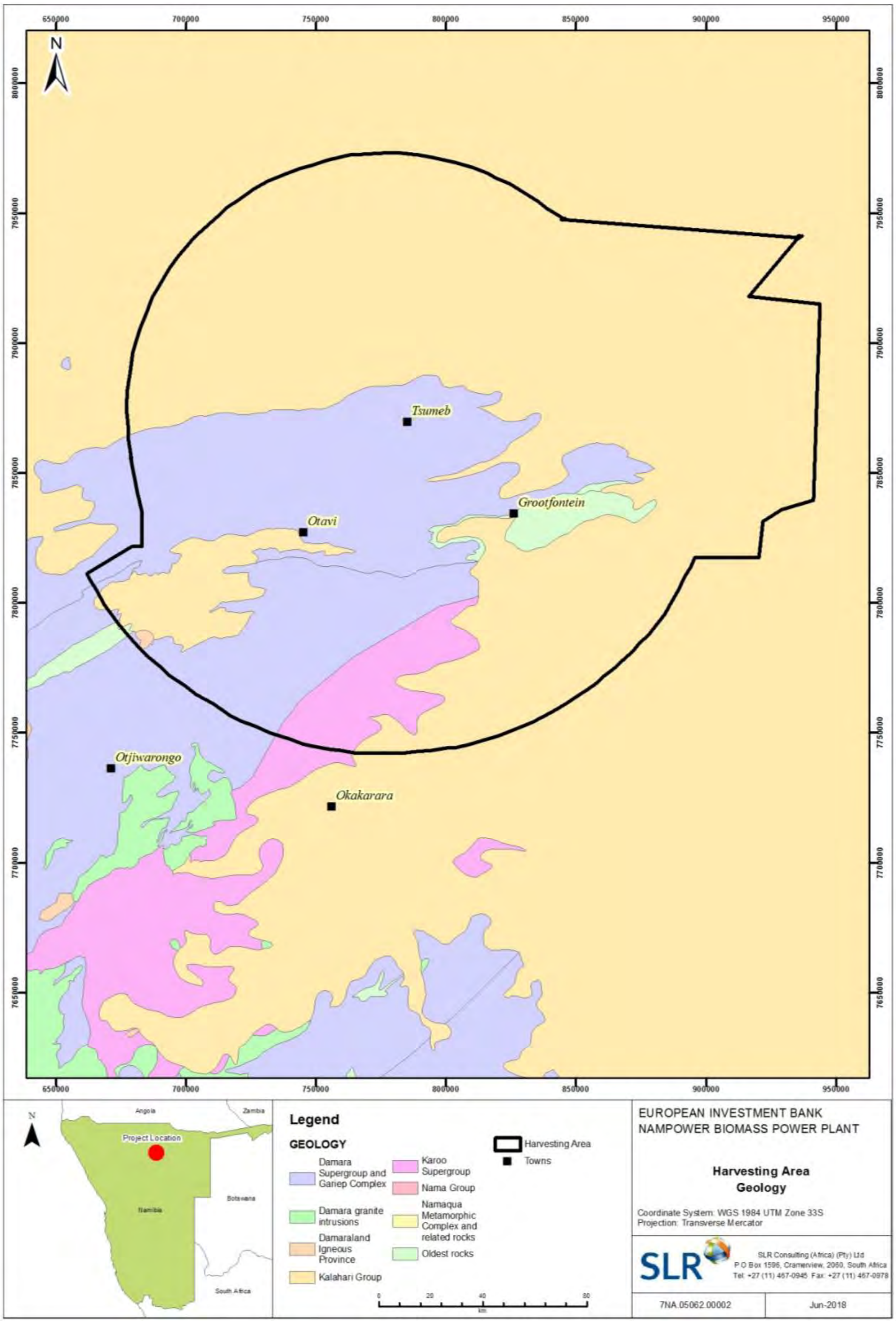


FIGURE 6-25: GEOLOGY (SOURCE: ACACIA, 2018)

6.6.3 Soils

6.6.3.1 *Spatial Distribution – Proposed Power Station Area*

The soil map of the proposed plant site is presented Figure 6-26, and the map units are defined in Table 6-8. The soils of the proposed plant site consist of shallow, grey to reddish brown, weakly structured, loamy textured A horizons, with or without very thin subsoils consisting of similar material, over a petrocalcic horizon (calcrete) or unweathered dolomite rock. Those underlain by a petrocalcic horizon were classified as Calcisols and those on dolomite rock as Cambisols.

TABLE 6-8: DESCRIPTION AND CLASSIFICATION OF THE SOILS OF THE PROPOSED PLANT SITE

Map unit	Abbreviated profile description	WRB Reference Soil Group with qualifiers
1	Dark grey-brown, calcareous, weak blocky, sandy clay loam A horizon, 10 cm thick over Petrocalcic C horizon	Petric Leptic Calcisol (Loamic)
2	Dark grey-brown, calcareous, weak blocky, sandy clay loam A horizon, 20 cm thick over Petrocalcic C horizon	Petric Leptic Calcisol (Loamic)
3	Dark reddish brown, weak blocky sandy clay loam A horizon, 30 cm thick over Petrocalcic C horizon or dolomite	Petric Calcisol/Dolomitic Cambisol (Loamic, Epilithic)

FIGURE 6-26: SOILS OF THE PROPOSED PLANT SITE

6.6.3.2 *Spatial Distribution – Harvesting Area*

The reconnaissance soil map units produced for the potential project harvesting area as well as the soil groups are indicated in Figure 6-27. The map units identified by the observations made during the site investigation, by the Soil Specialist Team, in the harvesting area are defined in Table 6-9.

TABLE 6-9: SOIL MAP UNITS AND LAND FORM OF THE PROPOSED HARVESTING AREA

SOIL GROUP	MAP UNIT	DOMINANT SOILS	ASSOCIATED SOILS	LAND FORM
ARENOSOLS	A1	Deep[1] red sands	As for dominant soils but yellow-brown	Level[2] plains
	A2	Deep yellow-brown sands	As for dominant soils but red	Level plains
	A3	Deep red or yellow sands	As for dominant soils but moderately deep on petrocalcic horizons (Calcisols) or on heavier textured subsoils (Luvisols)	Undulating plains with paleo dunes with gentle to moderate slopes
CAMBISOLS	B1	Deep red or brown loams	As for dominant soils but moderately deep on rock	Level or gentle footslopes
	B2	Moderately deep red or brown loams on rock	As for dominant soils but deep	Level or gentle footslopes
CALCISOLS	C1	Moderately deep or deep white or grey-brown, calcareous loams	As for dominant soils but with structured, sandy clay loam subsoils	Lower footslopes
	C2	Shallow or moderately deep dark or grey-brown calcareous loams on petrocalcic horizons	As for dominant soils but very shallow or on dolomite or limestone	Level or gently sloping plains

SOIL GROUP	MAP UNIT	DOMINANT SOILS	ASSOCIATED SOILS	LAND FORM
	C3	Very shallow grey-brown calcareous loamy sands on petrocalcic horizons; abundant exposed petrocalcic horizons or dolomite	As for dominant soils but shallow	Level or gently sloping plains
LUVISOLS	P	Moderately deep or deep grey-brown loamy sands over structured, calcareous, loam, sandy clay loam or sandy clay subsoils	As for dominant soils but with less clay and weaker structure in the subsoils	Level or gently sloping plains or footslopes
FLUVISOLS	F	Deep, grey-brown, stratified, calcareous, sands or loamy sands	Bottomland shoulders with shallow or moderately deep, grey-brown, calcareous, loams on petrocalcic horizons (Calcisols); Deep sands (Arenosols)	Level or gently sloping bottomlands
LEPTOSOLS	L1	Shallow red or brown loams on rock	As for dominant soils but moderately deep or on petrocalcic horizons (Calcisols)	Level or gently sloping plains or footslopes
	L2	Shallow red or brown loams on rock with	As for dominant soils but moderately deep	Gently to moderately sloping crests,

SOIL GROUP	MAP UNIT	DOMINANT SOILS	ASSOCIATED SOILS	LAND FORM
		common to many(3) rock outcrops		midslopes or footslopes
	L3	Shallow or very shallow red or brown loams on rock with abundant rock outcrops	As for dominant soils but with fewer rock outcrops	Steep hillslopes
(1) Soil depth classes:		[2]Land Form		
Deep ≥75 cm Moderately deep ≥25-75 cm Shallow ≤25 cm Very shallow ≤10 cm		Level land <2% slope Gently sloping land 2-5% slope Moderately sloping land 5-8% slope Steep hillslopes >8% slope Common to many outcrops <50% of surface area covered by rock Abundant outcrops >50% of surface area covered by rock		

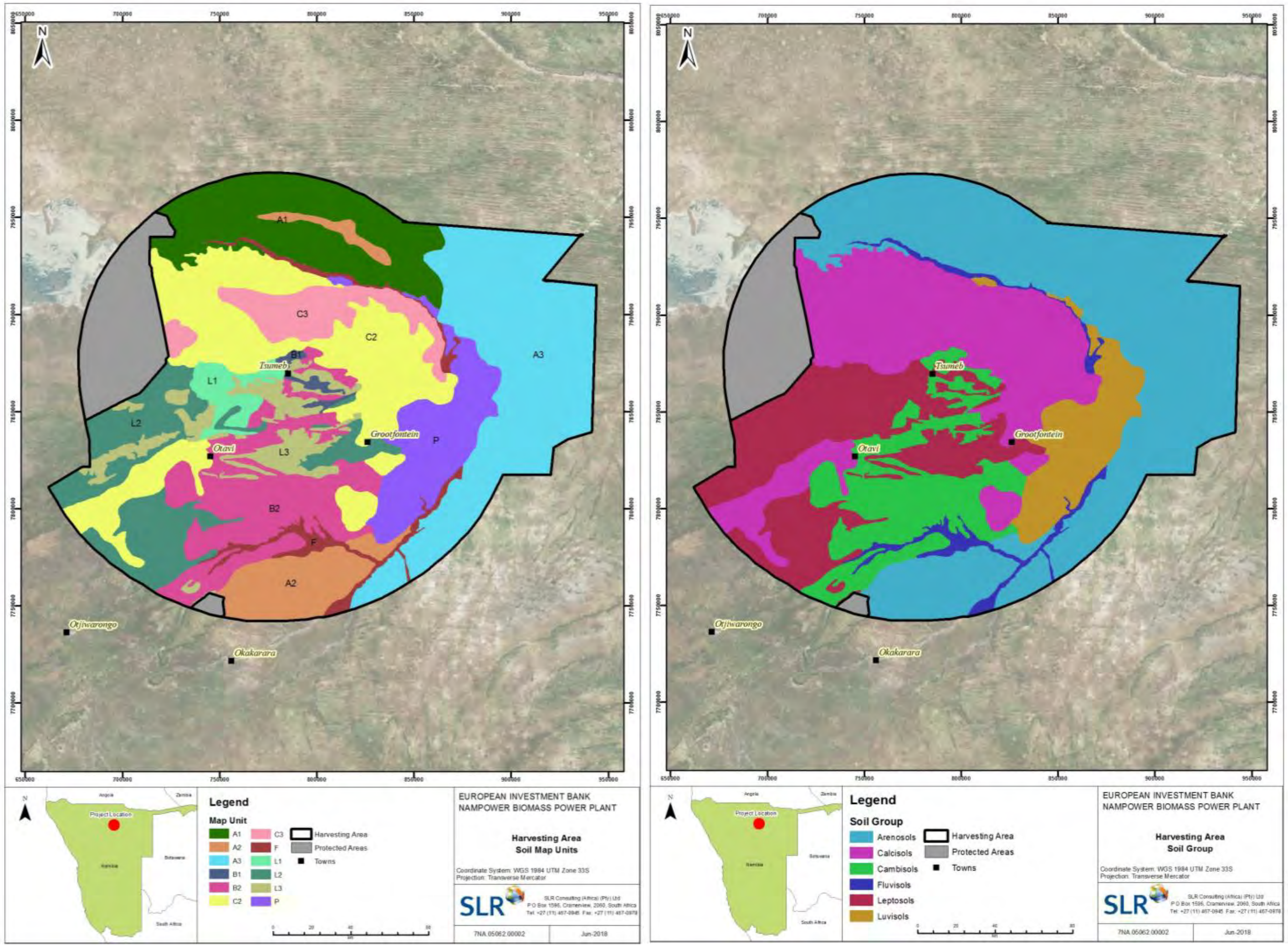


FIGURE 6-27: RECONNAISSANCE SOIL MAP OF THE POTENTIAL PROJECT HARVESTING AREA SHOWING SOIL MAP UNITS (LEFT) AND SOIL GROUPS (RIGHT)

6.6.4 SOIL MORPHOLOGICAL AND PHYSICAL CHARACTERISTICS

The soil resource base is largely composed of five main soil-landscapes as detailed below:

1. Deep red and yellow-brown sands in the east (map units A1, A2 and A3).
2. Moderately deep or deep red loams on pediments and valleys of the Otavi mountainous area (map units B1 and B2).
3. Shallow or very shallow grey-brown/dark grey-brown sandy loams or loams on Petrocalcic horizons (pdogenetic calcrete), dolomite or limestone on level or undulating plains.
4. Shallow red/reddish loams on undulating or irregular plains underlain by dolomite or schist (map units L1, L2 and L3) and
5. Greyish “luvic” soils with relatively sandy A horizons over loamy or sandy clayey B horizons (map unit P), probably associated with paleo drainage areas.

Each of these broad soil-landscapes have different chemical characteristics and land use/land capability options.

6.6.5 SOIL CHEMICAL PROPERTIES

During a field investigation, the Soil Specislists Team took various soil samples for laboratory analysis (refer to Appedix 12 for more detalis regarding the field investgation, sampling methodolgy, analytical data used to descirbe the chemical and soil fertility properties of the soils, etc.

6.6.5.1 *Chemical and Soil Fertility Properties*

6.6.5.1.1 Base Status

Extractable acidity was not detected in any of the samples analysed. This corresponds with the slightly to moderately alkaline pH values found. The soils can consequently be regarded as having a high base status (and being hypereutric in WRB terminology). The Calcisols are per definition oversaturated with bases. Sodium affected soils appear to be very rare. Only one Luvisol sample, F57B contained elevated sodium. The signs of sodicity could be noticed in the consistence of the particular soil in the field.

6.6.5.1.2 Salinity Status

All the samples are shown to be non-saline, i.e. with EC_e values below 200 mS/m.

6.6.5.1.3 Cation Ratios

The general trend found by the Soil Specialists is low potassium levels in relation to calcium, and to a lesser degree, magnesium. It is possible, however, that a knowledge gap exists as to how nutrient relationships in the soils under consideration affect the growth of the particular natural vegetation of the area. What follows below may thus have more relevance to arable agriculture than to natural veld.

<u>Arenosols</u>

With respect to the Arenosols, the cation ratios in the upper subsoils sampled tend to exhibit remarkably high variation. It is uncertain, however, how much of this may be due to sampling and analytical factors at the very low concentrations present in these sandy soils. The broad picture that emerges is that the excess of calcium (together with magnesium in places) and the relative deficiency of potassium that is noticeable in the other soil groups appear to be less severe in the Arenosols.

Luvisols and deep/moderately deep Cambisols

In these soils (perhaps the only rainfed arable soils of the study area as well as the country), potassium appears to be very low in relation to both calcium and magnesium.

Leptosols and shallow Cambisols

Also, in these soils, calcium concentrations are high or very high in relation to both magnesium and potassium.

Calcisols, shallow/moderately deep or deep

As can be expected, the Calcisols exhibit high calcium and moderately high magnesium but very low potassium.

In summary it can be stated that the soils are enriched with the bases calcium and magnesium, resulting in a high base status and slight to moderate alkalinity. They are generally non-sodic and non-saline but are low in potassium and phosphorus.

6.6.6 DERIVED SOIL PROPERTIES

Selected physical soil properties that are complex and impractical to measure on a routine basis were derived in a qualitative manner from soil survey data. The following is highlighted:

- rainwater infiltration is not a limitation but the water holding capacity is low in the shallower soils;
- the soils are well drained, and ponding is not to be expected;
- the sandy soils are particularly susceptible to wind erosion;
- all the soils are susceptible to compaction by heavy vehicular movement in the moist state; and
- there is a moderate potential for dustiness.

6.6.7 LAND CAPABILITY

The following land capability classes are defined:

- Land suited to cultivation:
  - Class I – Arable land with slight or no limitations.
  - Class II – Arable land with moderate limitations that reduce the choice of plants or require moderate conservation practices.
  - Class III – Arable land with severe limitations that reduce the choice of plants or require special conservation practices, or both.
  - Class IV - Marginally arable land with very severe limitations that restrict the choice of plants, require very careful management, or both.
- Land with limited use – generally not suited to cultivation
  - Class V – Non-arable land with little or no erosion hazard but have other limitations impractical to remove (wetness, stoniness, climatic constraints) that limit its use largely to pasture, range, woodland or wildlife food and cover.
  - Class VI – Land with severe limitations that render it generally unsuited to cultivation and limit its use largely to pasture and range, woodland or wildlife food and cover.
  - Class VII – Land with very severe limitations that render it unsuited to cultivation and that restrict its use largely to grazing, woodland or wildlife.

- Class VIII – Land with limitations that preclude its use for commercial plant production and restrict its use to recreation, wildlife, water supply or aesthetic purposes.

Table 6-10 shows the land capability class of each map unit, accompanied by what were considered as the main climatic and soil restraints with respect to rainfed plant growth and production. For ease of reference, abbreviated descriptions of the classes present in the project area are included in the Table (see Figure 6-28).

Rainfall and evaporation are the main climatic constraints placing a ceiling of Class III on all non-irrigated land in the project area. Major additional soil constraints are soil depth and excessive sandiness.

TABLE 6-10: LAND CAPABILITY

Map unit	Dominant soils	Key constraints for rainfed plant growth and production (expressed as a severity class rating)						Land capability class	Abbreviated class description
		Rainfall	Evaporation	Soil depth	Soil Texture	Slope	Chemical		
A1	Deep red sands	Mod	Severe	None	Severe	None	Low	VI	Non-arable – mod. grazing potential
A2	Deep yellow sands	Mod	Severe	None	Severe	None	Low	VI	Non-arable – mod. grazing potential
A3	Deep red or yellow sands	Mod	Severe	None	Severe	None	Low	VI	Non-arable – mod. grazing potential
B1	Deep red or brown loams	Mod	Severe	None-Low	None	None	Low	III	Arable – low to moderate potential
B2	Moderately deep red or brown loams on rock	Mod	Severe	Mod-Severe	None	None	Low	IV	Arable – marginal
C1	Moderately deep or deep white or grey-brown, calcareous loams	Mod	Severe	Low-Mod	None-Low	None	Low	IV	Arable – marginal
C2	Shallow or moderately deep dark or grey-brown calcareous loams on petrocalcic horizon or dolomite	Mod	Severe	Severe	Low	None	Low	VI	Non-arable – Mod. grazing potential
C3	Very shallow grey-brown calcareous loamy sands on petrocalcic horizons; abundant exposed	Mod	Severe	Very Severe	Low	None	Low	VII	Non-arable – Low to mod. grazing potential

Map unit	**Dominant soils**	**Key constraints for rainfed plant growth and production (expressed as a severity class rating)**						**Land capability class**	**Abbreviated class description**
	petrocalcic horizons or dolomite								
P	Moderately deep or deep grey-brown loamy sands over structured, calcareous, loam, sandy clay loam or sandy clay subsoils	Mod	Severe	Low-Mod	Low	None	Low	IV	Arable – marginal
F	Deep, grey-brown, stratified, calcareous, sands or loamy sands	Mod	Severe	None-Low	Severe	None	Low	V	Non-arable – sensitive land
L1	Shallow red or brown loams on rock	Mod	Severe	Severe	None	None	Low	VI	Non-arable – Mod. grazing potential
L2	Shallow red or brown loams on rock with rock outcrops[3]	Mod	Severe	Very severe	None	None-Low	Low	VII	Non-arable – Low to mod. grazing potential
L3	Shallow or very shallow red or brown loams on rock with abundant rock outcrops	Mod	Severe	Very severe	none	Very severe	Low	VIII	Wilderness land

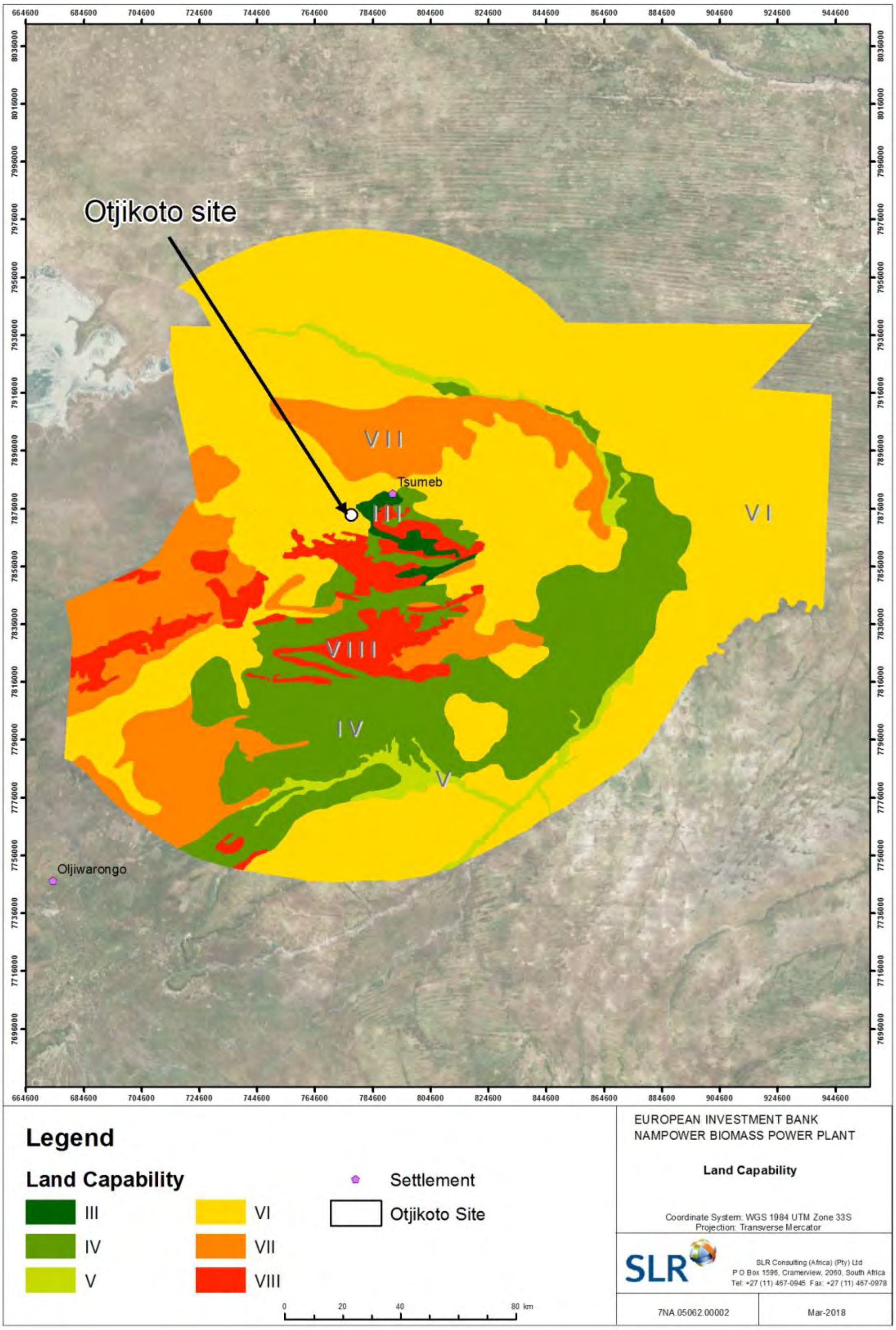


FIGURE 6-28: LAND CAPABILITY

6.6.8 ARABLE AGRICULTURAL POTENTIAL

Four map units are considered arable under rainfed conditions: B1 (low to moderate potential), B2 (marginal), C1 (marginal) and P (marginal).

of these, map units B1 and B2 were considered suitable for irrigation development in accordance with the Food and Agriculture Organization (FAO) system for rating the suitability of land for irrigation, depending on the availability of water. B1 being “Highly Suitable or displaying none to slightly limiting conditions” and B2 “Moderately Suitable or displaying slightly to moderately limiting conditions” or “Marginally Suitable or displaying moderately limiting conditions” (FAO, 1985).

6.7 BIODIVERSITY BASELINE

The information in this section was sourced from the Avifauna Impact Assessment report, the Invertebrates Baseline Study and the Vertebrate and Vegetation Baseline Study, Integration of all Biodiversity Components and Biodiversity Impact Assessment, included in Appendices 6.1 to 6.3 respectively.

6.7.1 Link to Anticipated Impacts

The development of the proposed Power Station and overhead power line could cumulatively cause physical destruction and general disturbance of vegetation, terrestrial fauna and birds of the site itself and its adjacent environments as a result of site clearing activities and the erection of a new overhead power line. The largest and longest-lasting impact on biodiversity will however most likely occur through the harvesting activities.

With reference to section 1.3, in addition to electricity generation and decreased reliance on fossil fuel, other environmental benefits may also be realised simultaneously, including rangeland restoration resulting in increased productivity, increased soil water recharge rates and benefits for biodiversity through increased structural plant heterogeneity. The guiding principles for harvesting, as well as the methods and management approach during and after harvesting will play the most important role in determining and mitigating the potential negative impacts on existing savanna structure, function and composition; and achieving the restoration of savanna function and productivity.

6.7.2 Introduction to Bush Encroachment

Bush encroachment is defined as the invasion and/or thickening of indigenous, aggressive, undesired woody species resulting in an imbalance of the grass: bush ratio and a concomitant reduction in grazing capacity (De Klerk, 2004; Ward, 2005). The ratio between woody and herbaceous plants further shape animal assemblages and habitats, thus biodiversity, and influences earth-atmosphere feedbacks (Scholes & Archer 1997; Sankaran et al. 2005). Bush encroachment also affects other ecological services to society negatively, including groundwater recharge, tourism, and biodiversity (Birch et al. 2016). Bush encroachment is therefore from society’s perspective an undesirable state of savanna vegetation, although a natural process at the patch scale (Wiegand et al. 2006). Globally, there has been a trend towards increased woody cover and density in savannas and grasslands (Joubert 2014). In Namibia an estimated 45 million hectares are currently affected to some degree by bush encroachment (SAIEA 2016).

Bush encroachment has been recognized as a rangeland problem in southern African for almost a century (O'Connor et al. 2015). In Namibia the perception is that bush encroachment dramatically accelerated during the late 1950s and early 1960s (Bester 1996 in Joubert 2014). Nevertheless, landscape scale bush encroachment has been documented as early as the 1850s in Namibia (Anderson 1856 in Joubert 2014), which challenges the perception that it is only a recent phenomenon.

6.7.3 Correlation between soil groups and vegetation zones

With reference to sections 6.6.2 and 6.6.3.2 (and Figure 6-27), three main soil groups are derived from three main parent material sources: shallow to deep Arenosols and Luvisols from sands of the Kalahari basin, shallow Calcisols and Leptosols from planed-down dolomite, limestone and schist of the plains landscapes and Cambisols from the Otavi Mountain limestone. The soil groups broadly follow the spatial distribution of their geological parent material and correlates at least partially with vegetation zones (Refer to Figure 6-29).

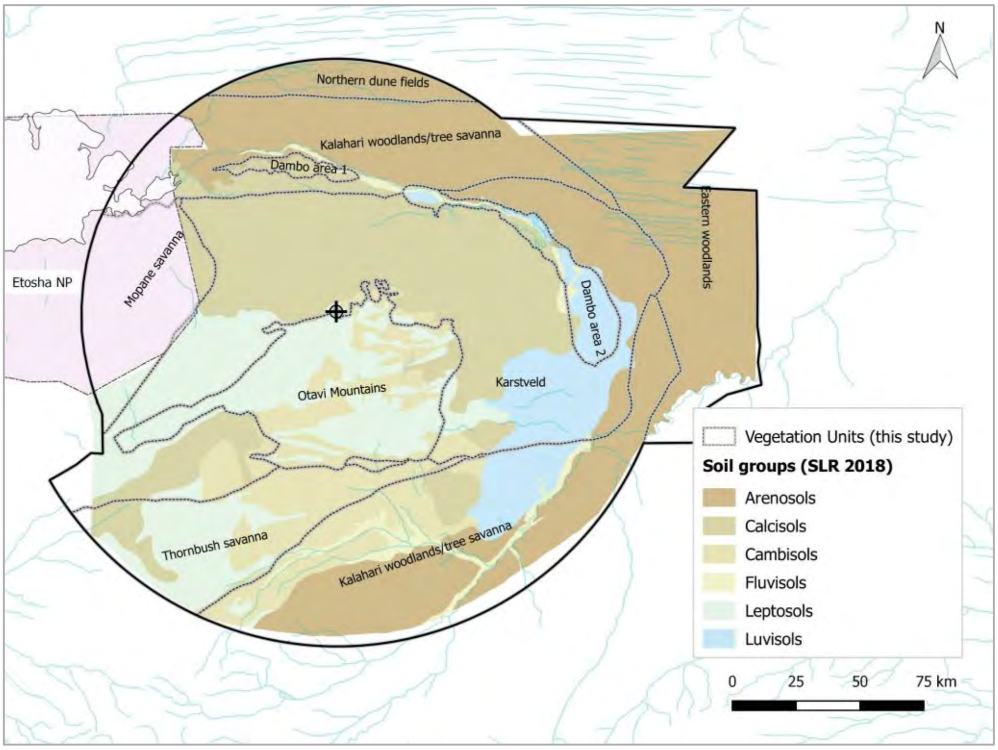


FIGURE 6-29: TWO SOIL CLASSIFICATIONS SHOWING REMARKABLE CONGRUENCE, BOTH OVERLAIN WITH THE VEGETATION TYPES

6.7.4 Biomes

The harvesting area, of which the Karstveld forms a large part, is part of the Savanna Biome of Irish, 1994 (Figure 6-30), where phanerophytes (woody perennials) and hemicryptophytes (perennials that die back in winter, such as grasses) are regarded as the dominant life forms, although in good rainy seasons therophytes (annuals) are also briefly abundant. This largely corresponds with the Tree-and-shrub Savanna Biome of Mendelsohn et al. (2002), who describe the vegetation type as mixed woodlands, with broadleaved woodland towards the north-east and Acacia woodland towards the south-east.

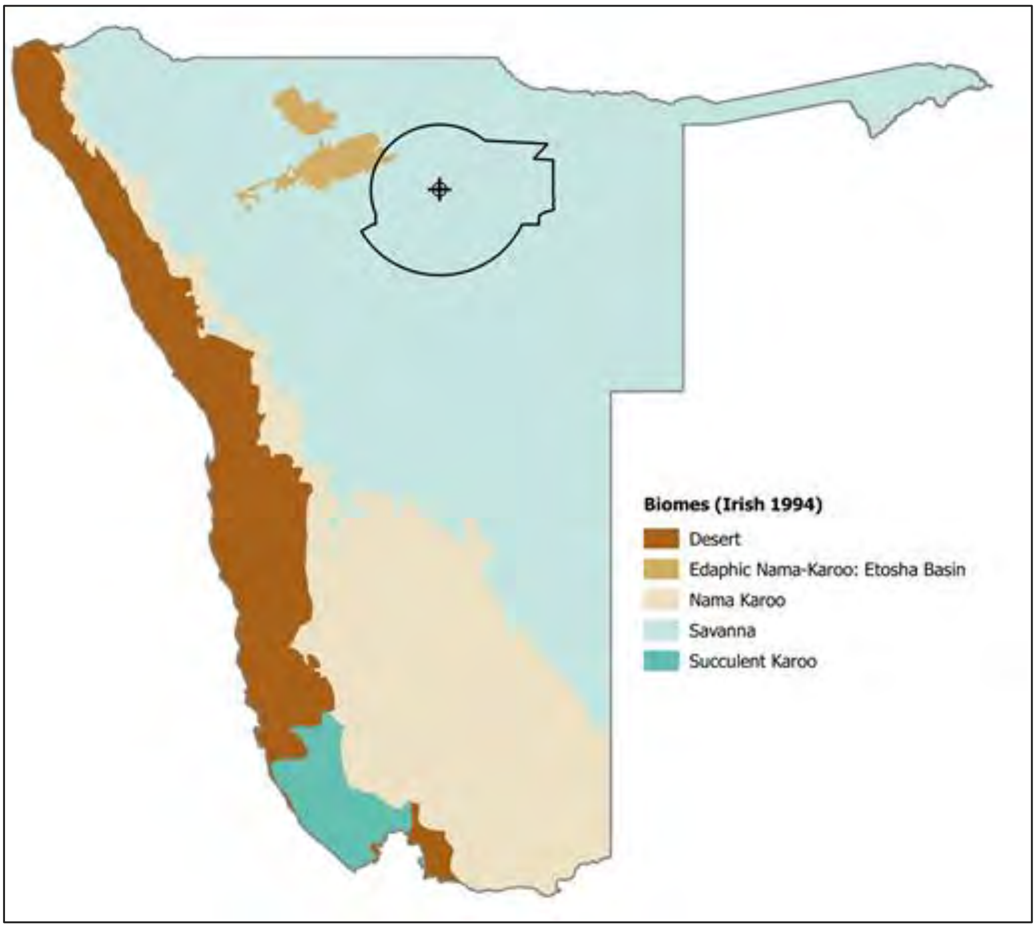


FIGURE 6-30: THE LOCATION OF THE HARVESTING AREA RELATIVE TO THE BIOMES OF NAMIBIA ACCORDING TO IRISH (1994)

6.7.5 Proximity to Protected Areas

The proposed Otjikoto Power Station site lies some 50 km east of the boundary of the Etosha National Park and about 100 km east of the Etosha Pan (Figure 6-31). It is 120 km north of the Waterberg Plateau Park. The Mangetti National Park is situated 145 km to the north-east. Several freehold conservancies lie to the south-east, within the harvesting area, bordered in turn by communal conservancies. Generally, the biodiversity in these conservation areas is relatively high, including of avifauna. The harvesting area adjoins all three of the above Parks.

The nearest Important Bird Area (IBA; Simmons, Boix-Hinzen, Barnes, Jarvis, Robertson 1998) is Etosha National Park, which is also classified as a Ramsar site (Wetland of International Importance; Kolberg undated) and home to around 340 bird species. The Waterberg Plateau Park is also an Important Bird Area (N008), with over 200 bird species. To the west, Lake Otjikoto and Lake Guinas are wetlands (large sinkhole lakes) that are considered to qualify for Ramsar status.

Biomass harvesting is not expected to take place within formally protected areas, nor within demarcated buffer zones around the Etosha National Park and Waterberg Plateau Park.

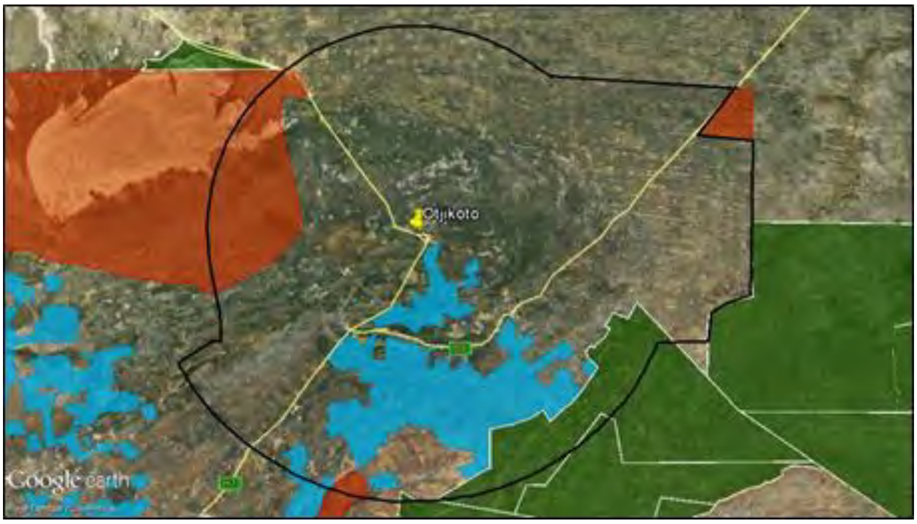


FIGURE 6-31: PROTECTED AREAS IN RELATION TO THE OTJIKOTO BIOMASS POWER STATION SITE AND HARVESTING AREA (RED= FORMALLY PROTECTED AREA; BLUE= FREEHOLD CONCERVANCIES; GREEN= COMMUNUAL CONCERVANCIES; GOOGLE EARTH MAP GENERATED BY THE EIS 2018).

6.7.6 General Diversity and Endism Patterns

Species lists for the harvesting and Power Station sites are provided in Appendix 6.1. The Otjikoto site and harvesting area tend to have a relatively high plant, reptile and mammal species richness, while moderate richness for amphibians. In terms of endemism, the Otjikoto site falls in an area of intermediate plant endemism, with relatively few endemic mammal and reptile species. In the harvesting area, plant and mammal endemism tend to be intermediate in the Otavi Mountain areas, which range south and southwest of the Otjikoto site, while low in the north-eastern parts of the harvesting area. Reptile endemism tend to be low throughout the study area.

6.7.7 Floristic Diversity, Endemism and Conservation Issues

The proposed site for the Power Station lies in a highly compromised and bush encroached area of the Tsumeb townlands, which falls within the Karstveld valley zone. A low number of protected trees occur here, and some endemic herbs are present, none of whose threat status will change as a result of the Power Station's construction activities.

Plant species diversity in the harvesting area is regarded as very high, at over 500 taxa (Mendelsohn *et al.* 2002). This may be ascribed in part to topographic/niche diversity and high rainfall. Endemicity is also high, which is consistent with the presence of the dolomite mountains and hills of the Otavi Highlands, which has also long been recognised as a centre of diversity and endemism within Namibia and includes several narrow endemic species (Maggs *et al.* 1998, Craven & Vorster 2006). In general, mountains are noted for their high diversity and endemism, because of higher niche diversity and the effect of altitude, which often results in zones of higher moisture availability and lower temperatures. The Otavi mountains importance as plant habitats is further underlined by the tendency for it to support relatively higher numbers of protected tree species.

6.7.8 Vertebrate Diversity, Endemism and Conservation Issues

6.7.8.1 *Amphibians*

A moderate number of amphibian species could potentially occur[9] at the Power Station site (14 species) and in the harvesting area (18 species). of these, no species are of conservation concern except the endemic *Poyntonophrynus damaranus* (Damara Pygmy Toad), which is a Data Deficient species (suspected but not definitely known to be endangered because of insufficient information and which potentially occur in the harvesting area. Another endemic species, *Poyntonophrynus dombensis* (Dombe Dwarf Toad), may also occur in the harvesting area. The Spotted Rubber Frog, *Phrynomantis affinis*, is a rare[10] species that may occur at both the Power Station site and in the harvesting area. No amphibian species are currently protected in Namibia.

6.7.8.2 *Reptiles*

The Power Station site (53 species) and harvesting area (72 species) has a relatively high potential reptile diversity, but low number of endemic species.

No Critically Endangered or Endangered category species occur at the Power Station or in the harvesting area. Three species classified as Vulnerable in Namibia (Griffins 2003) may potentially occur at the Power Station site and harvesting area, namely: *Psammobates oculiferus* (Serrated/Kalahari Tent Tortoise), *Python natalensis* (Southern African Python) and *Varanus albigularis* (Veld Leguaan). One species, *Psammophis jallae* (Jalla's Sand Snake), is considered Data Deficient. Endemic reptile species that potentially occur include: *Leptotyphlops labialis* (Damara Worm Snake), *Lygodactylus bradfieldi* (Namibian Dwarf Gecko), *Cordylus jordani* (Namibian Girdled Lizard; only parts of harvesting area), *Naja nigricollis nigricincta* (Western Spitting Cobra; only parts of harvesting area), *Prosymna frontalis* (Southwestern Shovel-snout Snake; only parts of harvesting area) and *Psammophis leopardinus* (Leopard Whip Snake; only parts of harvesting area). Four reptile species that potentially occur in the harvesting area are protected in Namibia.

6.7.8.3 *Mammals*

Mammal species richness at the Power Station site (73 species) and harvesting area (102 species) are high. A relatively large number of mammal species of conservation concern potentially occur at the Power Station site and in the harvesting area. One Critically Endangered (IUCN) species, *Diceros*

[9] The likelihood of finding a species of any taxon (vertebrate and invertebrate) in a particular area is a complex function of a range of factors from their specific habitat requirements (which might be univerasal or highly specialised), through climatic variation, to their specific population biology and abundance (abundant species tend to be found everywhere, rare species are seldom found). In this report, "potentially occurring" means that their distribution ranges overlap with the particular area, but does not imply that their habitat requirements will be met on the area.

When referring to the Power Station site itself, the available habitat is relatively simple and uniform, hence only a portion of these species could ever be found there. Additionally, with the Power Station site being fenced, much of the surrounding habitat disturbed in some way and a lot of human activity all around, it is highly unlikely that any of the larger mammal or reptile species would ever occur here, regardless of their theoretical distribution ranges.

When referring to the larger harvesting area, the chances are high that the habitat requirements of all these species will be met at least once, but their population biology and climatic variation will still influence this. A lack of good data on all species' habitat requirements prevents a very deep analysis of their chances of occurring on any given site. With the principal aim here being a categorisation of the sensitivity of areas, we therefore stick to these broad categories of potential occurrence, especially for the larger harvesting area.

[10] "Rare" means a taxon with small populations which are not presently endangered but are potentially at risk.

bicornis (Black Rhino), occurs in the harvesting area and one Endangered species potentially occur in the harvesting area, namely *Lycaon pictus* (Wild Dog). At the Power Station site and harvesting area eight mammal species are considered Vulnerable (IUCN), namely *Acinonyx jubatus* (Cheetah), *Felis nigripes* (Black-footed Cat), *Giraffa camelopardalis* (Giraffe), *Panthera pardus* (Leopard), *Smutsia temminckii* (Pangolin), *Equus zebra* (Hartmann's Mountain Zebra), *Loxodonta africana* (Elephant) and *Panthera leo* (Lion). Near threatened species include: *Ceratotherium simum* (White Rhino), *Hipposideros vittatus* (Commerson's Leaf-nosed Bat), *Parahyaena brunnea* (Brown Hyaena) and *Equus quagga* (Plains Zebra). No rare mammal species are expected at either site or in the harvesting area. Only one endemic mammal species is expected at the Power Station site, *Elephantulus intufi* (Bushveld Sengi). Three endemic species potentially occur in the harvesting area, namely *Equus zebra* (Mountain Zebra), *Herpestes flavescens* (Kaokoveld Slender Mongoose) and *Petromus typicus* (Dassie Rat), but none of them are expected at the Power Station site. A large number of locally protected species potentially occur at the Power Station site (20 species) and in the harvesting area (27 species).

6.7.9 Invertebrates

A minimum of 550 invertebrate taxa have been recorded from the study area in the literature by the Invertebrates Specialist (Dr. Irish) (refer to Appendix 6.3).

A field study conducted by Dr. Irish consisted of a preservative pitfall trapping survey. Two sites were subjected to detailed sampling. At each site, two separate trap lines were set out, one in an area that is currently suffering from bush encroachment, and one in a proximate area where bush clearing had been done. The first site, Otjikoto substation, was chosen for its proximity to the proposed Power Station site. It included both currently bush encroached and previously cleared areas. A second was the farm Kakuse 300. The encroaching species was different at each site, as was the bush clearing method used. Refer to Figure 6-32 for the location of the two sample sites.

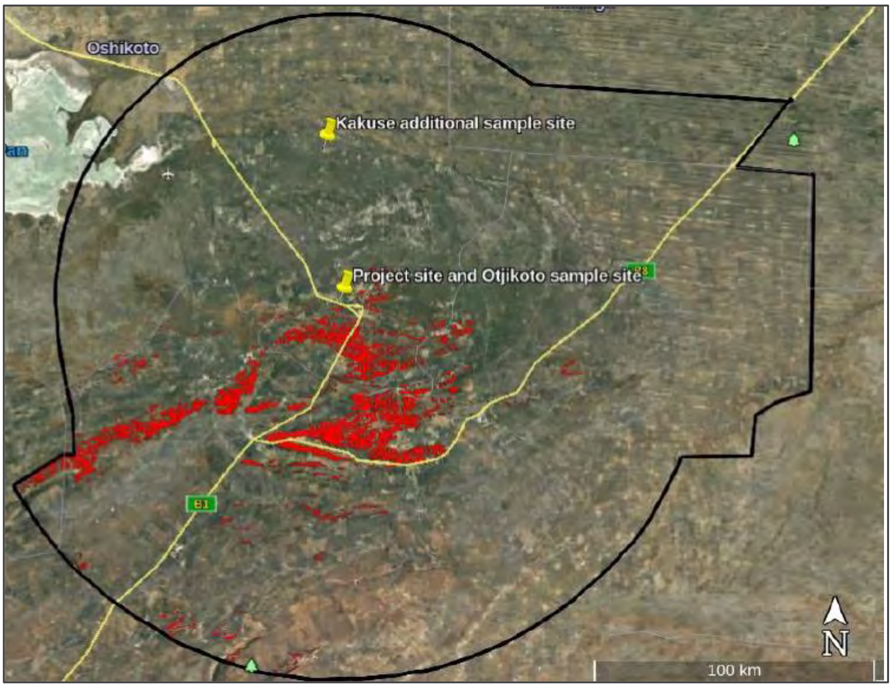


FIGURE 6-32: LOCATION OF PROJECT SITE AND TWO SAMPLE SITES WITHIN THE PROPOSED HARVESTING AREA

A total of 6690 individuals belonging to 107 taxa were recorded. Refer to Appendix 6.3 for detailed results.

Table 6-11 lists some standard ecological indices, based on the pit trap results at each site. The Shannon Index, that measures general biodiversity, indicates higher biodiversity at Kakuse than at Otjikoto. At both sites, biodiversity is higher at the cleared than the encroached area. The reciprocal Evenness and Dominance indices measure the ecological 'health' of that biodiversity, with both higher Evenness and lower Dominance indices indicating relatively better functioning ecosystems. The Evenness Index is higher, and the Dominance Index lower, at Kakuse compared to Otjikoto, suggesting a 'healthier' situation at Kakuse. This is mirrored in the absolute values, with higher Evenness and lower Dominance values at Kakuse.

TABLE 6-11: ECOLOGICAL INDICES FOR EACH TRAP LINE.

	Otjikoto, cleared	Otjikoto, encroached	Kakuse, cleared	Kakuse encroached
Shannon Index	0.4952	0.3655	1.1488	0.9331
Evenness Index	0.2742	0.2110	0.6728	0.5906
Dominance Index	0.5959	0.7351	0.1905	0.2239

It is possible that the generally more positive values for Kakuse compared to Otjikoto might have a biogeographical basis, in that background biodiversity might be inherently different at the two sites, therefore similarity indices were calculated to test this. In a case of different background biodiversity, both trap lines at each site would be expected to be more similar to each other than to any line at the other site. Table 6-12 shows that the two trap lines at Otjikoto are indeed more similar to each other than to those at Kakuse. However, the encroached Kakuse line is actually more similar to either of the Otjikoto lines than to the adjacent cleared Kakuse line, while the cleared Kakuse line is about as similar to the encroached Otjikoto line than to the adjacent encroached Kakuse line. The implication is that there is no inherent difference in background biodiversity at the two sites, hence differences between the sites are likely to be attributable to the different bush clearing methods used.

TABLE 6-12: SIMILARITY INDICES FOR EACH PAIR OF TRAP LINES.

	Otjikoto, cleared	Otjikoto, encroached	Kakuse, cleared
Otjikoto, encroached	0.64	-	-
Kakuse, cleared	0.40	0.46	-
Kakuse, encroached	0.53	0.57	0.47

6.7.10 Avifauna

6.7.10.1 *Avifaunal Environment and Habitats and Their Sensitivities*

6.7.10.1.1 Rivers and Other Water Bodies

Ephemeral rivers, drainage lines and pans (refer to section 6.4) are regarded as sensitive habitats in terms of birds, with large trees and bush that provide habitat for perching, roosting, nesting and foraging. In particular, large trees may be used as nesting sites by vultures and other raptors, as well as for cavity breeders. These watercourses may also serve as movement corridors for birds, including migrant species; bird diversity is likely to increase for the short periods that the rivers do hold water. Small dams and irrigation facilities may also attract birds. Biomass harvesting is however not expected to take place along (ephemeral) watercourses.

6.7.10.1.2 Mountainous Areas

The Otavi Mountains to the south and south-west of the biomass plant site are a major topographical feature within the harvesting area. Areas with a slope of more than 12.5° are indicated in Figure 4.2.

Mountainous areas with cliffs are also regarded as a sensitive habitat in terms of avifauna, providing a nesting and feeding habitat for groups such as eagles and other raptors, as well as other birds. Rocky outcrops and hillsides are also the preferred habitat of species that include several Namibian near-endemics, such as Monteiro's Hornbill, Hartlaub's Spurfowl and Rockrunner. Biomass harvesting is however not expected to take place in mountainous or rocky areas, and not on steep gradients (slopes of more than 12.5°).

6.7.10.2 *Sensitivities in Terms of Bird Species*

Sensitivities of the bird species at the Power Station site and in the surrounding harvesting area are discussed below, according to relevant criteria.

6.7.10.2.1 Biomass Power Station Site, Including Power Line

The checklist for determining the sensitivities of the bird species at the Biomass Power Station site is based on the species recorded for the larger Quarter Degree Square (QDS) in which the plant site falls.

Note that risk assessment and mitigation efforts are directed towards those species that have a high biological significance, i.e. primarily Red Data and/or species endemic or near-endemic to Namibia, as well as Red Data species with migrant status. Factors such as general and local abundance, habitat preferences and breeding sites, and sensitivities to disturbance/habitat destruction, and in terms of power line interactions, were used to determine the potential sensitivity of these priority species to impacts from the construction of the Power Station site and power line.

Bird Species Diversity

A total of 155 bird species have been recorded for the larger Quarter Degree Square (QDS) in which the biomass plant site falls. This number represents 23% of the 676 species currently recorded in Namibia (Brown *et al*. 2017), a diversity that is regarded as relatively moderate.

Although at least 25 bird species were identified at the Otjikoto Substation site during the field trip, the combined Southern African Bird Atlas Project (SABAP) data (SABAP1 = 153 species and SABAP2 = 28 species) provide a more comprehensive reflection of bird diversity in the greater QDS area.

Red Data Status

For the plant site, these Red-listed species are as follows:

- Martial Eagle (Endangered, also Globally Vulnerable)
- Tawny Eagle (Endangered)
- Booted Eagle (Endangered)
- Red-footed Falcon (Near Threatened, also Globally Near Threatened)
- Black-necked Grebe (Near Threatened)

It should be noted that large birds that collide with power lines, such as raptors (and flamingos and bustards), have recently been identified as one of four major groups of Threatened birds in Namibia (Simmons *et al*. 2015).

Endemism

Three of the species identified are near-endemic to Namibia and of potential conservation concern as more than 90% of the population occurs in this country, these are:

- Damara Red-billed Hornbill;
- Bare-cheeked Babbler; and
- Carp's Tit.

Although the abundance of the above near-endemic species varies, none are specifically confined to the Otjikoto plant site area. Damara Red-billed Hornbill was described only relatively recently (being differentiated from Red-billed Hornbill), with no SABAP1 records, but its occurrence in the area has been confirmed (Simmons *et al*. 2015).

A further 24 species are endemic or near-endemic to Southern Africa. These species are considered of lower conservation concern as their populations occur in a wider area.

The level of endemism in the plant site area is considered as relatively low-moderate.

Residency and Abundance

of the above eight priority species i.e. Red Data species and near-endemic, Booted Eagle is a migrant (with populations of both breeding intra-Africa migrants and non-breeding Palearctic migrants) and Red-footed Falcon is a non-breeding Palearctic migrant. The other species are all resident, apart from Black-necked Grebe which is highly nomadic. Nomadic/migrant habits result in high mobility and consequently increase the risk of impacts such as collisions on overhead structures.

Apart from Damara Red-billed Hornbill, all the priority species are rated as rare in the plant site QDS (mainly <20% reporting rates for the SABAP1 QDS, with no recent confirmations for the SABAP2 pentad). Damara Red-billed Hornbill was described only relatively recently and occur in the plant site area where it is rare-uncommon (Simmons *et al*. 2015).

Sensitivity to Power Line Interactions

Bird species may be sensitive, in varying degrees, to power line impacts such as disturbance/habitat destruction, collisions and/or electrocutions. The incidence of Red Data power line-sensitive bird species per QDS for the biomass plant site and surrounding QDSs is shown in Figure 6-33. This sensitivity is regarded as relatively moderate. It is however likely that the incidents observed are an under-estimate.

Most of the incidents (mainly collisions [89%], but also electrocutions [11%]) recorded in north-eastern Namibia to date on record have involved Flamingos (40%) and Korhaans (28%); a further 11% have involved raptors, mainly Vultures as well as Eagles, Snake-eagles and Owls; and 12% have involved other water birds. Existing power lines in the vicinity of the Otjikoto Substation would add to the cumulative effects of this impact.

of the above eight priority species for the study area, at least six are considered sensitive in terms of potential power line interactions (mainly collisions but also electrocutions), namely Martial Eagle, Tawny Eagle, Booted Eagle, Red-footed Falcon, Black-necked Grebe and Damara Red-billed Hornbill.

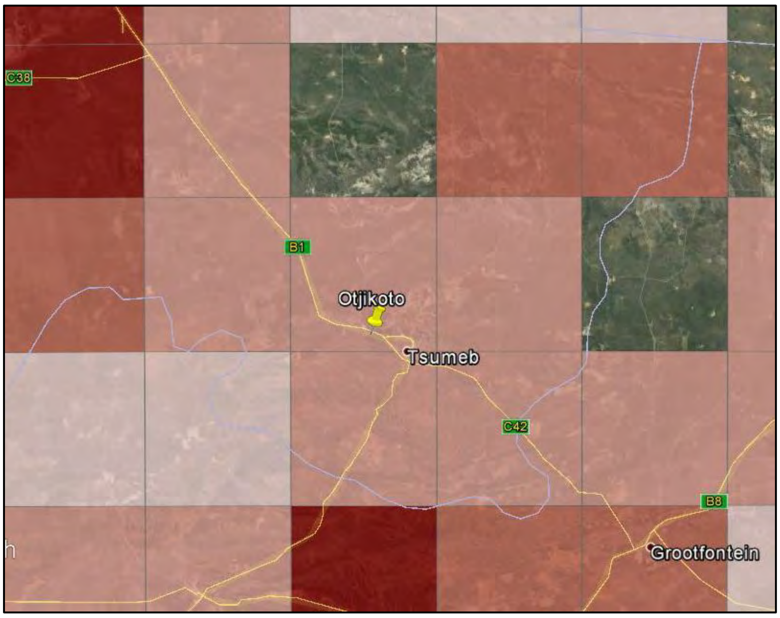


FIGURE 6-33: RELATIVE OCCURRENCE OF POWER LINE-SENSITIVE RED DATA SPECIES IN THE OTJIKOTO POWER STATION SITE AREA (RANGE OF SENSITIVITY FROM HIGH [DARK] TO LOW [LIGHT]; (ECS, 2018).

6.7.10.2.2 Harvesting Area

The sensitivity of the bird species in the harvesting area was based on priority species identified in the 77 Quarter Degree Squares (QDSs) represented in this area.

The potential sensitivity of the priority species to impacts from harvesting activities was determined on the basis of factors such as general and local abundance; habitat preferences and breeding sites; and sensitivities regarding disturbance (especially when breeding; and including poaching) and habitat destruction, and road mortalities.

Bird Species Diversity and Priority Species

Bird species diversity within the harvesting area ranges from >230 species per Quarter Degree Square (QDS) in the west to 81-110 species per QDS in the east (Mendelsohn *et al*. 2002; Figure 6-34). This diversity is considered relatively high, especially in the western parts of the area where the diversity is amongst the highest recorded for Namibia.

A total of 15 priority bird species have been identified for the harvesting area (based primarily on SABAP1 records for 77 QDSs in the area). The above species are regarded as a high priority, based largely on wider distribution rates and/or on status as breeding birds. These species are the focus of further consideration below.

A further 15 species are regarded as of lower priority and at very low risk to harvesting activities (see Appendix 6.2), due to very low distribution rates and/or non-breeding status (or breeding in habitats that will not be harvested).

Thirteen more largely aquatic priority species were also identified but considered at very low/no risk to harvesting activities.

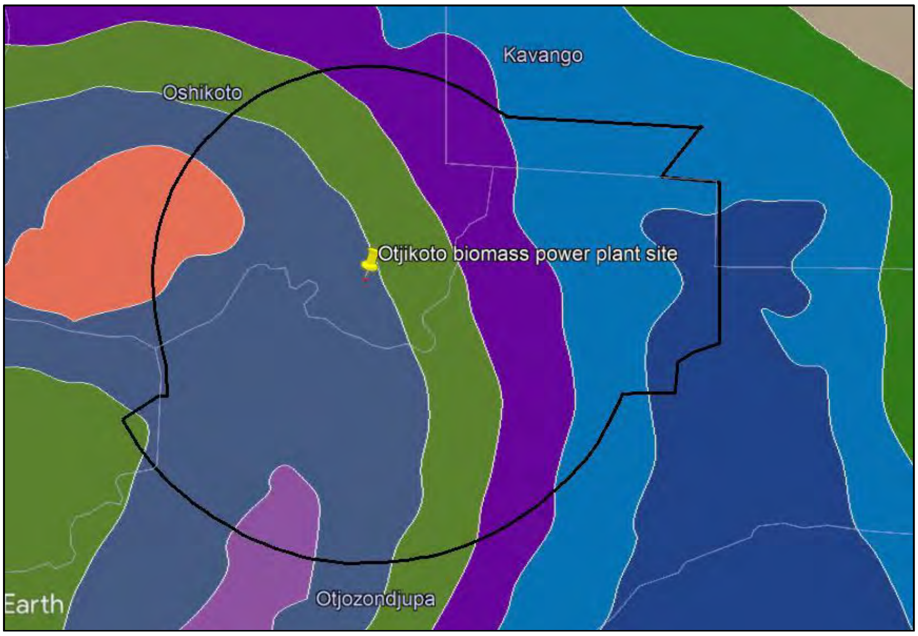


FIGURE 6-34: BIRD SPECIES DIVERSITY WITHIN THE BIOMASS HARVESTING AREA RANGE FROM > 230 SPECIES PER QUARTER DEGREE SQUARE (QDS) IN THE WEST (PINK AND PURPLE) TO 81 - 110 SPECIES PER QDS IN THE EAST (DARK BLUE; EIS 2018).

Red Data Status

For the harvesting area, these Red Data listed species are as follows:

- White-backed Vulture (Critically Endangered, also Globally Critically Endangered);
- White-headed Vulture (Critically Endangered, also Globally Critically Endangered);
- Lappet-faced Vulture (Endangered, also Globally Endangered);
- Martial Eagle (Endangered, also Globally Vulnerable);
- Bateleur (Endangered, also Globally Near Threatened);
- Tawny Eagle (Endangered);
- Secretarybird (Vulnerable, also Globally Vulnerable);
- Kori Bustard (Near Threatened, Globally Near Threatened); and
- Rüppell's Parrot (Near Threatened).

Endemism

The species near-endemic to Namibia are as follows:

- Rüppell's Parrot (also Near Threatened);
- Carp's Tit;
- Monteiro's Hornbill;
- Damara Red-billed Hornbill;
- Bare-cheeked Babbler;
- Hartlaub's Spurfowl; and

- Rockrunner.

Although the abundance of the above near-endemic species varies, none are specifically confined to the Otjikoto harvesting area. Damara Red-billed Hornbill was described only relatively recently (being differentiated from Red-billed Hornbill), with no SABAP1 records, but its occurrence in the area has been confirmed (Simmons *et al*. 2015).

The level of endemism in the harvesting area is considered as relatively moderate. Endemism is higher in the western/southern part of the area than in the east and north (Mendelsohn *et al.* 2002).

Additional species are endemic or near-endemic to southern Africa. These species are considered of lower conservation concern as their populations occur in a wider area.

Residency and Abundance

of the 16 priority species above, none are migrant; all are resident, with some nomadism/local movement. Nomadic/migrant habits result in high mobility and consequently increase the risk of impacts such as collisions on overhead structures.

Four of the above species are generally rare in the area (<20% reporting rates for SABAP1), five are uncommon (21-40%) and six are more common (41-60%).

Nesting birds

In terms of the above potential impacts associated with harvesting activities, one impact is highlighted in particular, namely disturbance and habitat destruction to nesting birds.

Amongst the priority species, the birds that breed within the harvesting area make use of a variety of nesting habitats. Large raptors nest in the tree tops, or in the canopies of large trees. This group includes White-backed Vulture, White-headed Vulture, Lappet-faced Vulture, Martial Eagle, Bateleur, Tawny Eagle and Secretarybird.

Birds that nest in cavities in the trunks of live or dead trees include four Namibian near-endemic species, namely Rüppell's Parrot, Carp's Tit, Monteiro's Hornbill and Damara Red-billed Hornbill. In some cases, the old nests of other cavity breeding species are also used.

Species such as Bare-cheeked Babbler make their nests in the fork of a branch.

Priority species that nest on the ground include Kori Bustard, Hartlaub's Spurfowl and Rockrunner.

Although many of the above species occur at low reporting rates, those of particular concern in terms of potential impacts of harvesting activities are nesting White-backed Vulture, and also Lappet-faced Vulture (although at lower densities), both of which are relatively common in the harvesting area and not confined to Protected Areas. The conservation status of both vulture species has recently been uplisted, both in Namibia and globally.

A nesting density of 0.38 nests per km^2 has been reported for the White-backed Vulture during a microlight survey on farms near the Waterberg area (in the southern part of the harvesting area), covering an area of approximately 150 km^2 (Doulton & Diekmann 2006). Vultures have large home ranges, ranging from 10,000-30,000 km^2, as demonstrated for the Cape Vulture in Namibia by means of satellite tracking (Mendelsohn & Diekmann 2009).

Tree-nesting vultures favour larger trees, especially along watercourses (refer to section 6.4). The main tree species used for nesting is reported to be the camelthorn (*Acacia erioloba*; P Bridgeford, M Boorman pers. comm.), which also occurs throughout most of the harvesting area and is the most widespread tree in Namibia (Curtis & Mannheimer 2005). A few other tree species in the same habitats are also used for nesting (e.g. *Boscia* species, other acacias, palm trees; P Bridgeford, M Boorman pers. comm.). Large trees may also occur even in bush-encroached areas, but the encroachment would not prevent the vultures from using the trees for nesting. Bush encroachment does, however, have a negative effect on vulture foraging and feeding, and has been shown to reduce the chances of Cape Vultures finding carcasses (Schultz 2007, Mendelsohn & Diekmann 2009, Simmons *et al*. 2015) as well as make it difficult for the vultures to take off again (De Klerk 2004).

The harvesting of large trees is not permitted (SAIEA 2016). However, vultures are sensitive to disturbance, and the proximity of humans and machines associated with bush harvesting in adjacent areas could cause them to abandon their nests, especially the Lappet-faced Vulture.

Although breeding by vultures in the proposed harvesting area is considered unlikely, because it is relatively densely settled and for Namibia has relatively high levels of human activities, prior to the construction and operation of the Power Station (A Rothauge pers. comm.), the precautionary principle should still prevail in order to allow for any possible breeding events, given the conservation status and the recorded distribution of the vulture species, especially of White-backed Vulture (refer to Appendix 6.2). It has also been mentioned that vulture nests have been observed in areas where harvesting is currently taking place (C Lindeque pers. comm.).

Priority near-endemic species in the harvesting area breed in a variety of habitats (see Appendix 6.2), including in cavities (Ruppell's Parrot, Carp's Tit, Monteiro's Hornbill and Damara Red-billed Hornbill), as well as in tree forks (Bare-cheeked Babbler) or on the ground (Hartlaub's Spurfowl and Rockrunner). As mentioned above, the distribution of these near-endemic species is confined more to the western/southern part of the harvesting area than in the north-east (Figure 6-35), which would render these parts more sensitive to harvesting impacts from an avifauna point of view. No SABAP1 data are available for Damara Red-billed Hornbill, but it occurs in an area similar to the above species (Simmons *et al*. 2015).

Cavity-nesters are regarded as particularly sensitive to the above impacts; the breeding habits of hornbills are described below, by way of an example.

Hornbills nest in cavities in large trees. Laying dates peak in February-March, after the onset of the summer rains (Boix-Hinzen 2005). The breeding pair thus occupies the site for a minimum of about three months, a prolonged period where disturbance would have negative impacts on the breeding attempt. Damara Red-billed Hornbill families move away from their breeding territories during the dry season in search of food, when they are probably nomadic (Boix-Hinzen 2005).

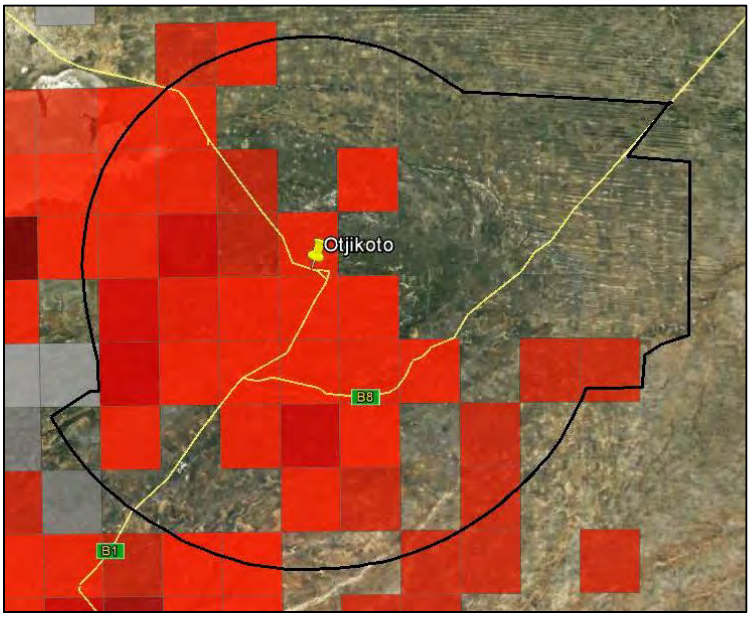


FIGURE 6-35: DISTRIBUTION OF SIX NAMIBIAN NEAR-ENDEMIC SPECIES IN THE HARVESTING AREA

Note: Distribution is for Ruppell's Parrot, Carp's Tit, Monteiro's hornbill, barecheeked babbler, Hartlaub's spurfowl and Rockrunner; no SABAP1 data available for Damara Red-billed hornbill (SABAP1).

6.7.11 Floristic Habitats of the Harvesting Area

There is considerable overlap between the different floristic habitats/vegetation zones regarding plant species of concern. Nevertheless, some are more important than others because they support species of conservation concern or would be difficult to restore after high intensity clearing. In addition, two historic impacts must be acknowledged: the felling of over four million large trees for the Tsumeb and Abenab mines in the 1970s and the more recent large-scale use of arboricides in vast areas within the harvesting area. Both have had severe consequences for large trees, most of them protected species but also large individuals of non-protected species such as *Acacia luederitzii*. The latter are often important as habitat and refuge for fauna, as well as for soil retention and cooling, and for nitrogen fixation.

The study area comprises four main vegetation zones, some of which can be sub-divided to give nine zones in total (these are depicted in Figure 6-36 and described further below). The four main zones are listed below:

- Karstveld, comprising the central zone and the bulk of the harvesting area, including the Otavi Mountain lands.
- Mopane Savanna in the west of the Karst area, bordering the Etosha National Park.
- Kalahari Woodlands/Kalahari Tree Savanna to the north, east and south-east of the Karst zone. This includes the Northern Dune fields and Eastern Woodlands, respectively in the far north and east of the harvesting area, and two similar dambos (Dambo 1 and Dambo 2).

- Thornbush Savanna south of Otavi.

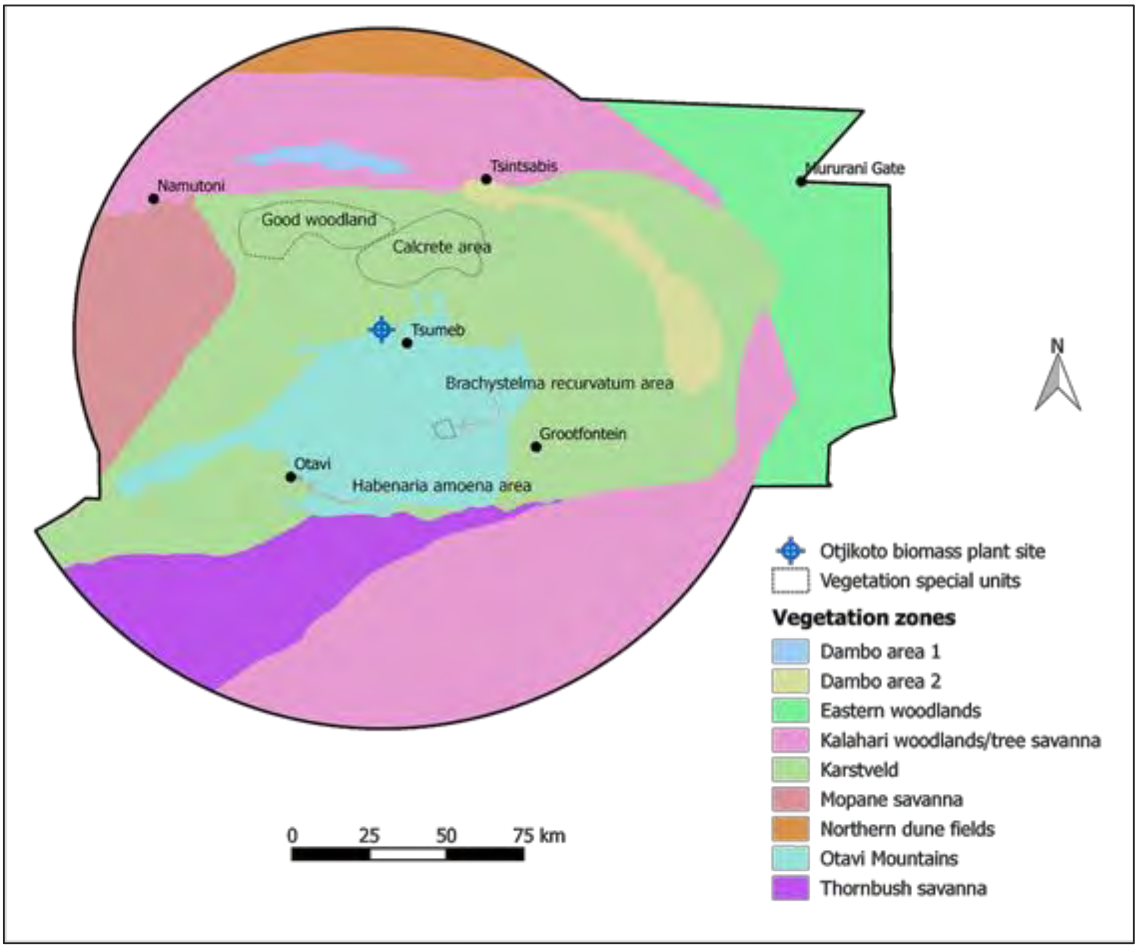


FIGURE 6-36: A MAP OF THE HARVESTING AREA SHOWING THE VEGETATION ZONES AND THE LOCATION OF SPECIAL ZONES DEFINED BY SPECIFIC PLANT POPULATIONS OR PARTICULARLY GOOD CONDITION HABITAT

6.7.11.1 *Karstveld*

Most of the central part of the harvesting area is Karstveld (Figure 6-36). This relates to the Mountain Savanna and Karstveld vegetation zone of Giess (1998), which, particularly on the mountain slopes, is characterised by a high density and diversity of broadleaved trees and shrubs (i.e. broadleaved woodland), including important species such as *Combretum imberbe*, *Ficus* spp., *Sclerocarya birrea, Kirkia acuminata, Berchemia discolor* and *Spirostachys africana* In addition, numerous endemic, near endemic and otherwise protected non-woody species are known to occur (see Appendix 6.1). The valleys and sandveld patches in between carry a slightly lower diversity of broadleaved trees and shrubs with thornveld components such as *Dichrostachys cinerea* and *Acacia* spp. more prevalent, often forming dense areas of encroachment (i.e.: mixed woodland). *Hyphaene petersiana* (the fan palm) is also common in places where water stands for a while in the rainy season. Dense stands of ancient and valuable *Ficus sycomorus* have also been observed.

Numerous endemic and/or protected geophyte species have been recorded in this zone, but it is unlikely that they will be heavily impacted by bush harvesting due to the survival of their subterranean corms or tubers.

Many endemic non-woody species occur that are likely to be badly impacted by mechanical harvesting. These include *Crassocephalum coeruleum, Petalidium rautanenii, Aloe* spp., *Duvalia polita, Huernia oculata* and *Stapelia* spp. However, they are reasonably widespread, or are most common on rocky hills and mountain slopes. The Karstveld zone may roughly be divided into:

- Dolomites mountains, koppies and ridges
- Narrow valleys lying between the mountains and koppies.
- Surrounding calcareous plains

6.7.11.1.1 Dolomite Mountains, Koppies and Ridges

Biogeographically forming part of the Otavi Mountains (Figure 6-36), which is known to harbour numerous endemic and protected species, this is a highly diverse habitat, incorporating permanent spring areas and carrying a very high density of large trees, many belonging to protected and/or range-restricted species. It also harbours several endemics with a preference for limestone substrates, such as *Ornithoglossum calcicola* and *Petalidium rautanenii,* with the latter being common. This zone supports one of the best developed and valuable woodland habitats in the country. Many large specimens of protected and/or restricted range species, such as *Sclerocarya birrea* (marula), *Berchemia discolor* (birdplum), *Pachypodium lealii, Lannea discolor, Combretum imberbe* and others are common, while others, such as *Ficus* spp. are more scattered. Species of conservation concern entirely or largely restricted to this zone include *Jamesbrittenia dolomitica, Jamesbrittenia fragilis, Heteromorpha stenophylla* var. *stenophylla, Cyphostemma juttae* and *Erythrina decora*. The notable population of *Pachypodium lealii,* an iconic pachycaul, present in the study area occurs virtually exclusively on these slopes. Furthermore, large scale damage here would substantially and negatively alter the conservation status of species such as *Kirkia acuminata* and *Gyrocarpus americanus,* which at present are not protected but would have to be urgently reassessed.

6.7.11.1.2 Valleys

The valleys between the highlands are home to many of the same tree species of concern as the highlands, but in lower densities overall. The range-restricted and habitat restricted non-woody species *Heteromorpha stenophylla* var. *stenophylla, Jamesbrittenia dolomitica* and *Jamesbrittenia fragilis* are absent, as are *Pachypodium lealii* and *Gyrocarpus americanus.* On the other hand, *Burkea africana* and *Pterocarpus angolensis* are present in places and there are areas where dense stands of *Olea europaea* (which is an evergreen tree) occur. *Acacia erioloba, Ziziphus mucronata, Albizia anthelmintica* and *Combretum imberbe* (all protected) are reasonably common, *Ficus* spp. are present, and non-protected fruit-producing species such as *Grewia* spp. and *Ximenia* spp. occur throughout. *Spirostachys africana* (tamboti) is present in high numbers and will be of concern, as will large specimens of *Kirkia acuminata.* Several useful species that do not enjoy protection are well represented and observations in charcoal harvesting areas indicate that the larger specimens will need to be careful monitored to ensure that they are not removed. These include *Philenoptera nelsii, Peltophorum africanum, Combretum apiculatum* and *Ozoroa paniculosa*.

6.7.11.1.3 Surrounding Calcareous Plains

The Karstveld plains outside of the mountain-valley zones carry many of the same tree species of concern as the valleys. Some, such as *Sclerocarya birrea* (marula) and *Berchemia discolor* (birdplum) are more scattered, but *Spirostachys africana, Combretum imberbe, Acacia erioloba* and *Ficus* spp. are more common. In the central area of these plains there appears to be a calcrete area where the water table is regarded as particularly shallow (P. Oosthuizen, famer, *pers. comm.*). This area (Figure 6-36) appears to carry a slightly different species complement, with numerous examples of *Securidaca longepedunculata,* high numbers of *Combretum imberbe,* and the dense stands of ancient and valuable *Ficus sycomorus* previously mentioned. The complement of non-woody species of concern is likely to be the same as that of the valleys. Note that large tracts of this zone have been treated with arboricides, which have had detrimental effects on protected and non-target species, so it is particularly important to conserve what is left.

6.7.11.2 *Mopane Savanna*

Just east of the Etosha National Park (ENP) there is an area of Mopane Savanna (Figure 6-36), which is recognised as distinct by Giess (1998) but is included in the Karstveld of Mendelsohn *et al.* (2002). Giess notes that it shares many species with the latter and is related to it. It is characterised by a prevalence of *Colophospermum mopane*, as well as quite high numbers of *Commiphora glandulosa.*

On the ground it is clearly dominated by Mopane, but it is important to note that the Mopane in this zone is not always dense, invasive scrub but in some areas is composed partially or largely of substantial trees. In the latter context Mopane is a protected species, and so of concern in this zone. Other tree species of concern are *Combretum imberbe, Spirostachys africana, Albizia anthelmintica, Boscia albitrunca* and *Berchemia discolor*.

6.7.11.3 *Kalahari Woodlands/Tree Savanna*

With the exception of an area of consistently deep sands (Figure 6-36; Northern Dune Fields) directly to the north of Tsintsabis, the Kalahari Woodlands/Tree Savanna is essentially a low dune field lying mainly to the north, east and south-east of the Karst zone, comprising Kalahari Sandveld carrying both broadleaved and fine-leaved woody species, such as *Acacia* spp. (including the protected *A. erioloba*), *Philenoptera nelsii, Peltophorum africanum, Boscia albitrunca, Terminalia sericea, Combretum collinum, C. apiculatum,* and others, as well as *Hyphaene petersiana*, which can form quite dense stands.

Along margins of drainage lines and in zones encircling depressions where water collects in the rainy season important tree species, such as *Ficus petersii, Acacia erioloba, Spirostachys africana,* and *C. imberbe* are common and represented by large, mature individuals. Two of the most important areas for this are shown in Figure 6-36 (Dambo Area 1 and 2), but depressions are scattered throughout the Kalahari woodland and all omiramba, of which several lie towards the south-eastern part of this zone between the Waterberg area, and are of very high concern.

In the east and the far north, the important broad-leaved species are concentrated on the dunes (although not confined to them), while important fine leaved species, such as *Acacia erioloba*, are more common in inter-dune areas.

Tree species of high concern recorded for this zone include, *Schinziophyton rautanenii, Berchemia discolor, Baikiaea plurijuga, Burkea africana*), *Dialium englerianum, Guibourtia coleosperma, Albizia* *anthelmintica, Pterocarpus angolensis, Sclerocarya birrea* and *Spirostachys africana,* and stands of *Ficus sycomorus* are very likely to occur. Many species that are encountered in this zone are utilised for uses such as food, medicine, timber or cash crops and many are important sources of food and shelter for birds and other animals. Some of the species fall into all those use categories. Non-woody species of concern likely to be affected by mechanical harvesting are the two stapelias, *Huernia oculata* and *Orbea lugardii* (all protected species). No other herbs are of high concern in this zone.

This zone is difficult to categorise because it includes diverse areas. In the dune areas there are inter-dune valleys where broadleaved woodland is replaced by mixed woodland or predominantly *Acacia* woodland. On the deep dune sands there are stands of extremely valuable broad-leaved woodland, especially in the far eastern parts, which not only support important protected species such as *Pterocarpus angolensis* and *Burkea africana*), but also carry non-protected species such as *Securidaca longepedunculata, Combretum collinum* and *Combretum psidioides* that have never faced large-scale threats before and thus do not enjoy protected status but which will be substantially affected by the harvesting of such vast areas unless careful controls and checks are implemented and enforced.

6.7.11.4 *Thornbush Savanna*

To the south-west of Otavi there is a belt of Thornbush Savanna characterised by a high prevalence of *Acacia* spp., interspersed with scattered *Boscia albitrunca* and patches where *Philenoptera nelsii, Peltophorum africanum, Kirkia africana, Combretum imberbe* and (occasionally) *Colophospermum mopane* are common. In addition, there are dense stands of *Olea europaea* in places that will need to be conserved in order not to change the conservation status of this species. None of the non-woody species of concern that occur in this zone are likely to have their conservation status changed by this project (over the long term), although *Pteronia eenii* is likely to be affected by large-scale mechanical harvesting.

Large tracts of this zone have been treated with arboricides, which has had detrimental effects on protected and non-target species. Current bush-clearing practices, especially over clearing (SAIEA 2016), seem to favour the conservation of only large individuals of protected species such as *Boscia albitrunca.* This is a poor management practice that will not result in a diverse, resilient and productive savanna and is therefore unacceptable as an approach in the management of impacts of this project.

6.7.12 Savana Ecology, with Specific Reference to the Dynamics of Bush Encroachment and the Effect of Harvesting

Savannas consist, by definition of, a continuous grass (herbaceous) layer interspersed with taller woody plants (Scholes & Archer 2003). The ratio of woody to herbaceous biomass is the dominant underlying structural[11] determinant of all savannas and is dynamic (inherently unstable) over time and space. The availability of soil water and nutrient resources (including CO_2) primarily controls savannas from the bottom up, while disturbances such as fire and bush harvesting modify the effects of resource availability from the top down (Sankaran et al. 2004; 2005; 2008; Bond 2008). The relative importance of these driving forces changes with mean annual precipitation (MAP). On a broad scale, the

[11] In the context of this study 'savanna structure' refers to the relative proportion of biomass apportioned in the woody or grass/herb layer, but also includes perspectives on the height distribution of woody plants in the vegetation. The savanna may thus be a specific type of woodland (e.g. open vs closed), but within that there may be one or more layers of woody plants that provide successively complex vertical structure. One of the characteristics of bush encroachment, apart from the high density of tree stems, is that there is very little.

percentage woody cover in African savannas is limited by mean annual precipitation up to about 650 mm per annum. Above that amount of precipitation, fire and herbivory become the main determinants of woody cover (Sankaran et al. 2005; Bond 2008).

The tendency for an increase in woody cover is an entirely natural part of savanna ecosystems, and it is only limited (in natural situations) by opposing disturbances caused by factors such as fire. Consequently, the savanna ecosystem can take one or several forms, sometimes simultaneously, depending on the balance of forces that swing the ratio either towards dominance by woody or by herbaceous species. In the semi-arid savannas extreme dominance by woody species is called bush encroachment or thicket formation. In the mesic savannas it could be closed woodland or even forest.

Savanna structure, which is drastically altered both by bush encroachment and harvesting, importantly controls ecosystem processes such as nutrient cycling, carbon sequestration patterns, forage quality and accessibility for herbivores, and micro habitat conditions for other organisms. It consequently controls the population sizes and composition of animal assemblages dependent on specific vegetation configurations for food and shelter (Scholes & Archer 1997; Sankaran et al. 2005; Gordon & Prins, 2008), thus influencing biodiversity patterns in general. The ratio of trees to grasses also determines forage availability for browsing and grazing herbivores and thus the relative abundances of grazers and browsers, and whether shelter is available or not. A number of antelope species depend critically on the appropriate ratio of shelter vs. open areas.

6.7.13 Integrated Discussion

6.7.13.1 *The Ecological Goal is a Significant Reduction of Woody Biomass, not Maximum Woody Yield or Bush Extermination*

Bush encroached habitats are virtual monocultures of the encroaching species, hence have low niche diversity resulting in low biodiversity and ecological dysfunction. Existing knowledge and evidence suggests that the region encompassed by the proposed harvesting area is indeed encroached by several species, with prominent species being Sickle Bush (*Dichrostachys cinerea*), Black Thorn/Swarthaak (*Acacia mellifera*) and Mopane (*Colophospermum mopane*). It also seems, from previous rough estimates, that the density of encroacher species is relatively high in the proposed harvesting area, which is also the stronghold of sickle bush. Hence it is widely agreed that the rangelands in this region are degraded. Degradation occurs from both a biodiversity and agricultural perspective because of the homogenisation of habitats and loss of the productivity of the grass layer, respectively.

Utilising the woody biomass for energy production seems like a logical and sensible way to address two different aspects: contributing to Namibia's goal to become self-sufficient in energy production while simultaneously improving agricultural production through the improvement of rangeland condition (MAWF, 2012). The proposed Biomass Power Project therefore occurs within this context of rangeland dynamics, with an underlying implicit goal of restoration of savanna structure, function and composition.

Improvement of rangelands is nothing more than the restoration of the ecological structure, function and composition (SFC) of the dryland savannas that make up the bulk of Namibia's rangelands. This includes emergent properties such as resilience (the ability to bounce back after a disturbance) and primary productivity (a measure of the ecosystem's ability to transform sunlight and nutrients into biomass. There might be some argument about the optimal ratio of woody to herbaceous/grass plants that constitutes an improved rangeland but there should be no argument about the veracity of the statement that a resilient and productive savanna will also be the one that has the highest level of biological integrity, even if productivity is measured in the relatively narrow definition of grass- and herb-layer production.

Moreover, and more germane, it is not the goal of the project to implement intentional bush farming. In defining the baseline and in assessing potential impacts and their significance, the risk that the restoration goal will not be reached therefore has to weigh heavily.

6.7.13.2 *Sensitivity and No-Go Zones Across All Taxa*

Biodiversity sensitivity is a fluid concept, without a precise definition that holds across all levels of ecological organisation from populations to ecosystems. Nevertheless, a few general concepts have emerged across all specialist studies. First, in terms of environmental management, it makes most sense to view sensitivity as a property of a habitat or a place, not so much of species (although a specific species might be sensitive to disturbance, it will ultimately contribute to the level of sensitivity of a place or a zone because that is where an activity will take place or can be avoided). Second, there are various criteria that relate to the presence and abundance of species of conservation concern (all aspects of rarity, endemicity and threats) and/or to the resilience of a habitat or ecosystem. The latter refers to the likelihood of recovery after a disturbance.

Furthermore, if a habitat or ecosystem is functionally important, contributing disproportionately to total ecosystem services (e.g. a habitat containing many large camel thorn trees potentially provides important nest sites for endangered vultures), it can be viewed as rare or critical to the continued functioning of other habitats or species and are thus sensitive. For the highly mobile birds, the proximity of the study area to protected areas (refer to section 6.7.10) additionally played a role in deciding sensitivity, as did the proximity of the study area to centres of endemism for invertebrates. Following established practice, where different specialists provided different sensitivity ratings, the highest (most sensitive) rating is taken for each habitat.

The rest of this discussion refers to Figure 6-38.

6.7.13.2.1 No-Go Zones

No-go means that these areas are recommended to be excluded from any harvesting activities and are similar to the 'Critical Habitat' of the IFC's 6 Standard (IFC, 2012). Clear geographic distinctions have emerged in terms of overall sensitivity in the study area, with especially the no-go areas being relatively clearly defined. First on this list is the Otavi Mountains. For many reasons, some of the areas in the harvesting zone have become strongholds of rare, threatened or endangered plant species. The rocky slopes of Otavi Mountains and other rocky outcrops are good examples of such species refuges that support high diversity and tend to support more endemic species of all taxa investigated. This includes all slopes, rocky or otherwise, that are steeper than 12.5% (SAIEA, 2017). Many of these habitats are too small to depict on a map at the scale of the study area (Figure 6-38), so the principle will have to be included into "Site Specific Harvesting Plans" and implemented at project level. These areas should be treated with care and their no-go status rigorously enforced to ensure that their high biodiversity value and underlying attributes are not compromised (IFC 2012).

Two dambos towards the northern half of the harvesting area appear to be unique habitats and support a complement of species that do not occur elsewhere. They are similarly considered no-go areas for somewhat different reasons. The omuramba associated with these two dambos is probably not only important ephemeral riverine habitat, but also supports the function or process of water transport and supply that will maintain species both on its fringe and in the adjacent dambos. Closely related to this aspect, all drainage lines are no-go zones, both because this is a key recommendation in the SEA (SAIEA 2016) and Harvesting Guidelines (Pallet & Tarr 2017) and because their loss will have a disproportionate impact on almost all organisms. Related to this, all other water features such as springs, other omiramba, pans and wetlands (even if they are ephemeral) are also rated as no-go. For the birds (and amphibians) all pan habitats and their fringes were rated as sensitive (refer to section 6.7.10 and Appendix 6.2), but for consistency's sake this rating is upgraded to no-go.

The following additional areas are also no-go due to the high probability that biomass harvesting, or related activities could negatively affect individuals, populations or ecological processes and attributes of a specific area:

- All formal protected areas. This should include a buffer zone of about two farms wide around the Etosha and Waterberg National Parks, to decrease the risk of poaching, particularly the critically important black rhino (pending agreement/decision of MEFT – Directorate of Wildlife and National Parks).
- All known locations where populations of very rare plants occur (Figure 6-37).
- As point features, special breeding, and nesting sites of any threatened species, e.g. raptors and vultures (see section 6.7.10 and Appendix 6.2). In this regard, emphasis should be placed on riverine fringes and any other areas that support large trees (see also above).

All no-go areas should be treated with care and their no-go status rigorously enforced to ensure that their high biodiversity value and underlying attributes are not compromised (IFC 2012). All no-go areas should be identified and mapped at a local scale in the site specific management plans (refer to the Harvesting EMP).

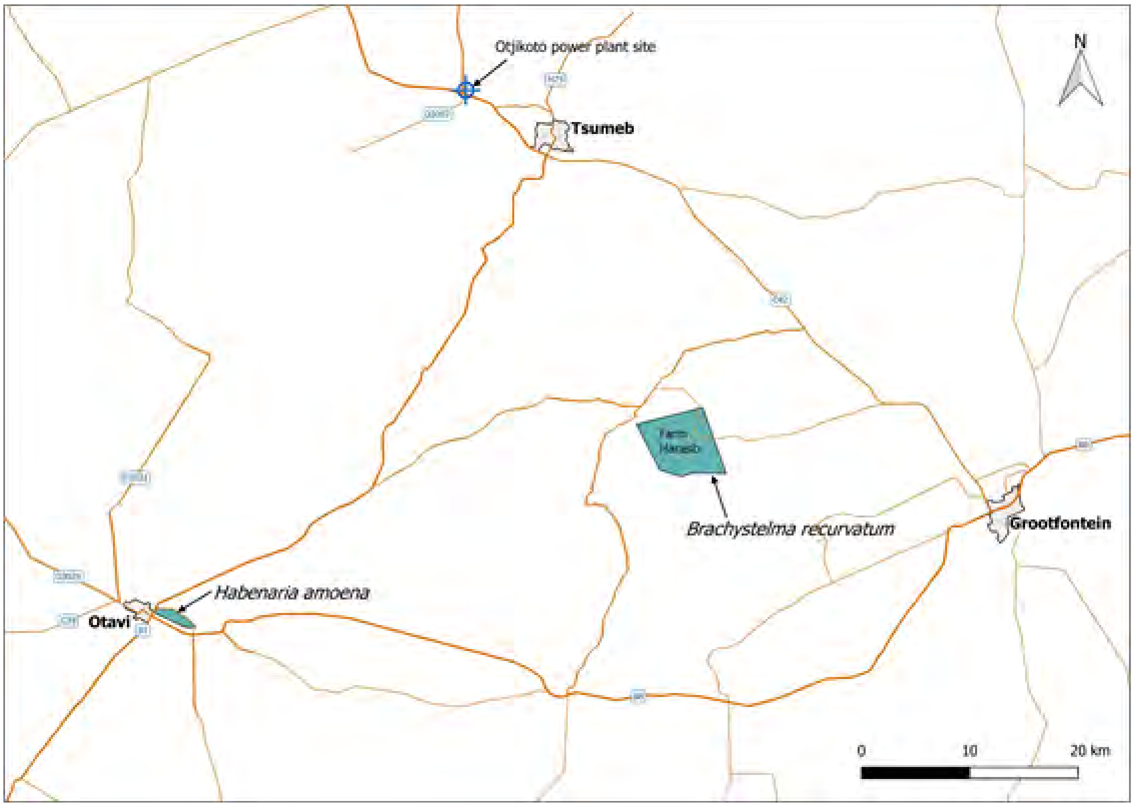


FIGURE 6-37: THE LOCATION OF *HABENARIA AMOENA* AND *BRACHYSTELMA RECURVATUM* TWO PLANT SPECIES OF SPECIAL SIGNIFICANCE.

6.7.13.2.2 Very Sensitive

The area surrounding the rocky slopes of the Otavi Mountains is considered here to be functionally closely integrated into the mountain itself, hence we view this all as one ecosystem and rate it as Very Sensitive. This does not preclude harvesting but does require a more robust assessment of impacts per harvesting site and a more rigorous application of harvesting guidelines and of monitoring. A similar approach is prescribed for the other Very Sensitive areas, the good quality woodland in the east of the harvesting area. Here the sensitive handling of large trees of all the indicated species and clusters of intact woodland will be very important.

Ephemeral rivers and drainage lines are regarded as very sensitive[12] habitats in terms of birds, with large trees and bush that provide habitat for perching, roosting, foraging and nesting (the latter is especially important for vultures and other raptors, as well as for cavity breeders) (see section 6.7.10 and Appendix 6.2). Watercourses may also serve as movement corridors for birds, including migrant species and bird diversity is likely to increase for the short periods that the rivers do hold water.

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[12] Scott & Scott (2018) rated this as sensitive, but they had only two categories of sensitivity and we interpreted their 'sensitive' rating as equivalent to our 'very sensitive'.

6.7.13.2.3 Sensitive

The Karstveld was rated as Sensitive mainly because it supports high numbers of species of conservation concern, species that are at future risk and many large trees, and the zone has undergone historical application of arboricides[13] and has low recovery potential. Arboricide treatment has had detrimental effects on protected and non-target species in these areas. It is therefore particularly important to conserve what is left. The northern dune fields are also Sensitive because of the presence of large trees of several typical species. Other than their botanical properties, there are no criteria for ranking these zones.

6.7.13.2.4 Least Sensitive

The Thornbush and Mopane savannas are both Least Sensitive. The rest of the Kalahari woodland/tree savanna zone is Least Sensitive in previously degraded areas, but large specimens of several typical woodland trees occur scattered throughout these should be treated as Sensitive, particularly where their population density is high. Other than their botanical properties, there are no criteria for ranking these zones.

6.7.13.2.5 Natural, Modified and Critical Habitiats

According to the IFC's Standard 6 a habitat is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the non-living environment. For the purposes of implementation of this Performance Standard, habitats are divided into modified, natural, and critical. Critical habitats are a subset of modified or natural habitats.

Applied to the study area, natural habitats[14] are areas composed of viable assemblages of plant and animal species of native origin, and where human activity has not essentially modified an area's primary ecological functions and species composition. In the study area the legally protected national parks were classified as natural habitat (Figure 6-39).

Modified habitats are areas that may contain a large proportion of plant and animal species of non-native origin, and where human activity has substantially modified an area's primary ecological functioning and species composition. The Biodiversity Specialists state that most of the communal and commercial farmland has been modified to some degree by introduction of livestock (cattle, sheep and goats) and conversion to crop fields, while ecological factors such as natural fires has been altered. Virtually the entire farmland area has experienced species compositional changes affecting both the vegetation (bush encroachment and related vegetation changes) and changes in large animal assemblages (extermination of large, native herbivores and predators). Some grey areas exist, however, such as communal areas with very low human and livestock densities that may functionally approach the natural habitat category.

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[13] Mr Leon Burger, a farmer in the area, reports a large-scale die-off as a result of frost some years ago (pers. comm.). At this stage it is not possible to distinguish between mortality as a result of frost (a natural factor) and arboricide.

[14] Natural habitats are those preserved in the legally protected National Parks. In the study area all farmland was classified as Modified habitat, while all the biodiversity No-go sensitivity zones and areas were classified as Critical habitat. Critical habitats include rocky and mountainous areas, drainage lines, dambos and pans, as well as specific areas where very rare plant species occur.

Critical habitats are areas with high biodiversity value, including habitat of significant importance to critically endangered and endangered species, habitat of significant importance to endemic and restricted-range species highly threatened or unique ecosystems (IFC 2012). In the study area these coincide with the No-go zones as delineated in Section 6.7.13.2.1 (see Figure 6-38).

For managing the potential impacts of biomass harvesting and processing in the study area, the Biodiversity Specialists propose that the biodiversity sensitivity zones (Figure 6-38) provides a more practical framework. The sensitivity zones provide more spatial details (i.e. least, sensitive and very sensitive zones) relevant to managing harvesting impacts (compare Figure 6-38 with Figure 6-39).

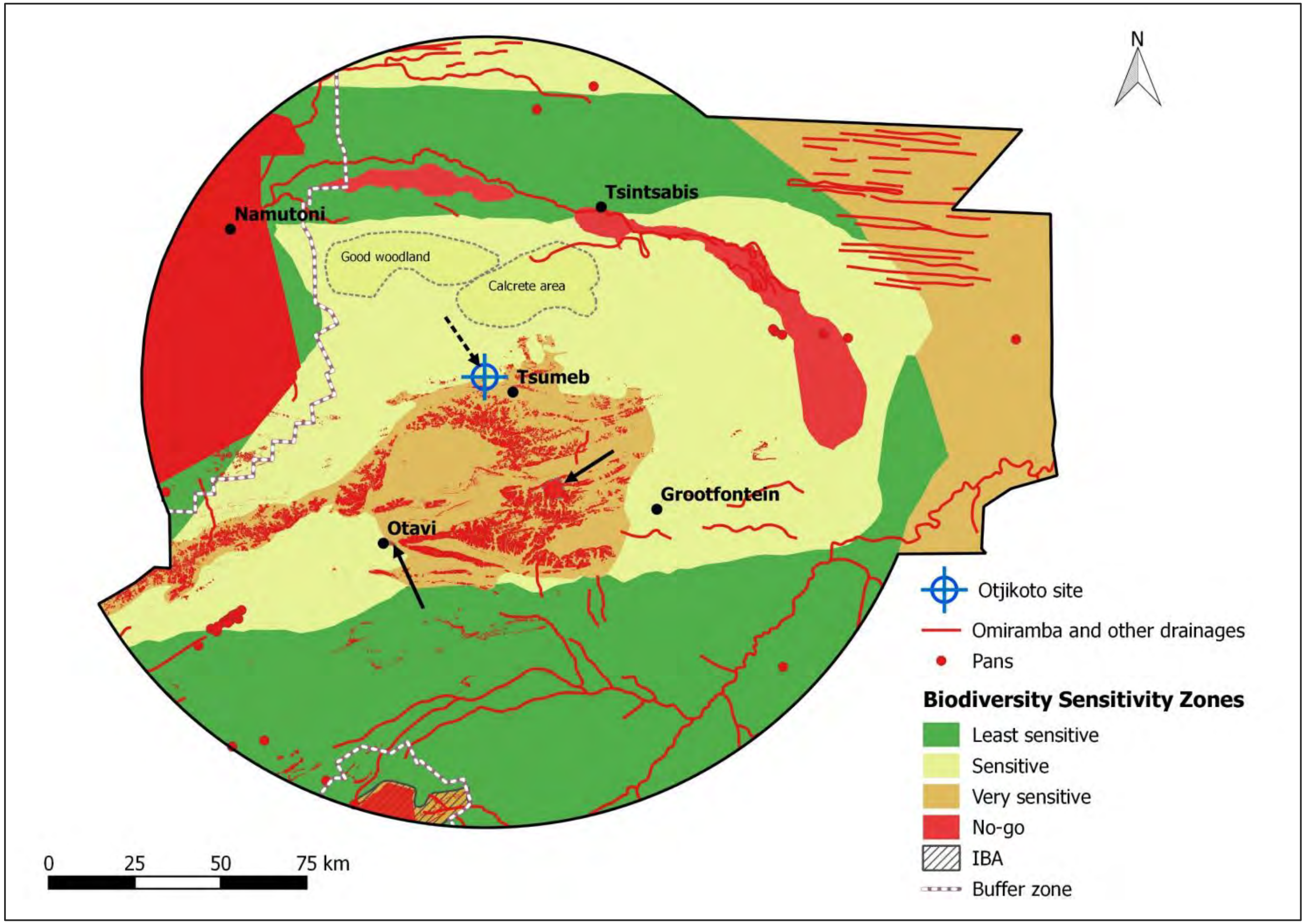


FIGURE 6-38: BIODIVERSITY SENSITIVITY ZONES IN THE HARVESTING AREA, COMBINED ACROSS ALL TAXA AND INCLUDING GENERAL GUIDELINES

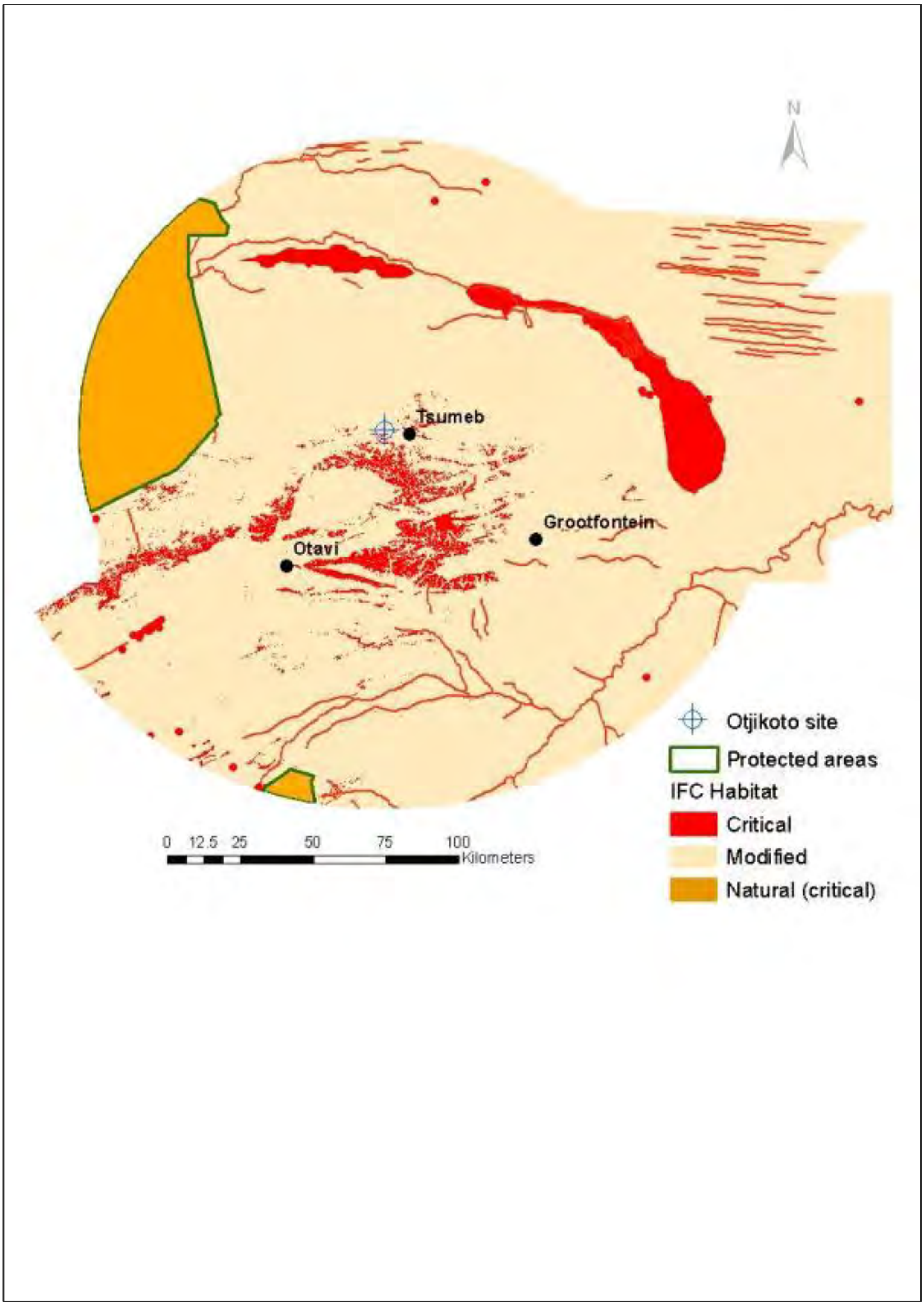


FIGURE 6-39: NATURAL, MODIFIED AND CRITICAL HABITATS AS DEFINED BY THE IFC'S STANDARD 6 BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES

6.8 ARCHAEOLOGICAL AND CULTURAL HERITAGE BASELINE

The information in this section was sourced from the Archaeology and Heritage Assessment Specialist Report included in Appendix 9.

6.8.1 Link to Anticipated Impacts

Heritage resources include all human-made phenomena and intangibles that are the result of the human mind. Natural, technological, or industrial features may also be part of heritage resources, as places that have made an outstanding contribution to the cultures, traditions and lifestyles of the people or groups of people of Namibia.

The project has the potential to disturb surface heritage resources through the establishment of the proposed Power Station and associated infrastructure. Physical damage to archaeological remains could also be caused by machinery during the bush-harvesting operations and related activities (such as transportation, construction of haulage roads, etc.).

As a baseline, this section identifies the archaeological and cultural heritage potential and significance of the proposed Power Station site, its immediate surrounding and the various landscapes that within the harvesting area.

6.8.2 Historic Background of the Project Area

The Tsumeb area is known for its mineral deposits, with exploitation and smelting occurring during both prehistoric and historic times. The place-name probably refers to "*place of frogs* (or *algae*)" in Herero ("*Otjisume*") because of the green colour from malachite-rich rocks. Although originally occupied by San Bushmen and Bergdama tribesmen, the ores from the Tsumeb area were traded and smelted further afield, with the Ovambo and Damara tribes for example.

Historically, and based on information supplied by the National Museum of Namibia[15], the pre-Colonial ethnic group occupying the area around Tsumeb were generically referred to as 'bushmen'. This ethnic group extended across most of northern Namibia. European contact did not occur until the 18th century. Following Colonial rule by Germany in 1905, the Tsumeb area became an important mining area for copper with a series of mining complexes located in and around Tsumeb; although there is evidence of small-scale smelting activity that extends into prehistoric times, and later by Damara and Owambo communities. From 1906, the town of Tsumeb was serviced by a narrow-gauge railway and road infrastructure; much of which survives today.

The cultural history over the past 150 years is reasonably well understood for the general area where the project is focused, but any specific cultural associations between existing communities and the proposed biomass plant location has been lost due to the upheavals of the colonial period. Some of the national monuments within the harvesting area surrounding the proposed Power Station site provide indications of cultural significance, but there are likely to be many more archaeological sites that have yet to be identified and added to the National Heritage Council's list.

[15] National Museum of Namibia - ACRE (Administration, Curation, Research, Library and Education Services).

6.8.3 Cultural Heritage Assets in and Around the Proposed Power Station Site and Harvesting Area

For this section of the report, the Archaeologists used universally-recognized terminology in order to discuss the archaeology and cultural heritage baseline of the proposed Power Station site.

Based on criteria set within guidance from Historic England (2012), a Designated Heritage Asset is:

"*a building, monument, site, place, area or landscape that is identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest*".

In the case of Namibia and its legislation (National Heritage Act 2004), known designated heritage assets are identified by the National Heritage Council of Namibia NHC. No recognized sites on the NHC list are present within the proposed Power Station site, nor within its immediate surroundings, however, up to eight sites are listed within the harvesting area surrounding the Power Station site. These sites are described in Table 6-13 and their locality shown in Figure 6-40.

TABLE 6-13: NHC MONUMENTS LISTED WITHIN THE HARVESTING AREA

NHC monument number	Name	Description	Location coordinates
038/1967	Ghaub Cave	Series of chambers, tunnels and passages and a petrified waterfall formed by circulating underground water. The formation "the organ" consists of stalagnites. Also, stalgmite fingers, curtains and bands can be found. First reported in 1914, in the "Deutsche Kolonialzeitung". First detailed account by F Jaeger and L Waibel before WWI.	19° 28' 37.92" S, 17° 46' 47.64" E
110/1990	Roman Catholic Church, Tsumeb		Latitude -19.2483 Longitude-17.7108
142	Otjikoto Lake		Latitude -19.203376 Longitude-17.578125
013/1951	Baobab Tree (No 1063)		Latitude -18.9809 Longitude-17.7786
019/1955	Hoba meteorite		Latitude -19.5833 Longitude-17.9166

140	Oshituthi shomagongo	Living festival	Latitude -18.934217 Longitude-17.094727
002/1950	Fort Namutoni	German Colonial era fort	Latitude -18.8076 Longitude-16.9402
070/1975	Fort (unnamed)	German Colonial era fort	Latitude -19.5605 Longitude-18.0978

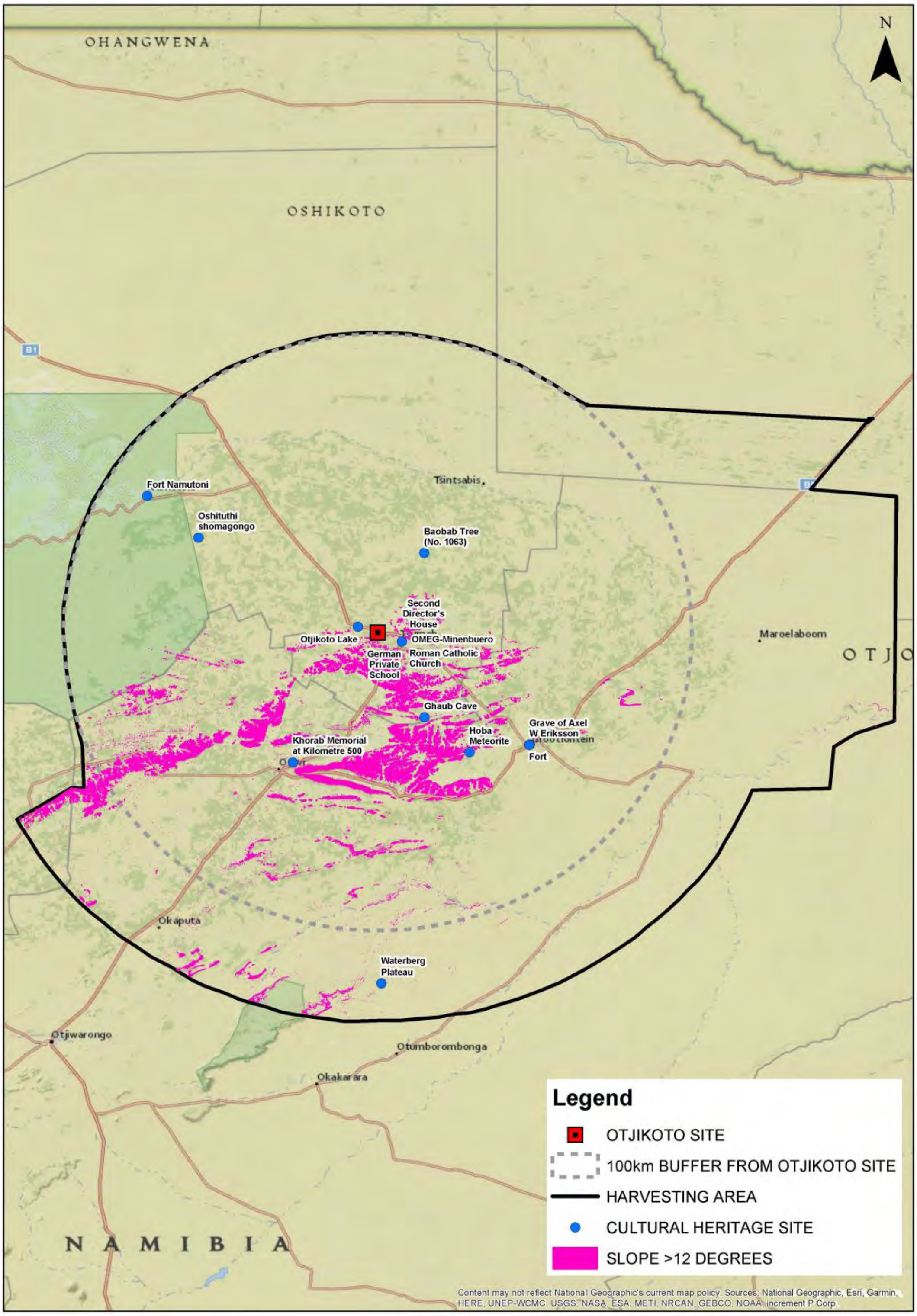


FIGURE 6-40: NATIONAL MONUMENTS LABELLED WITHIN THE HARVESTIN AREA

Non-designated heritage assets are those sites / places identified that are not statutorily recognized by the NHC and therefore not listed on the Namibian Heritage Register[16] Sites that are identified as non-designated heritage assets can be considered as a material consideration for any potential development projects such the construction of the Biomass Power Station and the associated harvesting activities.

Based on the walkover survey by the Archeologists, one non-designated heritage asset within the surrounding landscape of the proposed Power Station was identified, that of a small sub-circular cairn east of the existing NamPower substation. This site is of unknown date and provenance. Also considered as a potential non-designated heritage asset, was a large rock outcrop that stands to the west of the NamPower substation and the limestone quarry. This place may have symbolic significance to historic or contemporary communities within the locality.

The presence of the cairn located east of the NamPower substation may reflect a prehistoric and pre-colonial historic past. The cairn, standing up to 0.8m from the ground surface appears to originally have been a larger structure. Its denudation may have been the result of disturbance from the erection of the pylon the stands over it. However, the limestone quarry located west of the NamPower substation and north of the B1 road reflects modern human agency.

A viewshed analysis was undertaken during field observations. The viewshed analysis around the proposed Otjikoto Power Station site concluded that the buildings/structures plan for the proposed site option would not impact the identified sub-circular cairn feature. There may be an indirect impact however, between the natural rock outcropping and the proposed Power Station site.

Based on the historic landscapes elsewhere within the wider Tsumeb landscape (to include the harvesting area), five distinct archaeological / cultural heritage chronological landscapes are recognised (Kinahan, 2016):

- Prehistoric - scattered Holocene sites and mid- to late-Pleistocene stone [lithic] assemblages;
- Pre-colonial - tribal community activity in the form of settlement (secular) and ritual sites (burial and symbolic places);
- German colonial - German expansion into the Namibian interior, usually in the form of economic exploitation of the veld through cattle ranching, and military activity;
- British South African colonial - a consolidation and extension of previous Colonial rule through economic exploitation of the veld and military activity; and
- Modern (Post-1950) – a consolidation of economic resources, mainly through mining and quarrying enterprises and the growth in settlement activity.

6.8.4 Predicative Modelling Exercise

In order to fully appreciate the potential complexity of multilayered and multifaceted landscapes within the proposed harvesting area, the Archaeology Specialist Team undertook a predictive modelling exercise in order to highlight potential archaeological and historic sites / landscapes that may exist, summarised below (see Appendix 9 for more details).

A visual search for sites of potential archaeological and or cultural heritage significance was carried out with the aid of relevant data (files) imported into Google Earth Pro. These files included areas of sensitivity and

[16] The Heritage Register lists protected places, listed buildings and protected objects (Part IV of the National Heritage Act 2004, paragraph 25(2) a to d).

constraint, farm boundaries, geology, groundwater potential, rivers, and hillsides of more than 12 degrees. Such a large zone required a bespoke survey approach in order for a reasonable sample to be assessed as part of this project.

Given the size of the overall search area, and the difficulty in identifying potential sites in different terrains and vegetation types, the search would concentrate within the area of 2 transects each 20 km wide and 200 km long, one running NNW-SSE and the other running ENE-WSW), both transects ran through the proposed Otjikoto biomass Power Station site, which acts as the central point for the bush harvesting area (refer to Figure 6-41).

As a comparison to this remote scanning technique, results from a field survey of the Ohorongo site option (see section 1.4) and immediate surroundings identified nine manmade mounds/cairns (probable graves) c.2m x 1m, plus a very large cairn (5m x 7m and 1.5m high), which could have been for an elite burial, and other archaeological remains including a linear boundary of stones, none of which would not be visible using the remote scanning Google Earth survey techniques. Ohorongo lies within the c.100km radius harvesting area south-west of the proposed Otjikoto Power Station site and so the results from this field survey can be seen as generally indicative of the potential for non-settlement related activities and prehistoric remains to occur elsewhere in the study area.

A total of 67 potential sites were found although it should be stressed that there are likely to be more that were not visible. The details of these sites are listed in Appendix 9. Although the majority of sites lie within the transect areas, 17 are outside the transects, being part of an initial trial search, which involved visually scanning, in detail, the area north of Veterinary Cordon Fence, situated to the north of the bush harvesting area.

The majority of sites have been identified as a result of the clearing of land for the purpose of settlement or farming with a number of sites being identified within existing farms. Some sites identified consist of land which has been cleared but abandoned, and the National Heritage Act lists all remains over 50 years old as an archaeological monument.

of particular interest are the potentially much older sites identified as 'Old Enclosures,' which are characterised by irregular hedge boundaries for settlement, stock enclosure and/or farming. Five of these sites were recorded and were identified within the east-north-east, west-south-west transect. Further field work would be needed to establish their date of origin and use.

From the Google Earth remote survey undertaken for this study it was found that the density of archaeological sites is far greater towards the northern part of the harvesting area than elsewhere (refer to Figure 6-41).

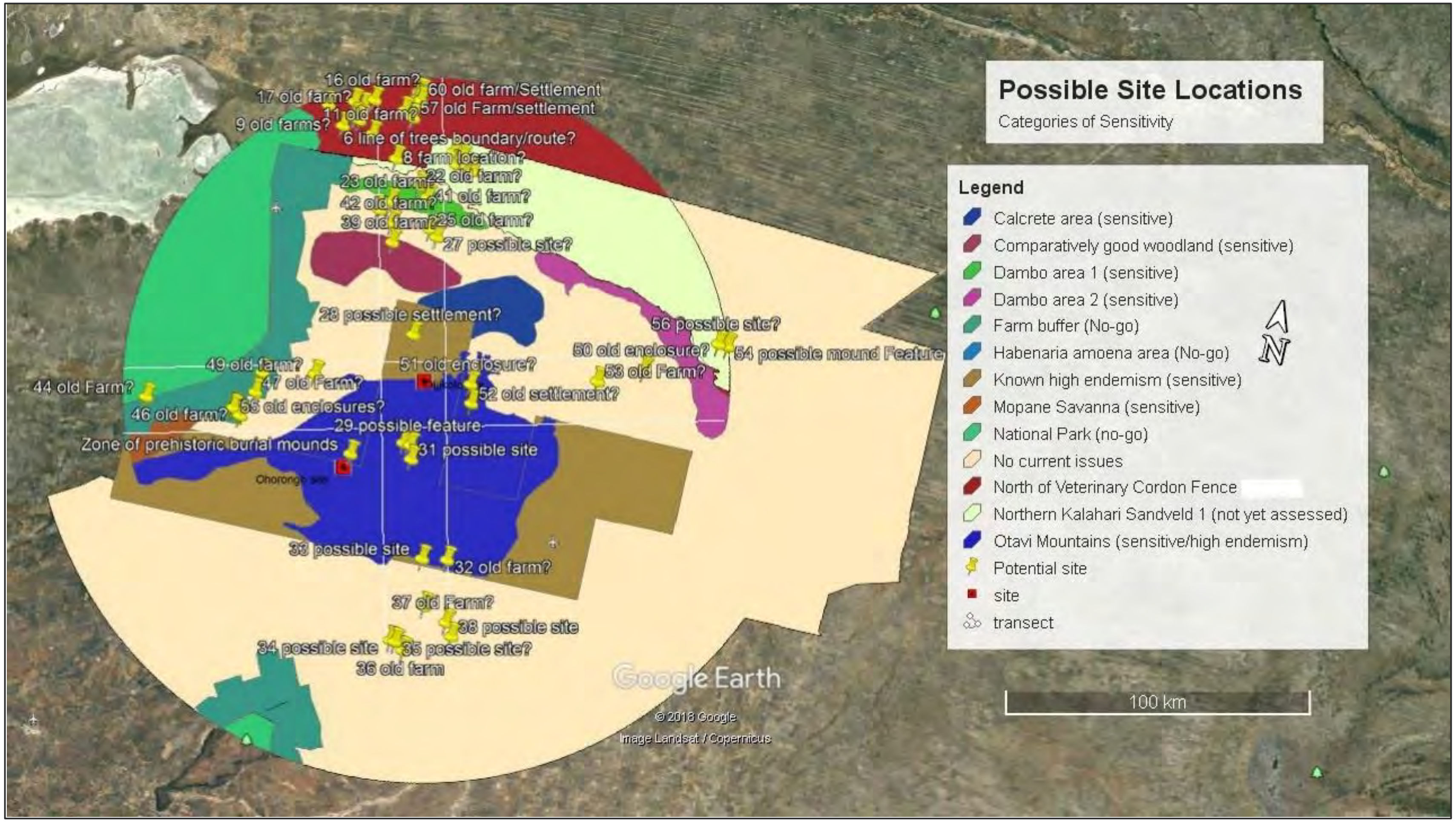


FIGURE 6-41: TRANSECT LINES AND ARCHAEOLOGICAL SITES MAPPED AGAINST THE GENERAL SENSITIVE AREAS

6.8.4.1 *Association of Archaeological Sites with Specific Geological Formations*

The association of archaeological sites with specific geological formations has been proven as important for better researched and surveyed areas in western Namibia, especially with the recent data-sets from surveys in advance of uranium mining. Therefore, the remote scanning compared to geology undertaken for the proposed Power Station site at Otjikoto and surrounding bush harvesting area, might assist with predictive modelling before harvesting activities begin.

The overall search area covers a wide variety of geological types, but the sites identified within the transects and the slightly wider original test area consist of six main classes of geological formation: Triassic, Quaternary & Tertiary, Namibian (Otavi), Namibian (Nosib), Namibian (Mulden) and Jurassic (Stormberg). By far the largest percentage of sites, 60%, were to be found in the Quaternary & Tertiary areas. Apart from the Kalahari Sandveld which forms the vast majority of the northern part of the bush harvesting area, the bedrock includes Dolomite, limestone, quartz, schist, and Aeolian sandstone (from north to south across the search area). The distribution of archaeological sites shows the majority lie on the Kalahari Sandveld, although there are 11 sites on Dolomite and limestone in the central search area with three more in the southern transect, and six on Aeolian sandstone (refer to Figure 6-42).

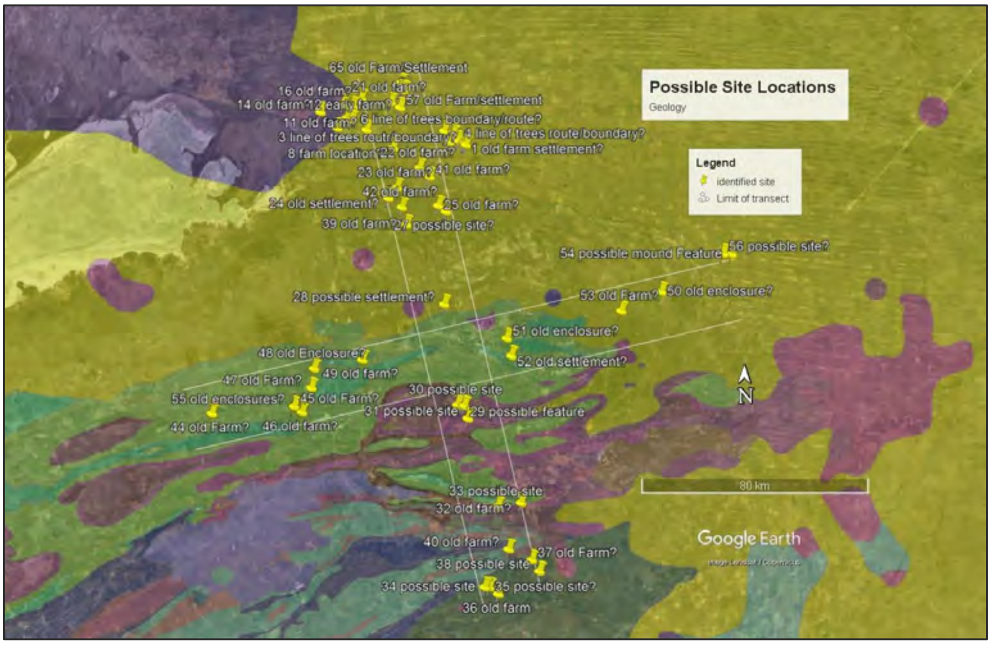


FIGURE 6-42: ARCHAEOLOGICAL SITES MAPPED AGAINST UNDERLYING GEOLOGY

6.8.4.2 *Association of Archaeological Sites with HYNAM Groundwater Potential*

The potential sites identified were also compared against HYNAM groundwater potential (refer to Figure 6-43) in order to calculate the potential for habitation. Five HYNAM categories were identified against the sites found: “fractured, fissured or karstified aquifers: High Potential”, “fractured, fissured or karstified aquifers: Moderate Potential”, “porous aquifers: High Potential”, “porous aquifers: Moderate Potential” and “rock bodies with little groundwater potential”. (Refer to section 6.5.3.2 for more details regarding the hydrogeology).

Not surprisingly a good correlation exists between archaeological sites and potential groundwater sources as 42% lie within the two “High Potential” categories, and 43% within the two “Moderate Potential” categories, whilst the last category represented the smallest percentage (15%) of potential sites identified. The geological types represented in this category consisted of Jurassic (Stormberg), Namibian (Mulden) and Namibian (Nosib).

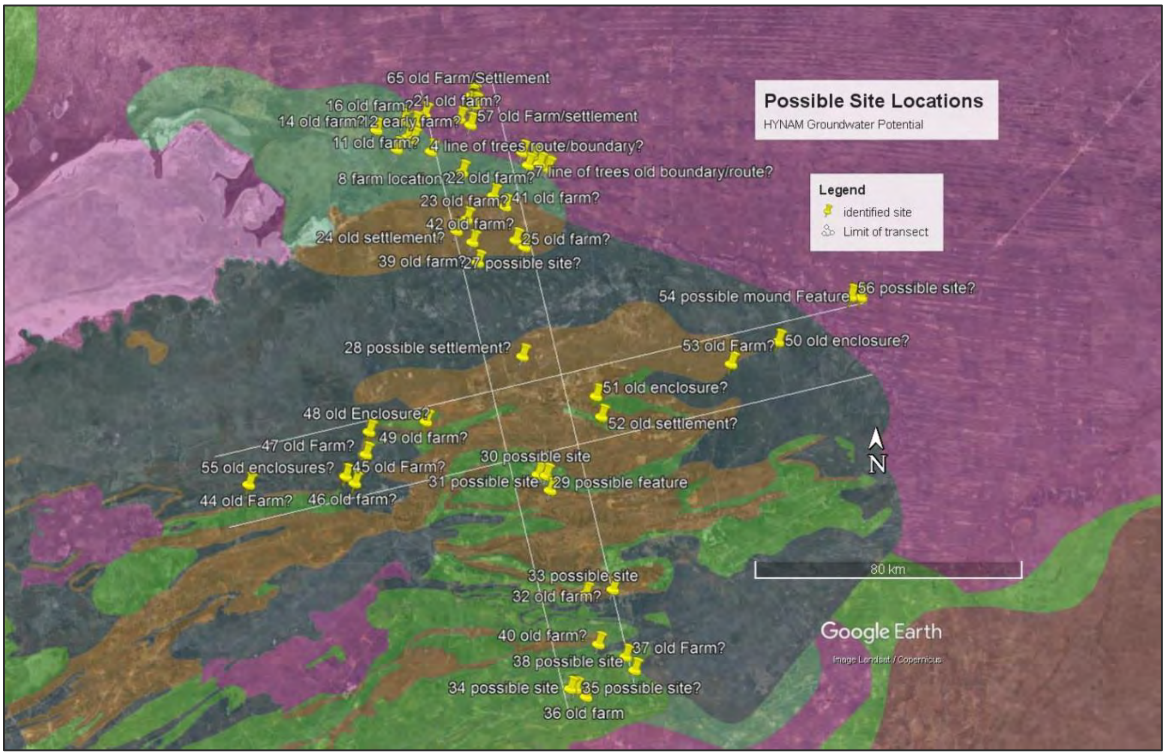


FIGURE 6-43: ARCHAEOLOGICAL SITES MAPPED AGAINST HYNAM GROUNDWATER POTENTIAL

6.8.4.3 *Association of Archaeological Sites with HYNAM Groundwater Potential Proximity of Sites to the Proposed Otjikoto Power Station Site*

The proposed Otjikoto Power Station option lies within the area where both transects cross. Although the immediate surroundings of the proposed site are a relatively level area, the 400 km^2 intersection zone for both transects includes a high density of steep slopes in the south which generally would be unsuitable for bush harvesting. These hills would mostly lie within Dolomite and limestone bedrock. The nearest potential site lies approximately 12.5 km to the north-west.

6.9 NOISE BASELINE

Information in this section was sourced from the Noise Specialist Study included in Appendix 7.

6.9.1 Link to Anticipated Impacts

Some of the noise generating activities associated with the proposed Biomass Power Project may cause an increase in ambient noise levels in and around the Power Station site and the harvesting activities. This may cause a disturbance to nearby receptors (see section below).

The sensitivity of noise receptors usually increases at night when conditions are still, and ambient noise levels are at their lowest. As a baseline, this section provides an understanding of existing conditions in the area from which to assess changes as a result of project-related noise.

6.9.2 Noise-Sensitive Receptors

With respect to defining a '*receptor*' for the purposes of the assessment, the EHS Guidelines state the following:

"A point of reception or receptor may be defined as any point on the premises occupied by persons where extraneous noise and/or vibration are received. Examples of receptor locations may include: permanent or seasonal residences; hotels/motels; schools and daycares; hospitals and nursing homes; places of worship; and parks and campgrounds."

The closest noise-sensitive receptors (NSRs) to the Power Station are detailed in Table 6-14. (See Figure 6-46) similar receptors are also referred to in the Air Quality study. These receptors are identified as permanent residences, as well as working cattle/game farms and are located within 2 km of the Otjikoto site.

TABLE 6-14: CLOSEST NOISE-SENSITIVE RECEPTORS

NSR ID	NSR Name	Direction & Distance from Site Boundary	Coordinates
NSR01 (9 in Figure 6-46)	Homestead / Cattle farm	East; approximately200m	777573, 7873854
NSR02 (10 in Figure 6-46)	Game farm	South-east; 1,500m	778588, 7872733

There are a number of additional receptors (see Figure 6-46) within 20km of the Otjikoto site, to include individual homes, communities and also the town of Tsumeb (and its suburbs to the south-east). These are located further from the site than those receptors identified in Table 6-14 above. As noise from a source decreases with distance, it follows that the resulting construction and operational noise levels at receptors located further away would be less than those reported herein.

With respect to the harvesting of biomass fuel, this would be undertaken in areas around the proposed biomass Power Station site, within a radius of approximately 100 km. It has not been possible to define the location of the closest NSRs for harvesting, as the exact location(s) for this activity is unknown.

6.9.3 Baseline noise conditions

Existing ambient noise levels in the vicinity of the Otjikoto site (and at the closest NSRs) are influenced by a number of sources including cattle and crop farming, traffic on nearby local and national roads and a nearby railway line.

Daytime and night-time baseline noise levels were measured on 17 May 2017 at two locations representative of the closest NSRs to the Power Station. These survey locations, used for the measurement of the baseline conditions, are described in Table 6-15.

TABLE 6-15: BASELINE NOISE SURVEY LOCATIONS

Survey Location	NSR Represented	Description of Survey Location
Location 1 (representative of NSR01)	Homestead / cattle farm	Baseline noise measurements were undertaken at a farm house, located approximately100m from the national B1 (TR1/10) road, with a cattle post situated approximately40m east of the survey location. Noise in the surrounding area was attributable to birds and insects; with cattle observed to be grazing around the survey location. Road traffic was audible but was not visible due to the presence of encroacher bush between the survey location and the national road.

Survey Location	NSR Represented	Description of Survey Location
Location 2 (representative of NSR02)	Game farm	Baseline noise measurements were undertaken at the entrance of a game farm located approximately 30m east of the national B1 road. This survey location was also influenced by noise from birds and insects but was noted to be subjectively quieter than Location 1; however, road traffic on the B1 national road was also audible at this location.

6.9.3.1 *Baseline Conditions at Location 1*

At Location 1, there was continuous noise from cars and trucks on the TR1/10 trunk road. Noise from goats at the farm was also audible. At this location, the daytime ambient noise level was 58.9dB $L_{Aeq,1hr}$ and the night-time ambient noise level was 56.1dB $L_{Aeq,1hr}$. From these measurements, it is noted that the existing ambient noise levels are in excess of the EHS guidelines for residential properties – these being 55dB $L_{Aeq,1hr}$ for the daytime and 45dB $L_{Aeq,1hr}$ for night-time.

6.9.3.2 *Baseline Conditions at Location 2*

At Location 2, noise sources included a dog barking, cattle, goats, voices and cars on the nearby B1 road. At this location, the daytime ambient noise level was 53.5dB $L_{Aeq,1hr}$ and the evening/night-time ambient noise level was 49.1dB $L_{Aeq,1hr}$. From these measurements, it is noted that the existing night-time ambient noise levels are in excess of the EHS guidelines for residential properties – this being 45dB $L_{Aeq,1hr}$ for during the night-time period.

6.10 AIR QUALITY AND THIRD-PARTY HEALTH BASELINE

Information in this section was sourced from the Air Quality, Climate change and Health Risk Assessment (Airshed, 2018) included in Appendix 5.

6.10.1 Link to Anticipated Impacts

Identification of existing sources of emissions in the region and the characterisation of existing ambient pollution concentrations is fundamental to the assessment of cumulative air impacts. A change in ambient air quality can result in a range of impacts for nearby receptors.

By conducting a background literature search on effects on human health deriving from wood biomass power generation; obtaining information on respiratory health problems and air quality related complaints in the study area; and the results from the air quality impact assessment, the potential for health risks associated with PM_{10}, $PM_{2.5}$ can be determined.

6.10.2 Current Ambient Air Quality Environment

6.10.2.1 *Existing Sources of Emissions in the Project Area*

The Dundee Precious Metals Tsumeb (DPMT) smelter is the main industrial source of air pollution in the area surrounding the proposed Power Station. Ambient SO_2 and arsenic levels are primarily because of emissions from this complex. There are several sources of atmospheric PM in the area. These include a quarry and concrete works adjacent to the project site, copper smelting operations at the Tsumeb smelter to the east, agricultural activities to the north, paved and unpaved public roadways, open areas exposed to wind, small scale industrial/commercial activities within and around Tsumeb and trans-boundary sources.

Other sources of emissions within a a 100 km radius from the Power Station i.e. the biomass harvesting area, include the Tschudi opencast copper mine and over 100 commercial farms.

6.10.2.2 *Existing Ambient Air Pollutant Concentrations in the Project Area*

DPMT owns and operates five ambient air quality stations in and around Tsumeb (Von Reiche, 2017). In addition to weather parameters, these stations record PM_{10}, SO_2 and arsenic concentrations, three key pollutants resulting from their operations. The closest stations to the study site are Stadium Site and Sewerage Works (approximately8 km to the southeast and east-southeast of the proposed Biomass Power Station site) (Figure 6-46).

6.10.2.2.1 Sulphur Dioxide Levels

SO_2 concentrations in and around Tsumeb are elevated. Annual average SO_2 levels varied between 9.41 µg/m^3 and 667 µg/m^3 (Figure 6-44). The highest 1-year average concentrations, all in exceedance of the 50 µg/m^3 limit, were recorded in 2014. A notable decrease is observed in 2016 levels with the only exceedance recorded at the Sewerage Works. This may be explained by the installation of the acid plant at DPMT. Future SO_2 levels are therefore expected to also much lower than during 2013-2015.

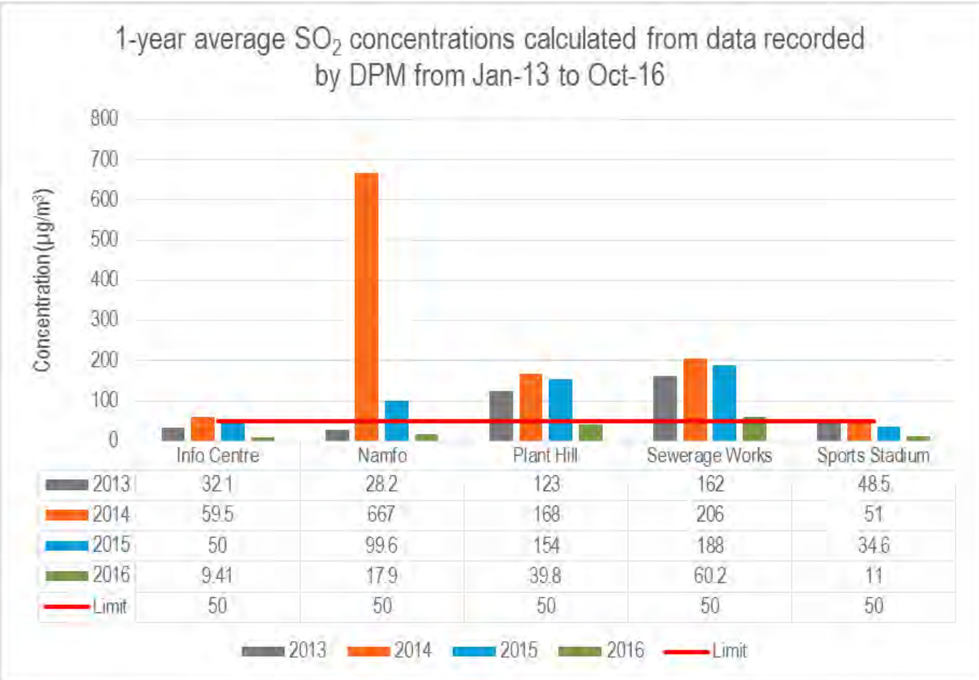
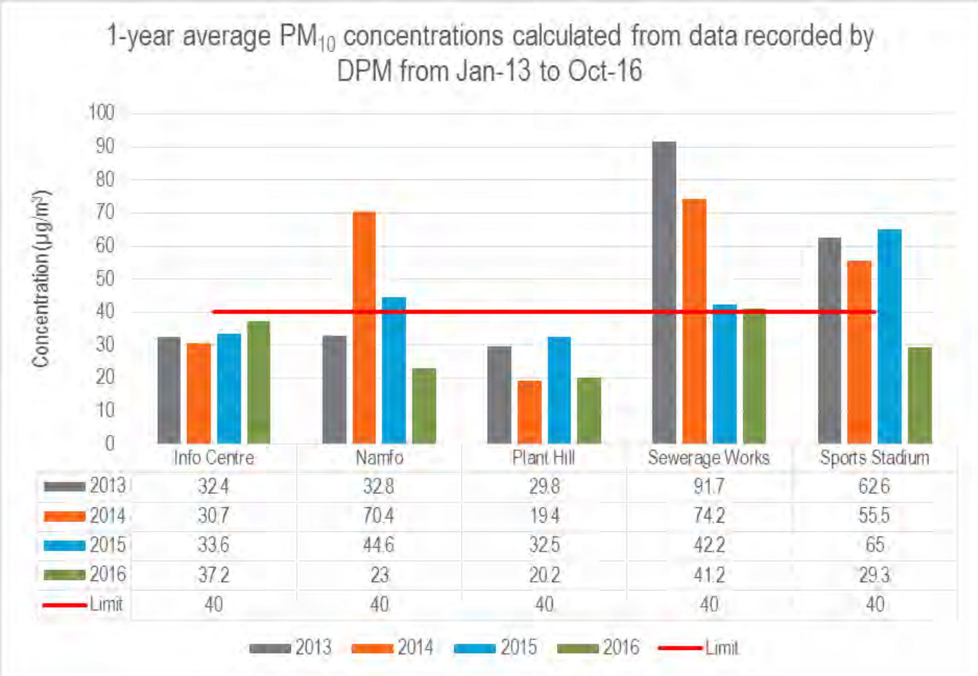


FIGURE 6-44: 1-YEAR AVERAGE SO2 CONCENTRATIONS CALCULATED FROM DATA RECORDED BY DPMT FROM JAN-13 TO DEC-16

Sewerage Works data indicate a large SO_2 source in an east-south-easterly direction from the station. Since the Sewerage Works station is situated to the east-southeast from the study site, this means that under strong wind conditions this SO_2 source may affect ambient SO_2 levels at the proposed Biomass Power site.

6.10.2.2.2 PM_{10} Levels

Annual average PM_{10} levels varied between 19.4 µg/m^3 and 91.7 µg/m^3 (Figure 6-45). Exceedances of the annual average limit of 40 µg/m^3 were recorded at Namfo, the Sewerage Works and Sports Stadium.



	Info Centre	Namfo	Plant Hill	Sewerage Works	Sports Stadium
2013	32.4	32.8	29.8	91.7	62.6
2014	30.7	70.4	19.4	74.2	55.5
2015	33.6	44.6	32.5	42.2	65
2016	37.2	23	20.2	41.2	29.3
Limit	40	40	40	40	40

FIGURE 6-45: 1-YEAR AVERAGE PM10 CONCENTRATIONS CALCULATED FROM DATA RECORDED BY DPMT FROM JAN-13 TO DEC-16.

Peaks in PM_{10} levels recorded at the Sewerage Works can be attributed to a source lying south-east of the station and under strong wind conditions. The waste disposal areas of the smelter complex are the likely sources. Since the Sewerage Works station is situated to the east-southeast from the proposed Biomass Power site, this means that under strong wind conditions this PM_{10} source may affect ambient PM_{10} levels at the project site.

6.10.2.2.3 NO_2 Levels

Since no NO_2 ambient data could be obtained for the project site, it was not possible to provide quantitative concentrations of the background NO_2 levels at the project site. However, apart from PM_{10} air concentrations, it is expected that the air concentrations of pollutants, such as oxides of nitrogen and volatile organic compounds would be low for semi-rural areas with some agricultural activities typically, less than 5 µg/m³ annual average concentrations.

6.10.3 Air Quality Sensitive Receptors

The local study area for the proposed Biomass Power Station air quality impact assessment was selected based on the extent of expected air quality impacts and possible sensitive receptors such as individual homes and communities. A study area of 20 km east-west by 20 km north-west with the Biomass Power Station study site located approximately in the centre, was identified. The study area includes the town of Tsumeb and its suburbs to the southeast, scattered farmsteads and the Namfo (Pty) Ltd agricultural area to the east-northeast (Figure 6-46). These are areas considered sensitive to changes in ambient air quality.

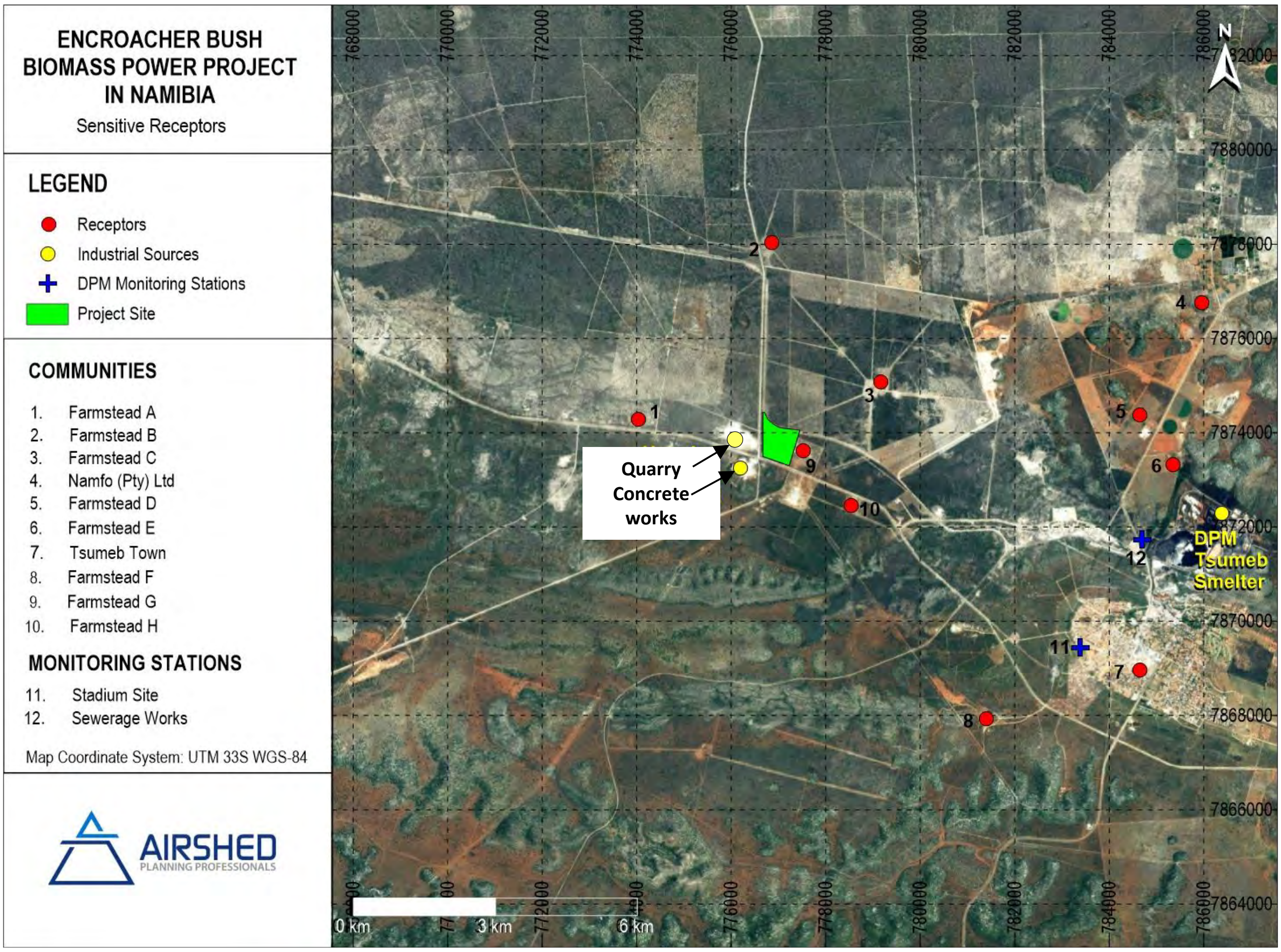


FIGURE 6-46: SENSITIVE RECEPTORS AROUND THE PROPOSED PROJECT SITE

The significance of impacts due to biomass harvesting were not determined with respect to specific sensitive receptors (since the harvesting area is so large), but rather as a function of distance from source (i.e. a specific biomass harvesting activity such as wood chipping). For example, if it was found that (i) impacts exceeding the recommended air quality limit value occurred up to 200 m away from the source of emissions, (ii) impacts below the recommended limit value decreased with distance up to 1 km from the source of emissions, and (iii) no impacts occurred beyond a distance of 1 km from the source of emissions, one could apply these findings to plan the placement of the wood chipper for e.g. with respect to the nearest sensitive receptors.

6.10.4 Regional Health Profile

The Oshikoto region suffers from a 25% rate of HIV/AIDS (WSP, 2012c) and is exposed to epidemiological hazards, mostly acute watery diarrhoea and malaria outbreaks (ORC, 2009). The prevalence of diarrhoea in children is 14.7% (GRN, 2015). Refer to the population profile, poverty deprivation and employment deprivation provided in the socio-economic profile (section 6.12).

6.10.4.1 *Asthma Related Symptoms in Relation to SO_2 in the Nearby Tsumeb Community*

A literature search was undertaken to gather information on respiratory infections due to SO_2 in the study region. A key study was found in the public domain in the form of a community health assessment undertaken by Myers (2016), as part of the Environmental and Social Impact Assessment (ESIA) process for the proposed Tsumeb Smelter expansion project (SLR, 2017).

The objective of the health assessment was to investigate the impact of the smelter operations on Tsumeb residents. A cross-sectional exposure control study was conducted of residents in Tsumeb and surrounds constituting the exposed area, and Oshakati[17] as the control area. It was found that, compared with the control sample in Oshakati, there was evidence of asthma related symptoms being significantly more prevalent in Tsumeb. Half of all those surveyed in Tsumeb had some asthma related symptomatology and half of these again experienced some degree of severity of these symptoms, constituting an appreciable burden of asthma related morbidity spread across all the areas of Tsumeb and the farms to the north (Myers, 2016). Myers found there is definitely some asthma-related impact from exposure to SO_2 from the smelter, but that this is mostly mild to moderate in severity.

An appreciable burden of physical effects of the SO_2 exceedances on the exposed Tsumeb population was evidenced based on responses from a respiratory questionnaire, when compared with the unexposed Oshakati control sample. The predominant symptoms reported were cough and throat irritation (upper respiratory system responses). Less prevalent symptoms reported were the more severe lower respiratory symptoms such as shortness of breath and chest discomfort. Myers (2016) concluded that, while not severe, these symptoms impose some burden of discomfort on the residents in all areas of Tsumeb i.e. a nuisance impact.

6.10.4.2 *Occupational Health associated with DPMT Plant Operations*

The study by Myers (2016) found that the main hazards associated with DPMT processes included chemicals, noise, heat and ergonomics. of the chemicals, arsenic and sulfur dioxide were the main concern. However, relatively few cases of occupational disease were identified, and there were no cases of work-related cancer or evidence of arsenic-induced occupational disease.

6.11 VISUAL BASELINE

Information in this section was sourced from the Visual Specialist Study included in Appendix 8.

6.11.1 Link to Anticipated Impacts

Project related activities have the potential to alter the landscape character of the site and surrounding area through the establishment of the Power Station, power line and associated infrastructure as well as from bush thinning activities and increased in vehicular movement activities. This section provides an understanding of the visual aspects (such as landscape character, visual resource and visibility) of the project area against which to measure potential change as a result of project activities.

6.11.2 Otjikoto Power Station Site

Figure 6-47 is an aerial photograph of the Otjikoto site. It illustrates the location of the existing substation and preferred Power Station site.

With reference to section 4.2, the site is located approximately 7km northwest of Tsumeb along Trunk Road (TR) 1/10 (i.e. the main B2) to Etosha. The landscape is characterised by a flat plain to the north of the site with rolling hills to the south which, form a backdrop to views from the B2 and other public roads north of the site (see section 6.2 for more details on the topography of the surrounding site). Both these landscape types are covered in medium to tall bush (see Appendix 8 for panoramas).

[17] Oshakati residents several hundred kilometres to the north were included as unexposed controls (Myers, 2016).

The general area is characterised by mining activities to the east and south-west of the study area, with a stone quarry to the immediate west of the substation. Several power lines converge at the substation (Figure 6-47).

The value of the visual resource of the Otjikoto study area is: Moderate as it has areas that exhibit positive character, but which have evidence of degradation of features resulting in areas of a more mixed character. The area is potentially sensitive to change in general and change may be detrimental if inappropriately dealt with, but it may not require special or attention to detail.

Figure 6-48 is a viewshed analysis of the potential visibility of the plant at the Otjikoto site, conducted by the Visual Specialist. Due to the nature of the terrain as described above most potential views to the site will originate in the west, east and north of the project site. The hills, approximately 3,0km to the south block most views from the south as is clearly illustrated in Figure 6-48.

Public viewing sites occur primarily along the B2 and the dirt road that passes through the western section of the study area. A small number of residential properties occur within the study area east and north-east of the site, as indicated in Figure 6-48 but due to the bush cover, views to the project site will be blocked.

FIGURE 6-47: OTJIKOTO SITE- STUDY AREA

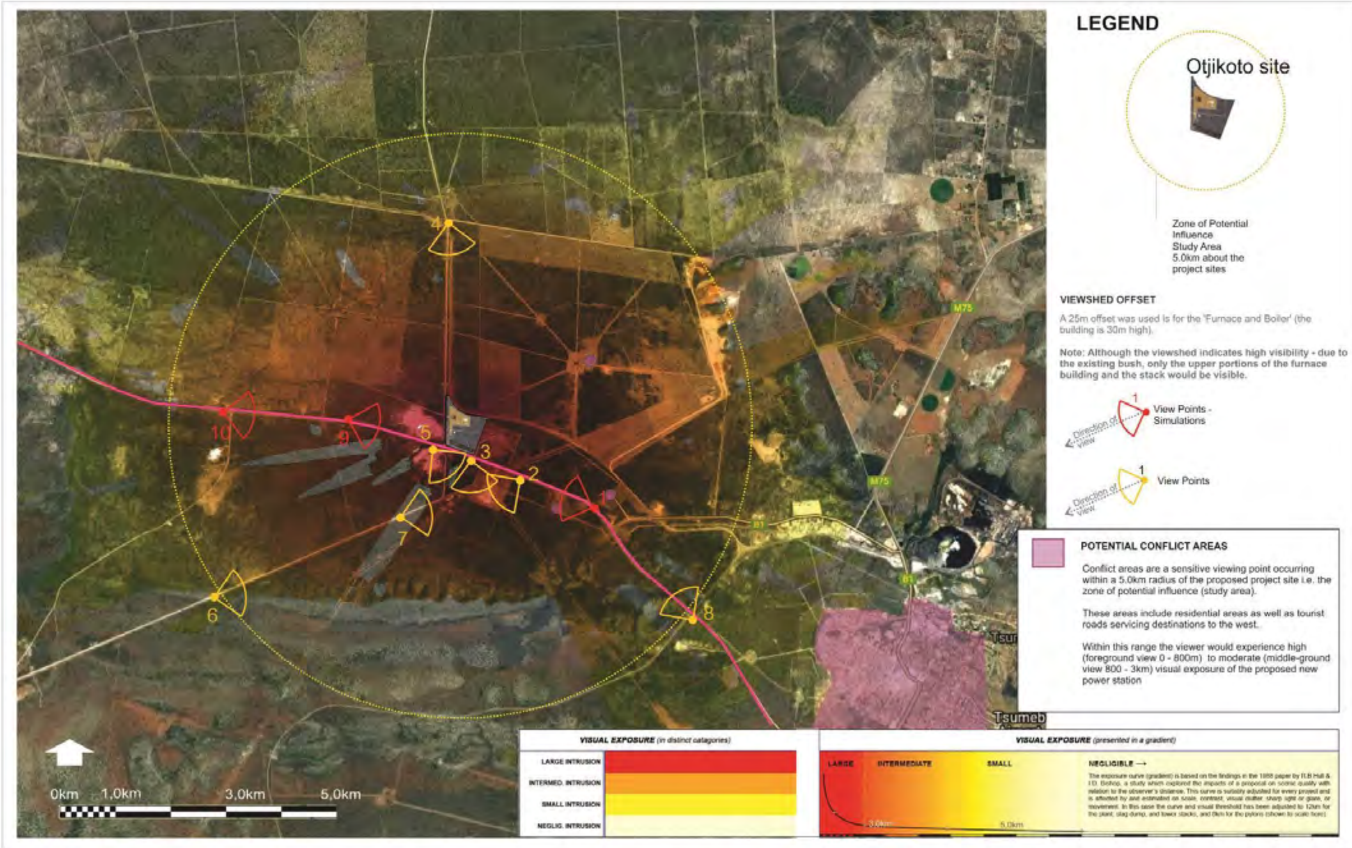


Figure 8: OTJIKOTO SITE_VIEWSHED ANALYSIS

GYLA
PO Box 331
Groenkloof 0027
+27 (0)82 462 1491

FIGURE 6-48: OTJIKOTO SITE- VIEWSHED ANALYSIS

SLR

6.11.3 Otjikoto Harvesting Area

The Otjikoto harvesting area is illustrated in Figure 4-2 and represents approximately 100 km radius about the site. This vast area stretches from Etosha National Park in the north-west to east of Grootfontein in the south-east and approximately 70 km north of Otjiwarongo in the south east and includes many potentially sensitive viewing areas (i.e. residential and tourist facilities).

Topography of the general area is undulating with low hills. The Otavi Mountains are a major topographical feature and occur south of the Power Station site approximately in a line from Otavi to Grootfontein. The relief of the harvest area shows the highest ground located to the south of the Otjikoto Power Station site, with an overall slope northward over the northern part of the study area and south-east and south-west in the southern part of the area. The northern half of the study area is mostly flat and slopes gently to the north (see section 6.2 for more details on the topography).

The Otjikoto site and associated harvesting area belong to the savanna biome. The Otjikoto harvesting area is dominated by the Karstveld vegetation type, however the condition of the veld is generally poor with higher species diversity in the hills and intermediate diversity on the flats (refer to section 6.7 for more details on the vegetation).

The general landscape character and aesthetic appeal of the study area is highest in the hills (visual resource rated high in terms of the region), which form a large east-west band across the study area south of the Power Station site. To the north and south of these hills, the landscape has fewer appealing features and within the context of the region the visual resource is considered to be low.

6.11.4 Potential Sensitivity and Visual Intrusion of the Study Areas

Potential sensitivity of the Power Station and harvesting projects is considered low, as, during the public participation process there was no mention of visual concerns. The IFC Standards for Power Stations (2012) does not list visual concerns in its guidelines, perhaps indicating that the public generally do not perceive these as being significant, when other concerns are taken into account.

However, due to the vastness of the harvesting study area and the fact that there will most likely be conflict between harvesting activities and tourist facilities, the potential sensitivity of harvesting activities could be high if these activities are not managed properly.

Visual intrusion is considered moderate for the Power Station and harvesting projects due to the following reasons:

- The project could have a moderate negative effect on the visual quality of the landscape;
- The project contrasts moderately with the patterns or elements that define the structure of the landscape; and
- The project is partially compatible with land use, settlement or enclosure patterns.

6.12 SOCIO-ECONOMIC STRUCTURE/PROFILE

6.12.1 Overview

The Oshikoto Region will be most affected as it is the site of the Power Station, the main source of its labour and the closest harvesting region (see section 4.2 for the Power Station site and associated harvesting area location). In addition, the Otjozondjupa Region is likely to be a major source of biomass and harvesting may also take place in the Kavango West Region which is over 50 km away from the Power Station. Overall, nine constituencies may be impacted by the proposed project as shown in Figure 6-49 and Table 6-16.

TABLE 6-16: LIST OF POTENTIAL REGIONS AND CONSTITUENCIES IMPACTED

Regions	Site constituency	Harvesting constituencies within radius of 0-50km	Harvesting constituencies beyond 50km
Otjikoto	**Tsumeb**	Tsumeb and Guinas	Omuthiyagwiipundi, Guinas and Eengondi,
Otjozondjupa		Otavi and Grootfontein	Otavi, Grootfontein and Okakarara
Kavango West			Mpungu and Tondoro

FIGURE 6-49: MAP SHOWING THE REGIONAL SETTING OF THE BIOMASS POWER STATION AND HARVESTING AREA

6.12.2 Population Profile

Approximately 16% of the Oshikoto Region's population lives in the two constituencies which are within a 50 km harvesting radius. In 2016, the Oshikoto Region has an estimated population of 195 165 spread over 38 673 km^2 making it of average population density for Namibia at 5.0 people per square kilometre. The region's population has grown by 13 192 between 2011 and 2016 indicating an annual growth rate of 1.4% which is also about average for the country as a whole. There are slightly more males than females but 50.7% of households are headed by females compared to the national average of 46%. The population distribution by age is fairly normal with 54% of the population in the economically active age group of 15-59 years, which is near the national average (57%). The majority of the region's population (84%) lives in rural areas and this has not changed significantly in the last ten years. The household size has dropped from 4.8 in 2011 to 4.3 which is still higher than the national average of 3.9. Among the 45 407 households in the region, the main language spoken at home is Oshiwambo (87%) (NSA, 2017).

The Otjozondjupa Region has a population of 153 903 of which 39% lived in the three constituencies which are likely to be targeted for bush harvesting. The Otavi Constituency has a total population of 12 488, which comprises of 46.1% females and 53.9% males possibly as a result of the influx of males to work in the dominant commercial farms. The Grootfontein Constituency has a total population of 24 878, which is more balanced between women and men (49% and 51% respectively). The Okakarara Constituency has a population of 22 747 of which 52% are males.

The Kavango West Region has a total population of 86 529, of which 25% live in the Mpungu and Tondoro Constituencies which could be reached by bush harvesting. The region comprises of 52.8% females and 47.2% males (NSA, 2014), probably due to the outmigration of males in search of work elsewhere.

6.12.3 Literacy and Education

Literacy is the ability to read and write with understanding in any language (NSA, 2016). The Oshikoto Regional literacy rate for the population aged 15 years and above is relatively high at 88% (which is the national average) and ranked 5th out of 14 regions in Namibia. Otjozondjupa is the third least literate region in Namibia after Kunene and Omaheke Regions due to the significant numbers of San-speaking people who do not access mainstream education when they are semi-nomadic (NSA, 2012).

A bigger barrier to secondary school in Oshikoto is income. Only 57% of 17 year olds in Oshikoto had ever attended junior secondary, and the disparity by income is large. Among children from poor households (poorest 20%), only 44% entered junior secondary, compared to 94% of children from the wealthiest 20% of households. Only half of those who enter junior secondary reached grade 10. Among the poorer children (bottom 40% of incomes), only 10% completed junior secondary compared to 64% of the wealthiest (top 20%) children (MOE-UNICEF, 2013).

The Kavango West Region grade 12 pass rates is ranked the 2nd lowest in Namibia according to statistics published by the Ministry of Education in 2015. Generally, a high failure rate calls forth, a society with the youth heading down a path that leads to lower-paying jobs, poorer health and the possible continuation of a cycle of poverty that creates immense challenges for families, neighbourhoods and communities (Furger, 2008).

6.12.4 National Economic Context

Namibia's per capita Gross Domestic Product (GDP) ranks it as an upper middle-income economy. However, this hides great inequalities as shown by a Gini Index of 57% and a dependency syndrome which threatens family/community cohesion and political stability. The country faces pervasive poverty although the level of household poverty has reduced from 28 % to 17% from 2003 to 2016. On average those poor households were only 6% below the poverty line, equivalent to N$31.2 on average per person below the upper bound poverty line (NSA, 2018a p. 15). Currently, poverty is highest amongst youth (37%), women (22.39%), marginalized and rural communities (27.15%) and children (34%). Although 72% of Namibia's potential workforce is employed, 86% of the total population earns less than the domestic worker minimum wage of N$1,353/month (RoN, 2017).

In 2017, taxes were the main source of government revenue amounting to over 57% while receipts from the Southern African Customs Union contributed 31%. Government revenue increased from N$54 billion in 2016 to N$58 billion in 2017 (NSA, 2018b).

The Namibian government has been spending more than its income since 2010 and since then, it has been borrowing and depleting its savings. In 2016, the government took big steps to curb spending and cancelled all non-urgent capital projects, froze job vacancies and reduced material expenditure wherever possible. This caused a decline in the overall economy as the construction sector shrank drastically having boomed from numerous private and public sector investments in the preceding years. Government spending cuts also affected the manufacturing, wholesale, retail and hospitality sector (IPPR, 2017). However good rainfall and an increase in production of major export commodities enabled the primary industries sector to grow by 10.7% which compensated for declines in the secondary and tertiary sectors (NSA, 2018b). Government cutbacks in 2017, enabled it to reduce its borrowing to N$9.9 billion compared to N$15.1 billion in 2016 (NSA, 2018b).

In 2017, the top four sectors which contribute to GDP were mining, wholesale retail trade and repairs, manufacturing, and the public administration and defence. Tertiary industries (such as wholesale and retail, telecommunication, hotels, restaurants and other business sectors) contributed around 58% of the share to total GDP while secondary industries (such as manufacturing, and construction) contributed 16% of GDP. The main primary industries are mining, agriculture and fishing which contributed about 19% to GDP (NSA, 2018b).

Namibia's electricity generation is largely dependent on the Ruacana hydro-electric plant and the Kunene River levels which has seasonal rainfall fluctuations and increasing off-take while it flows in Angola. In the 2017 dry season (May to December), imported electricity rose to 191 basis points[18] in November 2017. A total of 372,611 MWh was imported in December 2017 while 40,532 MWh were internally generated, and 9,728 MWh were exported. Over the whole year, there was a 64% increase of imported power (Figure 6-50)(NSA, 2018).

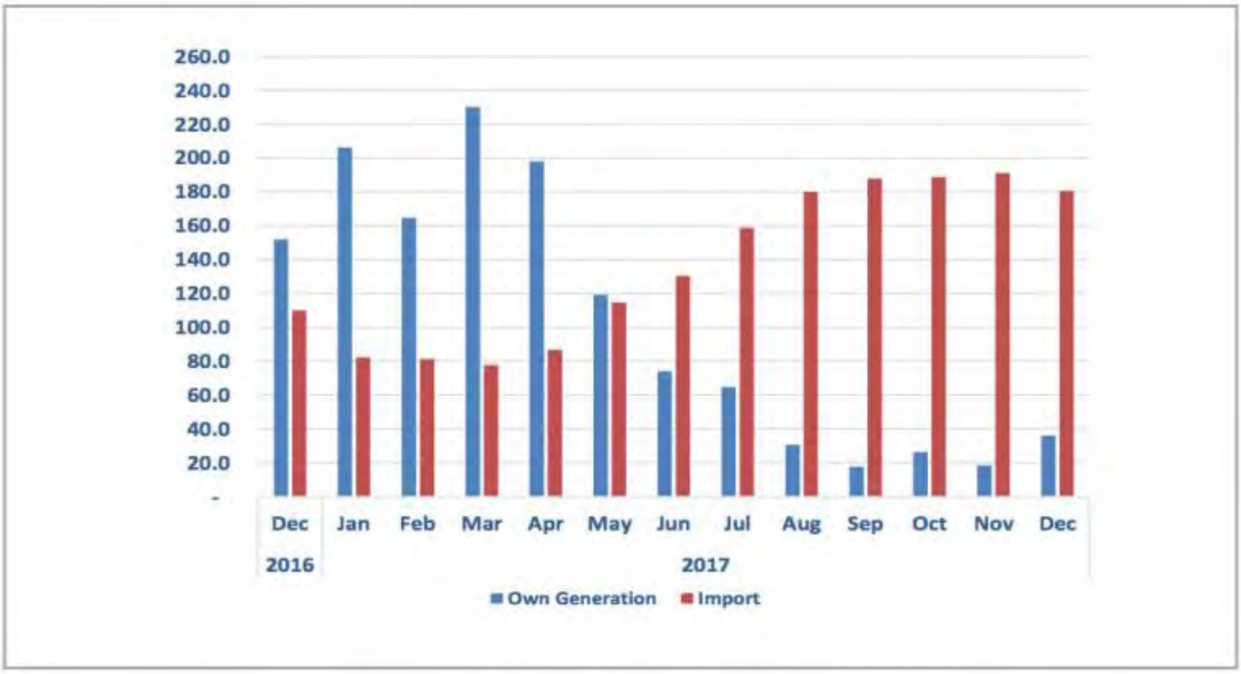


FIGURE 6-50: NAMIBIA'S OWN-GENERATED AND IMPORTED SOURCE OF ELECTRICITY 2017

The Minister of Finance stated in his budget speech in 2018 that the main challenges are as follows:

- "the structure of the economy remains dualistic and is in need of diversification and transformation;

[18] 2010 = 100

- poverty is on a declining path, but levels are still high for an Upper Middle Income country and so is inequality;
- at 34%, unemployment is structurally high and youth unemployment distinctively higher;
- the skills deficit is wide, and
- we need to hone competitiveness, productive capacity and innovation so as to expand our productivity frontiers and gains from trade, given the increasingly integrated and globalized regional economy" (MoF, 2018).

6.12.5 Poverty – Mulitple Deprivation

Poverty means not having enough financial resources to meet a need, whereas deprivation refers to an unmet need which is caused by a lack of resources of all kinds, not just financial resources.

At a national level, the Multidimensional Poverty Index based on 2013 data of 10 factors (nutrition, child mortality, years of schooling, children enrolled in school, cooking fuel, access to toilet water electricity, type of floor and assets) found that over 61% of Namibia's rural population lives in multidimensional poverty, compared to only 17% of the urban population. In addition, 19% of the national population are vulnerable to poverty and 13% are living in severe poverty.

The National Planning Commission of Namibia has recommended that development planners use the Namibian Index of Multiple Deprivation (NIMD), which is a composite index reflecting five dimensions of deprivation: material deprivation, employment deprivation, health deprivation, education deprivation and living environment deprivation. Deprivation refers to an unmet need which is caused by a lack of resources of all kinds, not just financial resources.

Figure 6-51 shows Tsumeb and the potential harvesting area superimposed on the Index of multiple deprivation at Datazone level. Areas of dark blue are most deprived compared to bright yellow which represent areas of least deprivation. There are areas to the north and the north east where people are deprived across the five parameters.

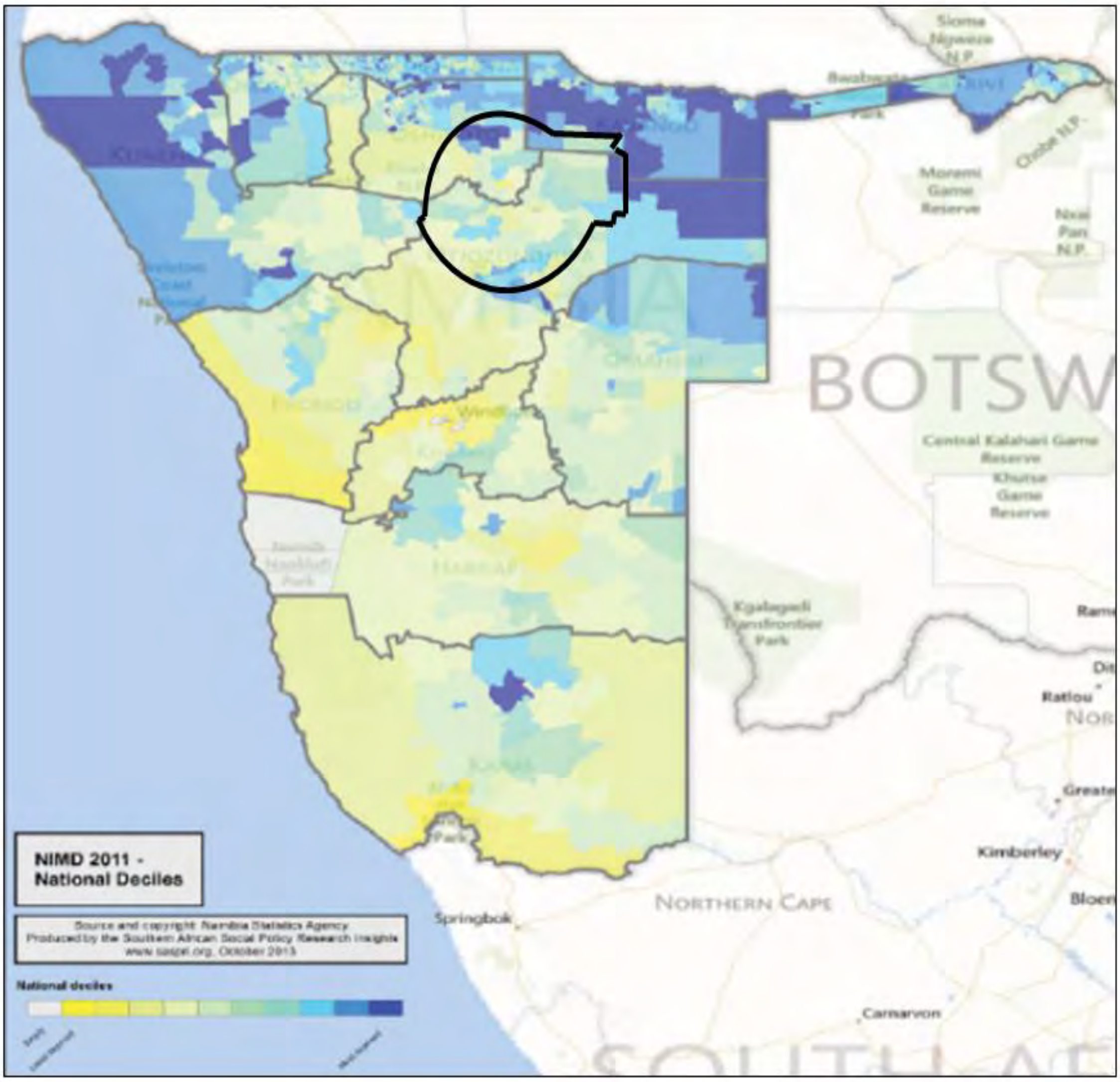


FIGURE 6-51: LEVELS OF MULTIPLE DEPRIVATION IN THE HARVESTING AREA (SOURCE: NPC 2015 NAMIBIA INDEX OF MULTIPLE DEPRIVATION)

6.12.6 Employment Deprivation

Employment deprivation refers to involuntary exclusion of the working age population from the world of work, by reference to the percentage of the working age population that is unemployed and falling in the 15 to 59 years inclusive age group. The exact definition of unemployment used in the 2011 census and used for this indicator is as follows:

- Without work, i.e. in a situation of total lack of work;
- Currently available for work, i.e. not a student or homemaker or otherwise unavailable for work; and
- Seeking work, i.e. taking steps to find employment or self-employment. The Census distinguished between the 'officially' unemployed and the 'discouraged' unemployed, but they are combined in this indicator.

Figure 6-52 below shows the Otjikoto site and harvesting area superimposed on the index of employment deprivation at constituency level. Most of the proposed harvesting area covers a population which is not very deprived in terms of employment. The exception is the Omuthiyagwiipundi Constituency, to the west of Tsumeb, which is the 6th most employment deprived constituency in the country (NPC, 2015). A large part of the constituency is taken up by the Etosha National Park in which reside many San people who face limited employment opportunities.

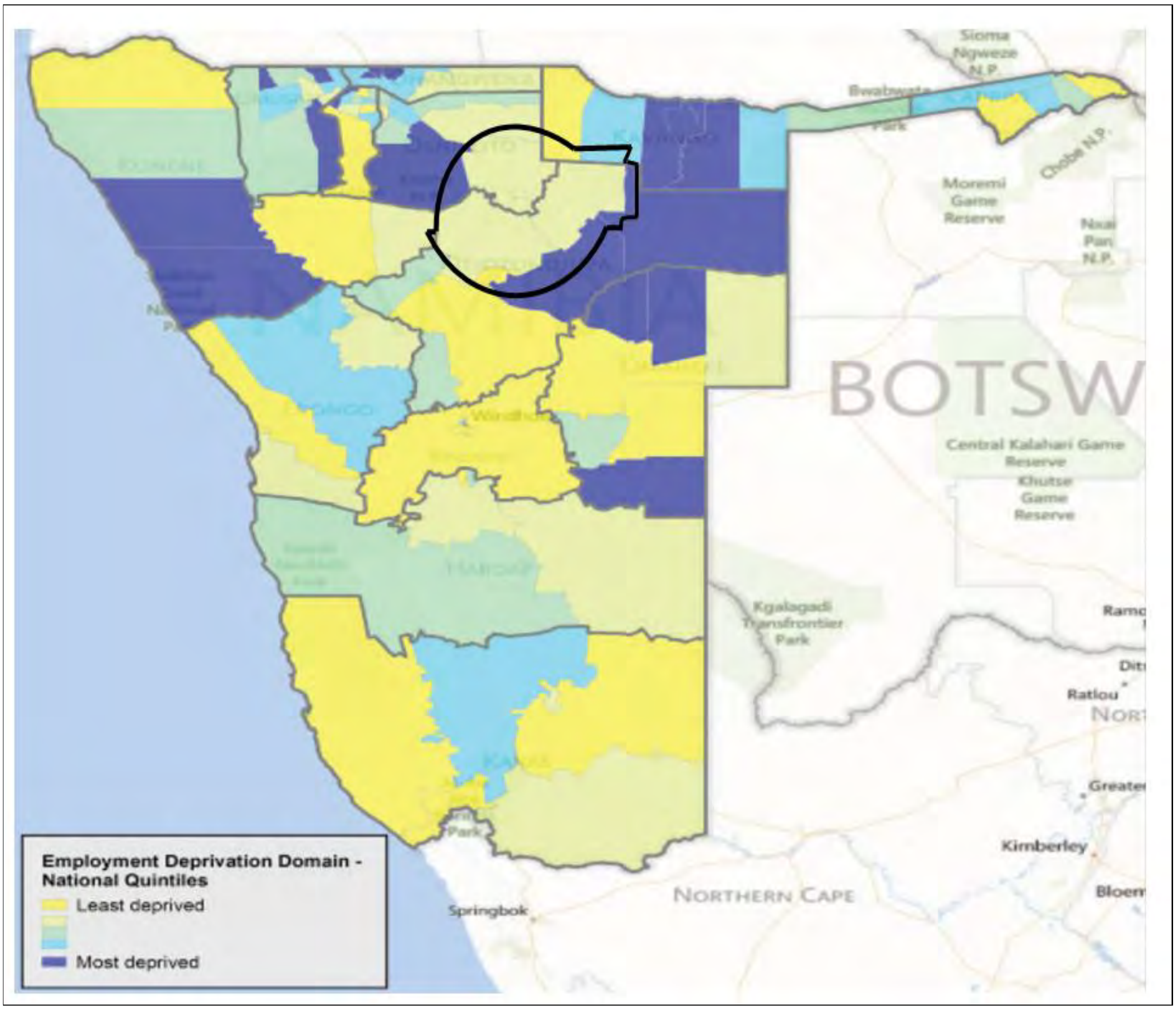


FIGURE 6-52: LEVELS OF EMPLOYMENT DEPRIVATION IN THE HARVESTING AREA AROUND TSUMEB (SOURCE: NPC 2015 NAMIBIA INDEX OF MULTIPLE DEPRIVATION)

Unemployment levels vary between 31% in the Grootfontein and Otavi Constituencies to 47% in the Okakarara Constituency. There are no figures given for the Omuthiyagwiipundi Constituency, but it is likely to be higher still, given the poverty levels there, particularly among the vulnerable groups.

Wages and salaries generate the main source of income in the Otjozondjupa Region for 60% of households which is significantly higher than the national average of 48% (NSA, 2014). Wages and salaries were the highest main source of income in Otavi Constituency (72%) and in the Grootfontein Constituency (74%) but only 27% in the Okakarara Constituency where income from farming was the main income source. The Mpungu and Tondoro constituencies rely heavily on farming as their main source of income, 70% and 59% respectively.

6.12.7 The Local Economic Environment

Tsumeb used to be the former capital of the Oshikoto Region and is regarded as the region's industrial and commercial agricultural hub. The new capital, Omuthiya, serves the largely rural, Oshiwambo-speaking people to the north west of the region.

The two largest power consumers and employers in the area are the Tshudi Copper Mine owned by Weatherly International Mining and Dundee Precious Metals Tsumeb (Pty) Limited (DPMT) formerly known as the Namibia Custom Smelter (NCS). DPMT is the largest employer in Tsumeb employing over 700 permanent workers and 87 temporary employees, with a further 400 supply chain related jobs. The company has invested heavily in a new smelter, which has state of the art gas filtration systems which can treat complex copper concentrates imported from Bulgaria, South America and Europe via the port at Walvis Bay. In 2017, the smelter produced over 45,523 tonnes of blister copper and 221,050 tonnes of sulphuric acid and had a turnover of over N$1.8 billion of which over N$379 million was spent on wages and salaries (COM, 2018).

The Tschudi mine is an open cast copper mine which produced 15,466 tonnes of pure copper cathode in 2017. In that year, it had 627 contractors and it employed 122 permanent employees and 27 temporary workers, spending over N$67 million on wages and salaries, out of a turner of N$1.18 billion (CoM, 2018 p. 51). The proposed Power Station will have power lines connecting directly to the grid at the Otjikoto substation to produce electricity for these major consumers.

Other than the mining industry, the local economy is largely supported by over one hundred commercial farms in a approximately100km radius of the Otjikoto substation, by charcoal production and the Henning Crusher (Pty) Ltd activities, regarded as one of the biggest stone crushers in Namibia.

The Tsumeb Municipality 5 Year Strategic Plan (2011-2016) aims to place the town as the regional strategic hub for the SME industry and to capitalise on the potential of the maize triangle to becoming the bread basket of the country. The Plan makes note of the fact that the town was hard hit by unemployment exacerbated by an influx of people who have largely settled in the informal settlement, located southwest of the town.

There will be no staff accommodation on site, the 300 construction contractors and workers will therefore be transported back and forth site from Tsumeb. It is likely that most construction workers could be sourced from existing residents but incoming workers could rent from existing accommodation owners during the approximately24 month's construction phase of the project, thus boosting the local economy. Tsumeb has a history of employment expansion and contraction and there is a range of housing available for the 62 skilled and semi-skilled employees expected to be employed during the operation phase.

Bush encroachment has contributed to the economic losses for farmers, farm labourers and their families that heavily rely on livestock productivity. It is having a severe impact on the Tsumeb-Grootfontein–Otavi triangle rangelands as a result of the dominant *Dichrostachys cinerea* (sickle bush) plant (refer to section 6.7). This bush covers a wide footprint within the approximately100km radius of the Otjikoto substation, thereby reducing livestock rangeland's productivity. The de-bushing activities aimed at feeding the proposed biomass Power Station should indirectly uplift the economy of the agricultural sector by increasing the carrying capacity and biodiversity of the grazing areas. This will also benefit the commercial farming of game which is widely practiced and generates revenue from international visitors for hunting and game viewing. However, post-harvest treatment of *D. cinerea* to reduce re-growth is time consuming and expensive and is proving to be a real challenge for farmers.

6.12.8 Closest sensitive receptors

With reference to sections 6.9.2 and 6.10.3, the closest noise-sensitive receptors (NSRs) to the Power Station are approximately 200m to the east and approximately 1,500m to the south-east. Other receptors within 20km of the Otjikoto site is presented in Figure 6-46, which include individual homes, communities and also the town of Tsumeb (and its suburbs to the south-east).

6.12.9 Involuntary Resettlement

"Involuntary Resettlement" protects the fundamental human rights of people and communities who are displaced from their original place of residence or economic activities or subsistence practices due to the project's activities. The Namibian Constitution, Article 16.2 states that property may be expropriated in the public interest subject to payment of just compensation.

With reference to section 4.2, NamPower owns the land where the proposed plant will be constructed. Also, the site is currently on vacant land so there are no households to be resettled.

Where bush harvesting takes place on farmland, the Harvesting EMP (Appendix 15) recommends a buffer zone of no harvesting around every habitation to prevent adverse environmental impacts affecting people, therefore there should be no need to resettle people in harvesting areas (refer to section 7).

Potential environmental and social impacts resulting from the project activities, also relating to the households living at the closest sensitive receptors (Section 6.12.8), are assessed in section 7. Taking the design requirements of the Power Station and management and mitigation measures into consideration (section 7 and the Power Station EMP), no resettlement is required.

As no household needs to be moved as a result of this project, there is no need for involuntary resettlement and will therefore not be discussed further in the report.

6.12.10 Vulnerable Groups

The EIB Standard 7 focuses attention on the rights and interests of vulnerable groups which are context-specific and may include women, children, the elderly, poor, minorities or indigenous groups. The IFC Performance Standard 7 recognises that Indigenous Peoples are often the most marginalised and vulnerable segments of the population. The Constitution of Namibia emphasises equality and freedom from discrimination on the grounds of sex, ethnic origin or social or economic status etc. It does not make specific reference to marginalised or indigenous groups, but Article 23 allows Parliament to enact legislation to provide affirmative actions to redress social, economic and educational imbalances.

6.12.10.1 *The San*

The Namibian Government prefers to speak about "marginalised" rather than "indigenous" communities, defining "indigenous" by reference to European colonialism, implying that the vast majority of Namibians are in fact "indigenous". The overarching group known as "San", who are former hunter-gatherer communities, include several different ethnic groups with distinct languages and dialects. In general, San individuals identify themselves according to their ethnic group, i.e. Ju|'hoansi, !Xun (or !Kung), Hai||om, Naro, Khwe or !Xoon, rather than as "San" (a generally accepted political label), which like "Bushmen", an external term.

There are between 27 000 and 38 000 San people in total in Namibia, (equivalent to about 2% of the national population) and it is not known how many live within the project area, but it is likely to be several thousand. They live on commercial farms, in the corridors between the farms, on resettlement farms, in communal areas among other ethnic majorities, in conservancies and community forests, in national parks and in urban townships. Despite these variations and forms of land tenure, all of the San groups share both a history and current experience of marginalisation. The level of poverty of the San is unmatched by that of any other group in Namibia. In the Human Development Index the San are ranked at 0.35, whereas the national average is 0.55 (LAC, 2014).

San representation at national level is problematic. Government recognises five San Traditional Authorities (TAs) – the Hai||om, !Xun, Ju|'hoansi, Omaheke North and Omaheke South but three of the five recognised TAs face serious challenges in respect of community support. The LAC study estimated that at least a third of all San in Namibia have no recognised TA representing their interests as San at national level (LAC, 2014). In addition to the San Traditional Authorities and the Namibian San Council, there are a number of smaller San community-based organisations, some of them fairly successful, others not (yet). Their main areas of work are tourism, culture, capacity building and conservancies.

Within the harvesting area, there are several government owned, resettlement farms on which live previously disadvantaged Namibians, destitute families such as evicted farmers workers and San families.

The ombudsman confirmed in September 2018 that there are 449 resettlement farms in Namibia, on which 5,731 beneficiaries were resettled. The aim of the resettlement programme is to attain self-sufficiency by means of creating employment through full-time farming. In the Oshikoto Region, the Ministry of Land Reform (MLR) has registered 1,467 beneficiaries registered on 14 resettlement farms (Table 6-17).

TABLE 6-17: RESETTLEMENT FARMS IN THE OSHIKOTO REGION WHICH ARE WITHIN THE HARVESTING AREA

Farm	Approximate Distance & Direction from Tsumeb	Responsible Ministry	Level of Bush Encroachment	Occupants
Excelsior; #825	35km, NE	MLR	Bush encroached	15 farmers, nine (9) female; mostly San families, resettled in 2018.
Tsintsabis; # 881	65km, NNE	MLR	Not bush encroached	256 households =~1280 people, mostly San; resettled in 1993
Ondera; #308	100km, NW	Office of Vice President	Bush encroached	Mostly San families
Hegwigslust; #307	90km, NW	Ombili Foundation	Bush encroached	Unknown
Rooiplaas; #772; portion 2	15km, ESE	MLR	150 ha farm. Bush encroached. Access only through a private farm which changes the locks to prevent access.	6 San families, resettled in 2009 (former farm workers). Water is shipped in; Water table is 200m deep. No borehole on that farm portion.
Vlakte #849 and Welgevonde #850	60km, NNW	Not sure. Given to the Damara Administration Pre-	Bush encroached	Mostly San families

		Independence & no line ministry has taken responsibility		
Ludwigshafen; #480	15km NE	MLR	Not bush encroached	Ludwigshafen Worker Trust; Mostly San families; resettled in 2008
Tsumore: #761	20km, W	MLR	Bush encroached	Two (2) beneficiaries. (1 male, 1 female) +-300 San living at the workers quarters, Unit A
Urwald; #1150 Or Oerwoud	50km, NNE	MLR	Not bush encroached	89 farmers in a group scheme (40male, 45 female) plus 69 outside demarcated plots; with 7 farming units resettled in 1992
Chudip-Nuut; #1137	60km, NNE	MLR	Bush encroached	13 farmers; 4 female; mixed ethnic groups; resettled in 2000
Leeupos & Hugeland; #390/866	60km, NW	MLR	Some charcoal production	6 farming units, all male; resettled in 2000
Welmoed; #848	35km, N	MLR	Heavily bush encroached	15 farmers, 5 females; resettled in 2000
Ramona; #886	50km, NNW	MLR	Bush encroached	6 farming units, 1 female headed unit; resettled in 2006
Walroda Ost, # 545	60km, SW	MLR	Bush encroached	2 farmers; 1 female; resettled 2005
				1467 beneficiaries as on Oct 2018

(Source: https://www.ombudsman.org.na/wp-content/uploads/2018/10/Oshikoto-Region.pdf and MLR office in Tsumeb)

In the Otjizondjupa Region, Farm Neu Sommerau (farm number 1359), was allocated to 234 named farmers in a group scheme in 2003.

Some resettlement farmers have been provided with the appropriate packages such as Affirmative Action Loan Schemes and the Farmers Support Programme which help them farm productively and manage their rangeland. However, on most farms, the farmers do not have security of land tenure to get loans, or sufficient resources or technical skills to manage their farm productively. When more than one household is allocated a farm portion, their combined livestock are often well beyond the carrying capacity of the land, even in good rainfall years.

For example, six San families were resettled on bush encroached Farm Rooiplaas (see Table 6-17) in 2009 and they have no water point, therefore government has to truck water in. There are now approximately 1,280 San people in 256 households on Farm Tsinsabis who are dependent on food aid from government. Farm Ondera & Komeva was bought by government in 2012 and now houses over 500 people, mostly San, in 130 households. Government and donors have purchased 600 cattle and 100 goats and established a 19 ha area under stable crop and vegetable production for this community, but it is unlikely that two farms will raise that number of people out of poverty.

The project could play a positive role in reducing the poverty of resettlement farmers, especially those occupying and in groups, such as the San. The impact is assessed in section 7.

6.12.10.2 *Women*

Section 6.12.5 gives some insight into the widespread multidimensional poverty experienced by up to 60% of Namibia's rural population. In 2011, 44% of households were headed by women of which 22% were classified as poor and 11% severely poor. Women in Namibia experience pervasive gender and intra-household inequalities. The fifth National Development Plan recognises that "poverty among females is linked to their unequal access to, control over and benefit from an uneven distribution of productive resources such as land, capital, education, labour and limited participation in political and economic institutions".

Women are poorer, less likely to be employed and, even when employed earn less than men on average in most sectors. However, the gender gap is not that large. For example, in 2018, the national labour force participation rate was 69% of women compared to the higher rate for men of 73.5%. This pattern was similar in rural and urban areas and in most regions. of those employed in urban areas, there were slightly more males (50.9%) employed compare to females (49.1%) while in rural areas there were more females (51.7%) employed, reflecting their work as subsistence farmers. In most rural communities, women and children make up 75% of the workforce responsible for collecting water and firewood.

Unemployment is higher among women (34%) compared to 32.5% for men. Unemployment rates for women in all age groups under 50 years are higher than for males in the same age groups but particularly so for the 20-24 age group where 60% of young women are unemployed compared to 53% of young men. The average monthly wage of paid employees across all industries was a bit higher for men (N$8,052) compared to N$7,789 for women.

The National Human Rights Action Plan notes discriminatory practices against women in respect of access to and ownership of land, and inheritance issues. The Committee on the Elimination of Discrimination against Women (2015) expressed its concern that women experience limited access to land and information on accessing microfinance and micro credit schemes. Land grabbing by relatives of deceased spouses, leaving the wife and children landless continues as traditional customs ignore the principles of equality and women's rights as set out in the Constitution and the National Land Policy of 1998 respectively.

In Namibia, women's educational attainment fares as poorly as men. From the 2011 Population Census, slightly more women have completed both primary education (19% women compared to 18% of men) and secondary education (43% women compared to 41% of men). Only 6% of both men and women have completed tertiary education. In most regions, a higher proportion of age-appropriate girls are attending school than boys. More girls attend school than boys up to the age of 14 and from 15 years more boys attend than females up to the age of 20 years, when again there are more females than males.

The most challenging area of gender equality centres around the family which is where most gender based violence takes place. Customary law remains almost untouched and overt sex discrimination exists around gender stereotypes, about men and women's roles in the family, and concerning marriage, divorce and inheritance. The majority of women of 15 years (59%) have never married. of the remainder, a majority reported that they are participants in household decision-making on financial matters, social and health care, together with their husband. Only 40% of married women decide on their own how to use their earnings. Decreasing household wealth increased the likelihood that the husband would decide on how to spend the wife's earnings.

The project could play a positive role in upholding and improving the rights and interests of women. The impact is assessed in section 7.

6.13 BACKGROUND TO CLIMATE CHANGE

Information in this section was sourced from the Air Quality, Climate change and Health Risk Assessment (Airshed, 2018) included in Appendix 5.

6.13.1 Link to Anticipated Impacts

Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect.

Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there is a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007).

Human activities since the beginning of the Industrial Revolution, taken as the year 1750, have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017 (NOAA, 2017). This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2017). Anthropogenic carbon dioxide (CO_2) emissions i.e. emissions produced by human activities come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

This section provides a background Namibia's intended Nationally Determined Contribution to Climate change.

6.13.2 Namibia's Response to Climate Change and the Country's Intended Nationally Determined Contribution

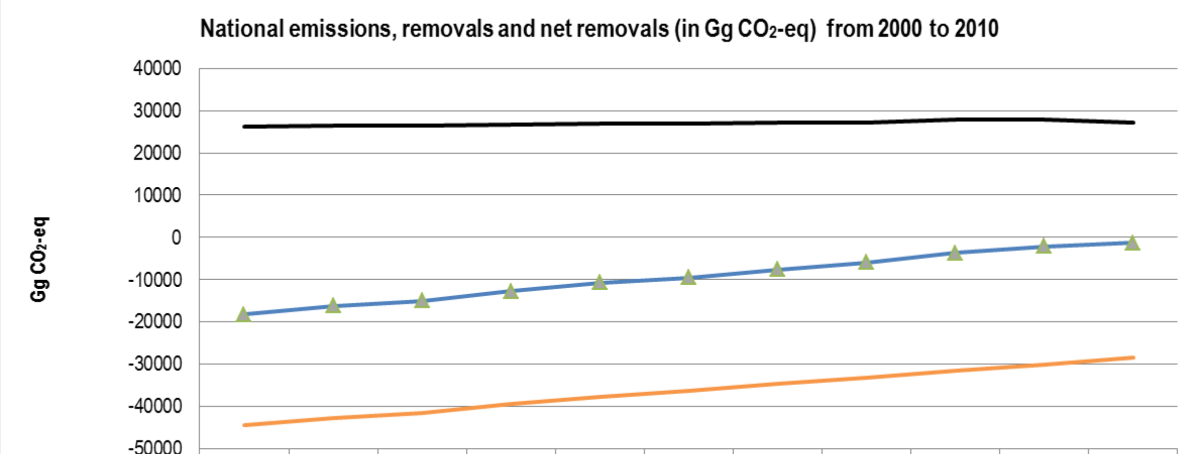
Climate change has been identified as a critical threat to sustainable development and general welfare of society in Namibia. Namibia has the most arid climate of all southern African countries and its economy is exposed to difficult and harsh conditions, with water accessibility a serious problem. A large proportion of the Namibian people are reliant on the natural environment for their livelihood i.e. it is a natural resource-based economy, and the existing fragility of the environment i.e. the arid climate and variability in climatic patterns, as well as a limited adaptive capacity of the population due to poverty and high divergence of income levels. This makes Namibia one of the most vulnerable countries to climatic change impacts (Kamwi, 2015). Namibia has recognized the threat posed by climate change and has put an appropriate policy framework in place to deal with this threat. The key milestones in Namibia's response to climate change are outlined in the Air Quality, Climate change and Health Risk Assessment (Appendix 5).

Namibia's Intended Nationally Determined Contribution (INDC) was submitted in September 2015 (Republic of Namibia 2015, cited in Namibia Country Diagnostic 2017) and converted to a Nationally Determined Contribution (NDC) in 2016 (Namibia Country Diagnostic, 2017).

Currently Namibia is already contributing a share of its resources to combat climate change; in the future this contribution will be about 10% of INDC requirements, fully conditioned to the provision of the differential 90% of means of implementation in the form of finance, technology transfer, and the associated capacity building from Annex 1 Parties, as stipulated under Article 4 of the UNFCCC (Namibia Country Diagnostic, 2017). Namibia also considers international market-based mechanisms a potential component in achieving its 2030 target[19].

According to the Third National Communication to the UNFCCC three national Greenhouse Gas Inventories have been prepared to date. It was found that Namibia's contribution to global greenhouse gas (GHG) emissions is negligible and that Namibia may be considered a net sink of carbon dioxide. This is attributed to the large uptake of carbon dioxide by trees into their woody tissues, and bush encroachment (part of the Agriculture, Forestry and Other Land Use (AFOLU) sector) (GRN, 2002).

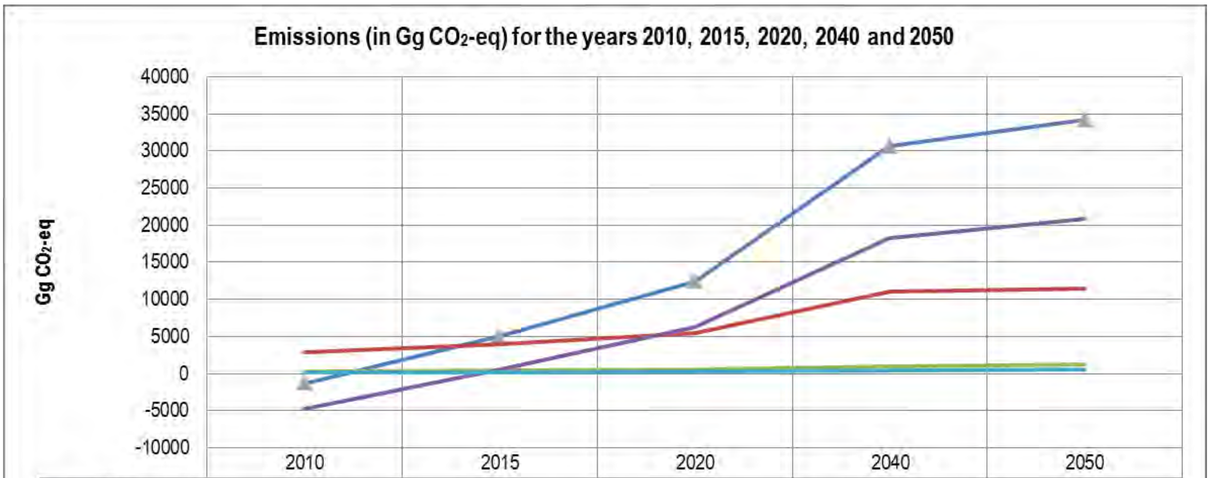
Namibia remained a net GHG sink over the whole period 2000 to 2010. However, this sink capacity steadily declined by 64% over this period. The net removal of CO_2 thus decreased from 18 278 Gg to 1339 Gg (Figure 6-53), as a result of the Agriculture, Forestry and Other Land Use (AFOLU) removals falling from 44 459 Gg CO_2-eq in 2000 to 28 534 Gg in 2010. Relative to the base year 2010, it is projected that the country will lose its sink capacity and become a net emitter of GHG under the Business as Usual (BAU) scenario (Figure 6-54).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Emissions	26180	26569	26433	26817	26999	26866	27204	27281	27976	27978	27195
Removals	-44459	-42739	-41501	-39532	-37707	-36402	-34781	-33264	-31641	-30075	-28534
Net Removals	-18278	-16171	-15069	-12716	-10708	-9536	-7577	-5983	-3664	-2096	-1339

FIGURE 6-53: NATIONAL EMISSIONS, REMOVALS AND NET REMOVALS (IN GG CO2-EQ) FROM 2000 TO 2010 (GRN, 2015)

[19] Namibia intends to establish a carbon register to record the outcome of all development activities linked with emission reductions and removals; the same carbon register will be used for emission offsets and trading on the international market.



	2010	2015	2020	2040	2050
Net Emissions	-1339	5012	12441	30649	34162
Energy	2904	3933	5434	11101	11459
IPPU	302	383	507	924	1267
AFOLU	-4691	513	6259	18200	20850
Waste	146	183	241	424	586

FIGURE 6-54: AGGREGATE EMISSIONS (IN GG CO_2-EQ) FOR THE NATIONAL INVENTORY, PROJECTED UNDER THE BAU SCENARIO FOR THE YEARS 2010, 2015, 2020, 2040 AND 2050 (GRN, 2015)

The most recent estimates as reported by Namibia Country Diagnostic (2017) puts Namibian GHG emissions per capita at 9.15 Gg CO_2-eq with the total national emissions estimated at 0.02% of the global total, viz approximately 7 252 Gg CO_2-eq (in 2016). Namibia aims to reduce GHG emissions by 89% by 2030, compared to the BAU scenario. The focus areas to achieve this mitigation objective are: sustainable energy; transport; and AFOLU.

7 ENVIRONMENTAL IMPACT ASSESSMENT

This chapter describes and assesses the significance of potential impacts associated with the proposed biomass Power Station activities, overhead power line, harvesting and associated actives.

7.1 INTRODUCTION

Potential environmental impacts were identified by SLR in consultation with I&APs, regulatory authorities, specialist consultants and NamPower.

The impacts are discussed under issue headings in this section. Impacts are considered in a cumulative manner where possible such that the impacts of the proposed Biomass Power Project are seen in the context of the baseline conditions described in Section 6. Information that has been included in section 6 will not be repeated in this section.

The discussion and impact assessment for each sub-section covers the construction, operational, decommissioning and closure phases where relevant. This is indicated in the table at the beginning of each sub-section. Included in the table is a list of project activities that could cause the potential impact per project phase. The activities that are summarised in this chapter, link to the description of the proposed project (see section 4). The potential impacts associated with the Power Station and powerline are furthermore separately assessed from the harvesting and associated activities, as indicated in the sections below.

Key management and mitigation measures to address the identified impacts are discussed in this section and included in more detail in the two EMPs (i.e. EMP for the propose Power Station and the overhead powerline and EMP for the harvesting and associated activities) that are attached in Appendices 14 and 15. In most cases, unless otherwise stated, these mitigation measures have been taken into account in the assessment of the significance of the mitigated impacts. In developing the management and mitigation measures, it is recognised that NamPower has a Safety, Health, Environmental and Quality (SHEQ) Management System in place. Where relevant, reference is made to this system in the EMPs. A copy of the NamPowr SHEQ Policy Statement is attached as Appendix 3 of this EIA Report.

Both the criteria used to assess the impacts and the method of determining the significance of the impacts is outlined in Table 7-1. This method complies with the Environmental Impact Assessment Regulations: Environmental Management Act, 2007 (Government Gazette No. 4878) EIA regulations. Part A provides the approach for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D. Both mitigated and unmitigated scenarios are considered for each impact. In addition, a comment on SLR's confidence in the significance rating is provided for each impact. The confidence options range from high, to moderate to low and must be read in the context of the assumptions, uncertainties, and limitations set out in section 8 and Appendices 5 to 13.

TABLE 7-1: CRITERIA FOR ASSESSING IMPACTS

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

PART B: DETERMINING CONSEQUENCE					
			SEVERITY = L		
DURATION	Long term	**H**	Medium	Medium	Medium
	Medium term	**M**	Low	Low	Medium
	Short term	**L**	Low	Low	Medium
			SEVERITY = M		
DURATION	Long term	**H**	Medium	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Low	Medium	Medium
			SEVERITY = H		
DURATION	Long term	**H**	High	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Medium	Medium	High
			L	**M**	**H**
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
			SPATIAL SCALE		

PART C: DETERMINING SIGNIFICANCE					
PROBABILITY (of exposure to impacts)	Definite/ Continuous	**H**	Medium	Medium	High
	Possible/ frequent	**M**	Medium	Medium	High
	Unlikely/ seldom	**L**	Low	Low	Medium
			L	**M**	**H**
			CONSEQUENCE		

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

Against the above background, the potential impacts associated with all the phases (construction, operations, decommissioning and closure) have been conceptually identified and described and reference has been made to the studies/investigations that are required to provide the necessary additional information.

Airshed however followed a different methodology for both the Health Risk Assessment and Climate Change Assessment (sections 7.12 and 7.13 respectively).

Health risk assessments evaluate the probability that exposure to a certain air pollutant will result in a given adverse effect in an individual or defined population. Since the emissions from a biomass Power Station will be released into the atmosphere, the dominant exposure pathway is inhalation; however, small quantities of the toxic pollutants enter the body via ingestion[20] and dermal exposure[21].

For the purpose of this study, the health risk assessment focused only on the inhalation pathway and on the pollutants flagged during the AQIA. The ambient air quality standards and guidelines, used in the AQIA, are aimed to provide safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. When simulated GLCs exceed these guidelines and standards, it indicates a potential for health risks.

The US EPA defines Health Risk: *Hazard x Exposure*. The hazard associated with substances or pollutants has been established to great extent by animal experiments and human studies. The potential for health effects is linked to the magnitude or level of a specific substance or pollutant and the duration of exposure (US EPA, 2014).

The main steps in evaluating a risk to human health include the following:

- Hazard quantification;
- Dose-response assessment;
- Exposure assessment; and
- Risk characterization.

The emission of greenhouse gases has a global impact, it was therefore not feasible to follow the normal impact assessment methodology, with regards to comparing the state of the physical environment after implementation of the project to the condition of the physical environment prior to its implementation for the Climate Change Assessment. Instead, this report assessed the following:

- The GHG emissions (carbon footprint) during the construction, operation and decommissioning of the project when compared to the global and Namibian emission inventory.
- The impact of climate change on the project, i.e. the robustness of the project over its lifetime with respect to climate change.
- The vulnerability of communities in the immediate vicinity of the project with respect to climate change.

7.2 TRAFFIC

The information in this section was sourced from the traffic specialist study, (Burmeister, 2018) (refer to Appendix 13).

With reference to Table 7-3 there are a number of transportation activities in all phases of this proposed project that have the potential to impact on the existing road transportation infrastructure, i.e. road capacity and road

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[20] It was ascertained from the literature (from a study for a similar sized plant and biomass fuel) that the substances that can be absorbed via ingestion, such as dioxins/furans, cadmium and mercury, will be released in very small amounts and do not pose a risk to human health.

[21] Dermal exposure is likely to occur only in an occupational setting, whereas the focus in this study is on the ambient population.

condition/deterioration (which could cause impacts to road users and safety). The increase in transportation activities during the construction and decommissioning will be temporary in nature, while the operational activities will be of a long term nature. No impacts are expected in the closure phase.

The traffic impacts were assessed for 5 scenarios as described below (Table 7-2). Traffic growth of 3% per annum was applied to the scenarios and the trips generated by the project added to the relevant scenarios (see section 6.3 for the existing scenario at CTO 19).

- Scenario 0 (S0): Current condition without the project.
- Scenario 1 (S1): Base Scenario in 2022, without the project.
- Scenario 2 (S2): Base Scenario in 2022, with the project, i.e. the Power Station is in operation.
- Scenario 3 (S3): Scenario after 20 years in 2042, without the project.
- Scenario 4 (S4): Scenario after 20 years in 2042, with the project, i.e. the Power Station has been in operation for 20 years and expected to be at the end of the plant lifespan.

TABLE 7-2: TRAFFIC ANALYSIS SCENARIOS

Scenario	S0	S1	S2	S3	S4
	Existing	Base without Project	Base with Project	Year 20 without project	Year 20 with project
Assessment Year	2018	2022	2022	2042	2042
ADT - Light vehicle	987	1230	1230	1910	1910
ADT - Heavy vehicle	610	760	842	1181	1263
ADT – All vehicles	**1597**	**1990**	**2072**	**3091**	**3173**
Peak Hour volume (both directions)	273	340	361	528	548
Peak Hour volume (one directions) ***30th highest peak of the year***	137	170	180	264	274
Typical normal day peak hour (one direction)	90	104	186	140	222

TABLE 7-3: IMPACT ON ROAD CAPACITY AND ROAD SAFETY – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	-	Moving equipment and workers to the specific harvesting area.	-
Transport of biomass and ash	Transport of the wood chips to the Power Station - 3 month pre-commissioning stockpile.	Transport of the wood chips to the Power Station and ash from the plant.	-
Power Station	Vehicle movement associated with earth moving activities. Transportation of construction workers.	Deliveries, including chemicals for the Power Station. Transportation of operational personnel to the Power Station and back, on a daily basis.	Vehicle movement associated with demolition and rehabilitation activities Transportation of workers

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
	Deliveries, including abnormal vehicles.	Collection activities, in particular waste and ash from the plant.	
Overhead power line		-	

7.2.1 Issue: Impact on Road Capacity and Road Condition/Deterioration – TR 1/10

7.2.1.1 *Introduction*

TR 1/10 is a two-lane highway and can be classified as a Class I two-lane highway where motorists expect to travel at relatively high speeds. Two-lane highways are in principle different from uninterrupted flow facilities, like a freeway, since the passing manoeuvres take place in the opposing lane of the traffic. The passing manoeuvres are therefore limited by the availability of the gaps in the opposing traffic stream and by the availability of sufficient sight distance for a driver to discern the approach of an approaching vehicle safely. As traffic increases, the opportunities to pass decrease. Platoons can create which causes a delay to the trailing vehicles. Two-lane highways operating quality decreases sharply as demand flow increases and operations can become unacceptable at relatively low volume-to-capacity ratios.

A single traffic lane theoretically has a capacity of 1,800 vehicles per hour. However, the actual capacity of a two-lane highway would be significantly less than the 1,800 vehicles per hour for the reasons stated above.

Volume-to-capacity ratios are therefore not effective in quantifying the level of service for two-lane highways.

The Traffic Specialists incorporated the following into the assessment of impacts:

- Average Travel Speed (ATS): ATS is the highway segment length divided by the average travel time.
- Percentage Time Spent Following (PTSF): PTSF represents the freedom to manoeuvre and the comfort and convenience of travel. It is the average percentage of time that vehicles must travel in platoons behind slower vehicles due to the inability to pass. PTSF also represents the approximate percentage of vehicles traveling in platoons.
- Percent of free-flow speed (PFFS): PFFS represents the ability of vehicles to travel at or near to the posted speed limit.
- On Class I two-lane highways, speed and delay due to passing restrictions are both important to motorists. Therefore, on these highways, the level of service is defined in terms of both ATS and PTSF.
- The level of service (LOS) criteria for two-lane highways is shown below.

TABLE 7-4: LOS FOR TWO-LANE HIGHWAY

LOS	ATS (km/h)	PTSF (s)
A	**> 89**	**< 35**
B	> 80.5 – 89	> 35-50
C	**> 72.5 – 80.5**	**> 50-65**
D	> 64.5 – 72.5	> 65-80
E	**< 64.5**	**>80**

(Refer to section 6.3.2) for a description of the LOS).

7.2.1.2 *Assessment of impact*

Severity

The analysis conducted by the Traffic Specialist to determine the LOS for both a 4.5% and 6% growth rates concluded that:

- The existing survey (i.e. current scenario) indicated that the ATS was 110km/h and the PTSF was 11%, both indicating that TR 1/10 operates at a LOS of A.
- For all scenarios on TR 1/10 the ATS remains at a LOS of A.
- The LOS on TR 1/10 remains acceptable for both the normal peak hour (LOS C) and 30th peak hour (LOS D).

The above analyses were done with the assumption that the biomass trucks will be evenly spread throughout the 9 hour day. A further sensitivity analysis was done whereby it was assumed that peak arrivals of biomass will be encountered.

Although the LOS does not change dramatically, the 30th peak (see Table 7-2) and 6% growth scenario reaches the LOS D at the end of the project lifespan. A LOS of D is still acceptable during the 30th highest peak but it is therefore recommended that receiving of biomass should be spread throughout a working day and platooning should be discouraged.

An important parameter in the analysis is the percent no-passing zones and is dependent on the road alignment. During the survey by the Traffic Specialist, the different centreline road markings were monitored to determine the road sections allowing passing (passing zones) and those sections that do not allow passing (no-passing zones). From Oshivelo to Tsumeb 40% was determined to be no-passing zones. It should be noted that the road markings are in a poor state and the 40% should be considered a conservative percentage and could well be less.

With reference to section 6.3.3.1, the crash rate on TR 1/10 is considered high but not abnormal for Namibian road conditions. The recovery area along TR 1/10 was found to be the best along the entire Trans-Kunene corridor

Overall, in the unmitigated scenario, a minor deterioration is therefore expected since the additional traffic on TR 1/10 is low. The change will not be measurable and recommended level of service of the trunk road will not exceed acceptable levels even with a constant high traffic growth rate applied over a 20 year period.

Taking the above mentioned into consideration, the severity in the unmitigated scenario (and mitigated scenario) is Low.

Duration

The duration of the potential traffic impacts is reversible over time and only for the duration of the project (i.e. for the duration of the construction, operational and decommissioning phases), therefore Medium in both the unmitigated and the mitigated cases.

Spatial scale

In all relevant project phases the impact will occur outside the site boundary, hence Medium in the unmitigated and mitigated scenarios.

Consequence

The determining consequence is Low in the unmitigated and mitigated scenarios.

Probability

The probability of the impacts, relating to the LOS on the TR 1/10, occurring is considered to be possible in the unmitigated scenario. With mitigation, the probability could reduce to Low.

Significance

In the unmitigated scenario, the significance of this potential impact is Medium. In the mitigated scenario, the significance is reduced to Low because of the reduction in probability. SLR's confidence level is high for this significance rating.

7.2.1.3 *Tabulated Summary of the Assessed Cumulative Impact – Impact on Road Capacity and Road Condition/Deterioration – TR 1/10*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**M**	**M**	**L**	**M**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.2.1.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated activities EMP (Appendices 15).

Objective

The objective of the mitigation measures is to minimise the impact on road transport infrastructure.

Actions

Specific actions include the following:

- The traffic impacts will be exaggerated if trucks platoon and arrive in fleets, especially during peak hours. NamPower and the harvesting contractors must play an active role in the scheduling of the biomass transport to ensure peak arrival do not occur.
- The grass on the road shoulders at the approaches to the intersection should be kept short to ensure sight distance to the intersection is maintained continually.
- Promote basic road safety behaviour for all NamPower employees and contractors through training and awareness. Typical issues include the following:
    - keeping to safe speed limits, but as a minimum all specified road speeds will be adhered to;
    - ensuring that drivers all have valid licenses;
    - making sure that all vehicles are roadworthy;
    - zero tolerance for drinking and driving; and
    - using lights appropriately for night driving.

Emergency situations

Any road accident involving or caused by project related traffic will be handled in accordance with the Biomass Power Project emergency response procedure.

7.2.2 Issue: Impact on Road Capacity and Road Condition/Deterioration – Gravel Roads (including the DR 3007)

7.2.2.1 *Introduction*

Section 7.2.1.1 explains that the theoretic capacity of a single lane road is 1,800 vph. The practical capacity is reduced due to various factors such as topography, vehicle composition and others. With reference to section 6.3.2 and Table 6-4, the average daily traffic, for the gravel roads in the vicinity of the proposed Power Station, is 14 vehicles per day (vpd) resulting in probably approximately 3 vph during the highest peak of the day.

Even with the project traffic added, the gravel roads do not have a capacity shortage. Furthermore, gravel roads become viable for upgrading to bitumen standards at about 200 vpd. The power project therefore also does not justify the upgrade of any gravel roads to bitumen standard.

Therefore, the assessment below focuses on the potential impacts associated with the condition of the gravel road and the deterioration thereof as a result of additional traffic.

7.2.2.2 *Assessment of impact*

Severity

With reference to section 6.3.3.2, traffic on gravel roads causes gravel loss and ravelling which is the generation of loose material. Ravelling also poses safety problems. Loose gravel may be distributed over the full width of the road but more frequently is concentrated in windrows between the wheel tracks or alongside the travelled portion of the road. These windrows area a safety hazard and the stones from the loose gravel may damage vehicles or windscreens.

Gravel losses for roads with ADT of less than 50 vpd are less than 10 mm/year. The current traffic on D3007 is estimated at 25 vpd (ADT) or 12.5 vpd per lane. The gravel loss is calculated between approximately 3.1 mm and 7.8 mm per annum.

The current traffic on D3007 is estimated at 25 vpd (ADT) or 12.5 vpd per lane. That can be expected to increase to 41 vpd (ADT) or 20 vpd per lane. The gravel loss will increase with 1 mm per annum taking the addition project traffic into consideration. Over a 20 year period the gravel loss with the proposed power project is therefore expected to be an additional 20 mm.

The DR 3007 road currently has a gravel thickness in the order of 70 mm and with the predicted annual gravel loss will require re-gravelling within about 2 years (2020) with or without the project. The road works for gravel roads include periodic blading, spot gravelling and large scale re-gravelling when a 50mm gravel thickness is reached.

There is only a small increase in the spot gravelling that will be required due to the proposed power project. Although there is additional road traffic on the gravel road, the increase is low with limited impact on the road deterioration and maintenance costs.

The width of DR 3007 was measured to be approximately9.5 m which would be sufficient. The horizontal alignment appears fairly straight with slight bends but no severe and sharp bends. DR 3007 is located on the flatter topography and the vertical alignment was assumed to be sufficient with no sharp changes in alignment.

Overall, in the unmitigated scenario, minor deterioration is expected on all gravel roads (i.e. DR 3007 and other gravel roads in the vicinity of the project), since the additional traffic on these roads are assessed as low. However, if platooning of trucks occurs for the biomass delivery at the plant, the discomfort due to dust experienced by other road users on the DR 3007 could be moderate resulting in some complaints.

Taking the above mentioned into consideration, the severity in the unmitigated scenario is Medium for the DR 3007 and Low for other gravel roads in the vicinity of the project. With mitigation the severity is rated as Low for all gravel roads.

Duration

The duration of the potential traffic impacts is reversible over time and only for the duration of the project (i.e. for the duration of the construction, operational and decommissioning phases), therefore Medium in both the unmitigated and the mitigated cases.

Spatial scale

In all relevant project phases the impact will occur outside the site boundary, hence Medium in the unmitigated and mitigated scenarios.

Consequence

The determining consequence is Medium for the DR 3007 and low for other gravel roads in the vicinity of the proposed Power Station in the unmitigated scenario. The consequence is Low for all gravel roads in the mitigated scenario.

Probability

The probability of the impacts occurring is considered to be possible in the unmitigated scenario for the DR 3007. This is due to the possibility of platooning of trucks. Impacts occurring on other grave roads are unlikely. With mitigation, the probability is assessed as Low for all gravel roads.

Significance

In the unmitigated scenario, the significance of this potential impact is Medium for the DR 3007 and Low for other gravel roads in the vicinity of the proposed Power Station. In the mitigated scenario, the significance is reduced to Low for all gravel roads. SLR's confidence level is high for this significance rating.

7.2.2.3 *Tabulated Summary of the Assessed Cumulative Impact – Impact on Road Capacity and Road Condition/Deterioration – Gravel Roads)*

Mitigation	Severity		Duration		Spatial Scale		Consequence		Probability of Occurrence		Significance	
	DR 3007	Other roads	DR 3007	Other roads	DR 3007	Other roads	DR 3007	Other roads	DR 3007	Other roads	DR 3007	Other roads
Unmitigated	**M**	**L**	**M**	**M**	**M**	**M**	**M**	**L**	**M**	**L**	**M**	**L**
Mitigated	**L**	**L**	**M**	**M**	**M**	**M**	**L**	**L**	**L**	**L**	**L**	**L**

7.2.2.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated activities EMP (Appendices 15).

Objective

The objective of the mitigation measures is to minimise the condition/deterioration of the DR 3007 and other gravel roads.

Actions

- The traffic impacts will be exaggerated if trucks platoon and arrive in fleets, especially during peak hours. NamPower and the harvesting contractors must play an active role in the scheduling of the biomass transport to ensure peak arrival do not occur.
- The increase of traffic on the gravel roads does not merit an upgrade to bitumen standards. Depending of the exact increase of traffic on these roads the ongoing maintenance by the Namibian Roads Authority (RA) on specific roads might have to occur more frequently. The RA has effective blading contracts and roads are bladed at the required frequency. Care should be taken during standard maintenance blading to ensure the blading smoothens and shape the surface. After grading, no potholes, corrugations, excessive loose material, large boulders, ruts or erosion channels should be present and straight portions of the road should have a definite crown and cross-fall while curves should have an adequate super-elevation for safety.
- Therefore, NamPower should engage with the RA prior to the project implementation and on an ongoing basis after the implementation to ensure that the blading and other maintenance activities are carried out as and when required.

Emergency situations

Any road accident involving or caused by project related traffic will be handled in accordance with the Biomass Power Project emergency response procedure.

7.2.3 Issue: Impact at the TR 1/10 and DR 3007 Intersection

7.2.3.1 *Introduction*

With reference to section 6.3.3.1, the current TR1/10 & DR3007 intersection has no deceleration, acceleration or passing lanes.

An intersection analysis was done to determine the LOS for the upgraded intersection (see Table 7-5).

TABLE 7-5: INTERSECTION LOS ANALYSIS

Traffic Movement / Direction		Existing Traffic		Biomass Traffic		Staff Traffic (operations)	Construction Traffic	Construction Year	Year 0 without project (S0)	Year 0 with project (S2)	Year 20 with project (s4)
		ADT	vph	ADT	vph	vph	vph	vph	vph	vph	vph
From East	Straight	981	196					208	196	196	376
	Right		3	22	2.75	23	20	28	3	29	31
From North	Left		3	22	2.75		20	28	3	6	8
	Right		3	10	1.25		5	8	3	4	7
From West	Left		3	10	1.25		5	8	3	4	7
	Straight	981	196					208	196	196	376
v/c for intersection								**0.13**	**0.13**	**0.13**	**0.24**
max delay (sec)								**9**	**9**	**9**	**9**
Level of Service (LOS)								**A**	**A**	**A**	**A**

7.2.3.2 *Assessment of Impact*

Severity

The intersection will operate at a LOS of A for the remainder of the project lifespan. The current intersection peak volumes are about 650 vph. The level of service of intersections are affected by various factors and mostly be the conflicting movements such as right turning movements that have to cross oncoming traffic. The overall intersection volumes are low and in order for the intersection to deteriorate to an unacceptable level of service the overall intersection volume has to increase to about 1500 vph and the right turning volumes should be tripled. The intersection therefore has ample capacity and will not pose a problem for the duration of the project lifespan as long as the intersection is upgraded as proposed.

However, with reference to section 6.3.3.1, due to the fact that the intersection has no deceleration, acceleration or passing lanes, moderate and measurable discomfort at the intersection will be experienced in the event of platooning of vehicles at the Power Station and if no upgrades are applied to the current intersection. Complaints on all right turning movements of the intersection can be expected. Minor to negligible discomfort will be experienced at the intersection if platooning is eliminated, the intersection upgraded, and grass kept short.

The severity in the unmitigated scenario is therefore assessed as Medium and Low in the mitigated scenario.

Duration

The duration of the potential traffic impacts at the interested is reversible over time and only for the duration of the project (i.e. for the duration of the construction, operational and decommissioning phases), therefore Medium in both the unmitigated and the mitigated cases.

Spatial scale

In all relevant project phases the impact will occur outside the site boundary, hence Medium in the unmitigated and mitigated scenarios.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability of discomfort at the intersection, if no upgrades are applied, is assessed as definite although discomfort is only expected during peak hours. With mitigation, the probability could reduce to Low.

Significance

In the unmitigated scenario, the significance of this potential impact is Medium. In the mitigated scenario, the significance is reduced to Low because of the reduction in severity and probability. SLR's confidence level is high for this significance rating.

7.2.3.3 *Tabulated summary of the assessed cumulative impact – Impact at the TR 1/10 and DR 3007 Intersection*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**H**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

Conceptual description of mitigation measures

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated activities EMP (Appendices 15).

Objective

The objective of the mitigation measures is to minimise the impact at the TR 1/10 and DR 3007 intersection.

Actions

NamPower to engage with the RA prior to the project implementation to ensure the following are implemented:

- Upgrade the intersection, a typical layout is attached in Appendix 13.
- Pave the portion of road to the Power Station entrance i.e. approximately 215 m section.
- Keep grass at the intersection cut at all times to maintain intersection sight distance.

Emergency situations

Normal national regulations will apply to any road accident on national or public roads.

7.2.4 Cumulative traffic impacts

The assessments relating to the potential traffic impacts in the above sections (7.2.1 to 7.2.3) were all conducted on a cumulative basis, taking the current (baseline) traffic conditions, as well as additional traffic, due to the proposed Biomass Power Project, into consideration.

7.3 SOILS

The information in this section was sourced from the soil specialist study, refer to Appendix 12.

Soil is an important natural resource and provides important ecosystem services, such as water filtering, provision of growth medium for plants, provision of shelter and habitat for specialist vertebrate and invertebrates.

Potential impacts on the soils at the proposed Power Station site and in potential harvesting areas are considered to include compaction, soil erosion and impacts on soil fertility. The severity of impacts is expected to depend on the soil properties of the area.

With reference to Table 7-6, there are a number of sources and construction, operation and decommissioning project activities that have the potential to impact negatively on soil in the Power Station and power line site area, as well as the bigger harvesting area.

TABLE 7-6: SOIL IMPACT – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Soil compaction through vehicle movement and machinery used for harvesting activities. This relates to the first 3 month pre-commissioning stockpile.	Soil compaction through vehicle movement and machinery used for harvesting activities. Oil and fuel spills from equipment and vehicles used. Removal of protective shrubs and trees causing erosion. Reduction in nutrient transfer from deep soil layers though seasonal leaf fall in the harvesting area. Improved soil carbon cycle and soil structure.	-
Transport of biomass		Soil compaction thought increased vehicular movements associated with the transport of the wood chips to the Power Station.	-
Power Station	Soil compaction through vehicle movement. Removal of soil for infrastructure development. Oil and fuel spills from equipment and vehicles used.	Soil compaction through vehicle movement. Removal of soil for infrastructure development. Deposition of ash material during the operational phase in the plant area. Oil and fuel spills from equipment and vehicles used. Clearing activities – i.e. removal of protective shrubs and trees.	Soil compaction through vehicle movement. Oil and fuel spills from equipment and vehicles used.
Overhead power line	Soil compaction through vehicle movement.	-	

	Oil and fuel spills from equipment and vehicles used.		

7.3.1 Issue: Soil Compaction – Power Station Area

7.3.1.1 *Assessment of Impact*

Severity

Compaction of the moist A horizon of all soil types identified in the proposed plant area (refer to section 6.6) is highly probable if traversed by heavily loaded trucks or other machinery that may be required to move over land where no roads exist. Compacted vehicle tracks, depressed to a lower level than the adjoining soil surface, may become incipient erosion rills. The soils become even more susceptible to compaction when vehicles move over soil in the wet state.

Relatively dry soils (e.g. soil cannot be compressed into a ball with the hands) are markedly less prone to compaction than wet or moist soils. In the dry condition depression of tracks to the degree that they may serve as erosion rills will be the exception. Grass seedlings have a fair chance of emerging and surviving.

Taking the above into consideration, the severity is medium in the unmitigated scenario and low in the mitigated scenario.

Duration

On-going during operational phase. The impact will however be aggravated by heavy rainfall events.

Spatial scale

The impact could extend beyond the site boundary, but local.

Consequence

The consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of the compaction of soils is Medium in the unmitigated scenario but reduces to Low with mitigation.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.3.1.2 *Tabulated Summary of the Assessed Impact – Soil Compaction – Power Station Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.3.1.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid or minimise the compaction of soil as far as practically possible.

Actions

- Whenever possible, limit vehicle movement during wet or very moist soil conditions.
- Restrict off-road vehicular movement as far as possible to marked routes in order to curb damage to the grass cover.

Emergency situations

None identified.

7.3.2 Issue: Loss of the Natural Functioning of the Soil as a Growth Medium – Power Station Area

7.3.2.1 *Assessment of Impact*

Severity

The construction of infrastructure on the soil surface will remove the natural functioning of the soil as a growth medium and habitat for fauna and flora as the surface will be covered completely. The soil in the plant area is classified as having a land capability which is characterized as non-arable land with a moderate grazing potential.

The severity of the impact is assessed as Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

In the unmitigated scenario the impact on site will extend after operations have ended. In the Mitigated scenario, the site would be rehabilitated, and the soil replaced.

Spatial scale

This is expected to happen within the plant boundary.

Consequence

The consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of the loss of the natural functioning of the soil as growth medium is High in the unmitigated scenario but reduces to Low with mitigation.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR’s confidence level is high for this significance rating.

7.3.2.2 *Tabulated Summary of the Assessed Impact – Loss of the Natural Functioning of the Soil as a Growth Medium – Power Station Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**L**	**M**	**H**	**M**
Mitigated	**L**	**M**	**L**	**L**	**L**	**L**

7.3.2.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid or minimise the loss of the natural functioning of the soil as growth medium.

Actions

- Topsoil shall be utilised for landscaping within the proposed Power Station site boundaries.

Emergency situations

None identified.

7.3.3 Issue: Soil Contamination Through Deposition of Ash Material from the Plant

7.3.3.1 *Assessment of Impact*

Severity

The deposition of ash material during the operational phase in the plant area (refer to section 4.4.4.4) may increase the level of trace metals in the soil. The soils dominated by a sandy texture such as the Arenosols, Luvisols and Fluvisols have a lower buffering capacity and are thus more susceptible to changes in pH than the loamy soils (Cambisols, Calcisols and Leptosols).

The severity of the impact is assessed as High in the unmitigated scenario and Medium in the mitigated scenario.

Duration

In the unmitigated scenario the impact on soil will be long term i.e. high, with mitigation it is reduced to Medium i.e. life of the project.

Spatial scale

The impact could extend beyond the site boundary, but local.

Consequence

The consequence is High for the unmitigated scenario and Medium for the mitigated scenario.

Probability

In the unmitigated scenario, the probability of soil contamination through the deposition of ash is possible, Medium. With mitigation, impacts can be prevented, Low.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is moderate for this significance rating due to limitation in the analytical results for the fly ash and bottom ash not being available for assessment.

7.3.3.2 *Tabulated Summary of the Assessed Impact – Soil Contamination Through Deposition of Ash Material from the Power Station*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**M**	**H**
Mitigated	**M**	**M**	**M**	**M**	**L**	**L**

7.3.3.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid soil contamination through appropriated deposition of ash material.

Actions

- Refer to sections 5.5.4 and 7.6.10.

Emergency situations

None identified.

7.3.4 Issue: Soil Contamination Through Fuel and Oil Spills at the Power Station site

7.3.4.1 *Assessment of Impact*

Severity

In the unmitigated scenario, the pollution of soils from numerous incidents, in particular hydrocarbon spills, can result in a loss of soil functionality as an ecological driver because it can create an unfavourable environment for vegetation, vertebrates and invertebrates that rely on the soil. It could also negatively impact on the chemistry of the soils such that current growth conditions are impaired. Hydrocarbon during operation would be storage of diesel on site for mobile plant and for auxiliary burners for starting the plant, however the tank would be bunded accordingly and pipe work would be designed to withstand operating pressure of the fuel lines.

Therefore, significant hydrocarbon spills are not expected, and the severity is rated Low to Medium in the unmitigated scenario. In the mitigated scenario, the number of pollution events should be significantly less which reduces the potential severity to low.

Duration

Potential pollution impacts will be within the life of the operation.

Spatial scale

Potential soil pollution is expected to be restricted to the project site in both the unmitigated and mitigated scenarios.

Consequence

The consequence is Low to Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

Due to the nature of the operations, the probability of impacts on soils through pollution incidents, are possible i.e. Medium probability. With mitigation, the probability will be significantly reduced to Low because emphasis will be placed on preventing pollution events and on quick and effective remediation if pollution events do occur.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this assessment.

7.3.4.2 *Tabulated Summary of the Assessed Impact – Soil Contamination Through Fuel and Oil Spills at the Power Station Site*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L-M**	**M**	**M**	**M-L**	**M**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.3.4.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid soil contamination through hydrocarbon spills.

Actions

- Proper oil spill cleaning kits should be available on site.
- Containers used to hold material should be clearly marked and preferentially stored on a covered surface.
- All equipment should be properly maintained to prevent oil and fuel spills.

Emergency situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure.

7.3.5 Issue: Soil Compaction – Biomass Harvesting Area

7.3.5.1 *Assessment of Impact*

Severity

Compaction of the moist A horizon of all soil types identified in the harvesting area is highly probable if traversed by heavily loaded trucks or other machinery that may be required to move over land where no roads exist. Compacted vehicle tracks, depressed to a lower level than the adjoining soil surface, may become incipient erosion rills. The soils dominated by a sandy texture, such as the Arenosols, Luvisols and Fluvisols (refer to Figure 6-27) are more susceptible to compaction than the loamy soils (Cambisols, Calcisols and Leptosols). In a wet state, the sandy soils are more susceptible to soil compaction than in a dry state. Compacted soil would lead to loss of nutrients from the ecosystem.

Relatively dry soils (e.g. soil cannot be compressed into a ball with the hands) are markedly less prone to compaction than wet or moist soils. In the dry condition depression of tracks to the degree that they may serve as erosion rills will be the exception. Grass seedlings have a fair chance of emerging and surviving.

The above mentioned could potentially affect the physical destruction of plants and animals above the soil surface, as well as soil macro-fauna (burrowing invertebrates, amphibians, reptiles and mammals) and microorganisms below the soil surface.

Taking the above into consideration, the severity is Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

On-going during operational phase. The impact will however be aggravated by heavy rainfall events.

Spatial scale

The impact could extend beyond the harvesting area boundary, but local.

Consequence

The consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of the compaction of soils is High in the unmitigated scenario but reduces to Low with mitigation. The soils dominated by a sandy texture, such as the Arenosols, Luvisols and Fluvisols are more susceptible to compaction than the loamy soils (Cambisols, Calcisols and Leptosols). In a wet state, the sandy soils are more susceptible to soil compaction than in a dry state.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR’s confidence level is high for this significance rating.

7.3.5.2 *Tabulated Summary of the Assessed Impact – Soil Compaction – Biomass Harvesting Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**H**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.3.5.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objectives of the management and mitigation measures are to avoid or minimise the compaction of soil in the harvesting area as far as practically possible.

Actions

- Whenever possible, avoid harvesting during wet or very moist soil conditions to avoid undue soil compaction. With respect to the sandy soils these conditions can be expected to last for two or three days after 25 mm or more rain in a single event and with respect to the sandy clay loam soils, for four to five days.
- Harvesters to be instructed to avoid very sensitive zones and no-go areas (see section 7.4).
- Harvesters to be instructed to use appropriate harvesting techniques and experienced operators.

Emergency situations

None identified.

7.3.6 Issue: Wind and Water Erosion in the Harvesting Area

7.3.6.1 *Assessment of Impact*

Severity

During periods of drought, wind erosion may follow on the removal of protective shrubs and trees before a grass cover had time to become established. This could be exacerbated by disturbance of the surface soil structure during cutting and loading of feedstock. Sandy soils (Arenosols, Luvisols and Fluvisols) (refer to Figure 6-27) are more susceptible to wind erosion than loamy soils (Cambisols, Calcisols and Leptosols) which has a moderate to low susceptibility to wind erosion.

The exposed soils can also be subjected to water erosion. The soils dominated by a loamy texture such as the Cambisols, Calcisols and Leptosols are more susceptible to water erosion than the sandy soils (Arenosols, Luvisols and Fluvisols).

Wind erosion may be expected to be exacerbated on the sandy soils only if the vegetal cover is disturbed over relatively large contiguous areas, particularly during the dry, windy months of July to September. The severity may become moderate under these conditions. The danger of the water erosion hazard increasing from a very low or low to a moderate level will only apply to disturbed topsoils on slopes of more that approximately five or six percent. The basal coverage of the grasses is low, but the protection rendered by the roots should be conserved as far as possible.

Taking the above into consideration, the severity is Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

The potential erosion impacts will be Medium term i.e. reversible over time.

Spatial scale

The impact could extend beyond the harvesting area boundary, but local.

Consequence

The consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of the erosion of soils is Medium to High in the unmitigated scenario but reduces to Low with mitigation. Sandy soils (Arenosols, Luvisols and Fluvisols) are more susceptible to wind erosion than loamy soils (Cambisols, Calcisols and Leptosols) which has a moderate to low susceptibility to wind erosion.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.3.6.2 *Tabulated Summary of the Assessed Impact – Wind and Water Erosion in the Harvesting Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**M-H**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.3.6.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objectives of the management and mitigation measures are to avoid or minimise the erosion impact of soil in the harvesting area as far as practically possible.

Actions

- Restrict off-road vehicular movement as far as possible to marked routes in order to curb damage to the grass cover.
- Harvesters should be encouraged to follow biomass harvesting guidelines (see the EMP in Appendix 15). It is important not to over clear: tree equivalents/ha that should remain after thinning should follow the recommended rainfall-TE guidelines per dominant encroacher species.

Emergency situations

None identified.

7.3.7 Issue: Reduction in Nutrient Transfer from Deep Soil Layers Though Seasonal Leaf Fall in the Harvesting Area

7.3.7.1 *Assessment of Impact*

Severity

The reduction in numbers of deep rooted leguminous shrubs and trees can be expected to result, over the long term, in less plant nutrients transferred from the subsoil and weathered rock to the surface soil horizons through seasonal leaf fall. Although an improved grass cover will also recycle nutrients and enhance the carbon cycle, the nutrients from the mentioned deeper layers may not be reached. This will apply to all the soils assessed.

The severity is assessed to be Low in both the unmitigated and mitigated scenarios.

Duration

The potential impacts will be Medium term i.e. reversible over time.

Spatial scale

The impact is fairly widespread, within the harvesting area, and rated as Medium.

Consequence

The consequence is Low for both the unmitigated and mitigated scenarios.

Probability

This impact is an unintentional outcome of the process of replacing a largely relatively deep rooted, deciduous, leguminous tree cover with a largely shallower rooted, grass cover. This potential impact is therefore possible.

Significance

The significance of this potential impact is Low in both the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.3.7.2 *Tabulated Summary of the Assessed Impact – Reduction in Nutrient Transfer from Deep Soil Layers Though Seasonal Leaf Fall in the Harvesting Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**M**	**M**	**L**	**M**	**M**
Mitigated	**L**	**M**	**M**	**L**	**M**	**M**

7.3.7.3 *Conceptual Description of Mitigation Measures*

Due to the nature of the impact mitigation does not appear possible.

7.3.8 Issue: Improved Soil Carbon Cycle and Soil Structure

7.3.8.1 *Assessment of Impact*

Severity

An improved and judiciously grazed grass cover can be expected to result, over the long term, in higher soil organic matter content, more soil microbes, improved soil structure and improved water holding capacity. All of this would curb wind erosion. The potential impact will depend on the success of establishing a grass cover in the harvested areas.

Therefore, a minor improvement i.e. Low positive severity in the soil carbon and soil structure is expected.

Duration

Very long term, if the area harvested is maintained. Harvesting of the invader bush may be expected to put the vegetal composition on an improving path with positive, albeit slow, consequences for soil health.

Spatial scale

The positive impact would be local, within the harvesting area, everywhere where there is improvement of grass cover and improvement towards a more mature vegetal composition.

Consequence

The consequence is Medium (positive).

Probability

This positive impact is assessed to be definite. However, it will only be achieved if the harvested areas area maintained i.e. no intentional bush farming allowed and aftercare of the harvested areas impacted is implemented.

Significance

The significance of this potential impact is High positive. SLR's confidence level is moderate for this significance rating.

7.3.8.2 *Tabulated Summary of the Assessed Impact – Improved Soil Carbon Cycle and Soil Structure*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**H**	**M**	**M**	**H**	**M+**
Mitigated	-	-	-	-	-	-

7.3.8.3 *Conceptual Description of Mitigation Measures*

Due to the nature of the impact i.e. positive, no mitigation is required. However, to ensure the positive impact is achieved aftercare of the harvested areas needs to be implemented (refer to section 7.4 for an assessment on the restoration of ecological goals and section 7.11.6 for an assessment on the bush thinning and land productivity i.e. improvement of rangelands).

7.3.9 Issue: Soil Contamination Through Fuel and Oil Spills in the Harvesting Area and Arboricide After Effects

7.3.9.1 *Assessment of Impact*

Severity

In the unmitigated scenario, the pollution of soils from numerous incidents, in particular hydrocarbon spills from harvesting equipment and trucks, can result in a loss of soil functionality as an ecological driver because it can create an unfavourable environment for vegetation, vertebrates and invertebrates that rely on the soil. It could also negatively impact on the chemistry of the soils such that current growth conditions are impaired. Concentration of arboricides (as part of the aftercare programme) could also lead to killing non-target plants.

The above mentioned could potentially affect the physical destruction of plants and animals above the soil surface, as well as soil macro-fauna e.g. burrowing invertebrates, amphibians, reptiles and mammals and microorganisms below the soil surface.

This is a Medium severity. In the mitigated scenario, the number of pollution events should be significantly less which reduces the potential severity to Low.

Duration

Potential pollution impacts will be within the life of the operation.

Spatial scale

Potential soil pollution is expected to be restricted to the harvesting area, i.e. localised.

Consequence

The consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability of impacts on soils through pollution incidents of hydrocarbons and concentration of arboricides (as part of the aftercare programme), is possible (i.e. medium probability). With mitigation, the probability will be significantly reduced to Medium – Low because emphasis will be placed on preventing pollution events and on quick and effective remediation if pollution events do occur.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR’s confidence level is moderate for this assessment due to the uncertainty of the long-term effects of arboricides, and the potential for it to cause mortalities of protected and other non-target species. Although all compounds have been cleared for use as safe, these tests were all done in mesic systems in the northern hemisphere. There are still many unknowns about their use in semi-arid and arid savannas.

7.3.9.2 *Tabulated Summary of the Assessed Impact – Soil Contamination Through Fuel and Oil Spills in the Harvesting Area and Arboricide After-Effects*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**M**	**M**	**L**	**L-M**	**L-M**

7.3.9.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and associated activities EMP (Appendix 15).

Objective

The objectives of the management and mitigation measures are to avoid soil contamination through appropriated management of hydrocarbons (i.e. fuel / oil.

Actions

- Proper oil spill cleaning kits should be available on site.
- All equipment should be properly maintained to prevent oil and fuel spills.
- Harvesters should be encouraged to avoid very sensitive zones and no-go areas (see section 7.4).
- Harvesters and landowners should be encouraged to use stem/foliar applied chemicals instead of soil-applied arboricides if using chemical aftercare.
- When using manual aftercare, plants should be uprooted to prevent regrowth. Manual aftercare is not recommended for controlling *Dichostachys cinerea*, which readily coppices from damaged roots.
- Aftercare using heavy machinery should be discouraged.
- Landowners should be encouraged to use integrated post-harvesting approach by including properly managed fire and browsers to lessen arboricide use.

Emergency Situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure.

7.3.10 Cumulative Soil Impacts

On a spatial scale, the potential cumulative soil impacts of the proposed Power Station and power line is relatively lower than for the harvesting activities. The harvesting takes place over a much larger area than the Power Station development, and larger areas would be potentially impacted.

7.4 BIODIVERSITY

The information in this section was sourced from the following specialist studies attached as Appendices 6.1 to 6.3:

- Avifauna Impact Assessment report (ACS, 2018);
- Invertebrates Baseline Study (Irish, 2018); and

- Vertebrate and Vegetation Baseline Study, Integration of all Biodiversity Components and Biodiversity Impact Assessment (AWR, 2018).

Overall, impacts may increase or decrease the risk of species persistence through indirect or direct effects on population processes, mainly as a result of alteration of habitat size, quality and cohesiveness, as well as alteration of key ecological processes.

The recovery of savanna rangeland productivity through the ecological restoration of beneficial ecosystem-level effects of bush clearing i.e. thinning, is perceived benefit of the proposed Biomass Power Project. This goal is supported by several national-level development goals and international commitments under three multilateral agreements to which Namibia is a signatory, namely the climate, biodiversity and desertification conventions.

Although the ultimate impact of restoring harvested areas will be positive with appropriate post-harvesting maintenance, negative impacts are bound to take place during the harvesting process and where mitigation measures fail or are not followed. Savanna ecosystems are by definition very complex (SEA, 2016) and therefore difficult to fully understand and predict responses to disturbances and management interventions.

With reference to Table 7-6, there are a number of activities in all phases of the proposed project that have the potential to impact on biodiversity through the physical destruction of organisms and habitats and/or the general disturbance associated. Positive impacts associated with harvesting of the encroacher bush are also shown in the table below and assessed in the section below.

TABLE 7-7: BIODIVERSITY IMPACT – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Soil compaction through vehicle movement and machinery used for harvesting activities. This relates to the first 3 month pre-commissioning stockpile.	Improvement of rangeland productivity. Improvement of biodiversity and ecological integrity of savannas. Harvesting operations (using heavy machinery and labourers) and transportation of the biomass causing physical destruction of organisms and habitats and / or the general disturbance to biodiversity.	-
Transport of biomass			-
Power Station	The various construction activities associated with the development of the Power Station and overhead power line could cumulatively cause physical destruction and general disturbance of vegetation, terrestrial fauna, birds and soil as a result of site clearing activities and the erection of a new overhead power line.	Possible pollutants, i.e. chemicals used at the Power Station, ash from the plant, sewage, etc. causing impacts to biodiversity habitats and populations.	General demolition and rehabilitation activities could cumulatively cause physical destruction and general disturbance of vegetation, terrestrial fauna, birds and soil as a result of site clearing activities and the erection of a new overhead power line.
Overhead power line		Potential power line impacts on birds include disturbance and habitat destruction during construction, especially with regards to breeding birds, as well as collisions and electrocutions during operation.	

7.4.1 Issue: Loss of Habitat, Destruction of Animals and Plants and General Disturbance of Biodiversity – Power Station and Power Line Sites

7.4.1.1 *Assessment of Impact*

Severity

Activities associated with clearing of existing natural bush before construction of the Power Station, as well as further construction activities of the plant will likely kill, remove and/or drive away all animals and plants from the development site, i.e. inside the footprint of infrastructure associated with the Power Station and its operations. In this regard the local habitat, species and biodiversity population will be impacted. Spillage of hydrocarbons, paints, other chemicals, etc. could also contaminate habitats of plants and animals.

With reference to section 6.7, the proposed site for the Power Station lies in a highly compromised and bush encroached area with a low number of protected trees in the area. The available habitat is relatively simple and uniform, hence only a portion of certain sensitive fauna species could ever be found here. Additionally, it is highly unlikely that any of the larger mammal or reptile species would ever occur here, regardless of their theoretical distribution ranges.

The main impacts during the operations phase of the Power Station on biodiversity relate the deposition or spillages of hazardous and non-hazardous substances, including waste, ash, sewage, waste water and chemicals. General littering may also interfere with ecological processes, including soil organisms and animals. It will furthermore also have an impact on the aesthetics of the area. This is potentially a cumulative impact should air pollutants of other sources may combine with that of Otjikoto Power Station (refer to section 7.7.1).

Birds and their habitats may also be disturbed, during all project phases, while going about their daily activities such as feeding, drinking, roosting and, in particular, during the various stages of the breeding cycle. Such disturbance could potentially result in displacement of birds (and destruction of bird eggs) from areas suitable for them before development. Priority bird species that may potentially be impacted by disturbance during construction of the Power Station and power line include Damara Red-billed Hornbill, Bare-cheeked Babbler and Carp's Tit. Any new open water habitats (e.g. evaporation ponds, or leaking pipes) may attract birds that would not otherwise be found in the area; if such 'aquatic habitats' are located close to power line structures, this could result in an increased risk to power line impacts.

Taking the above into consideration, the overall severity is Medium in the unmitigated scenario and Medium-Low in the mitigated scenario.

Duration

The duration of the impacts on biodiversity is rated as Medium in both the unmitigated and mitigated scenarios.

Spatial scale

Biodiversity processes are not confined to the proposed project site and therefore the spatial scale of impacts could extend beyond the site boundary. Key related issues are the migration of species and the flow of nutrients and linkages between biodiversity areas. The spatial scale is therefore rate as Medium in the unmitigated scenario and Medium-Low in the mitigated scenario.

Consequence

The consequence is Medium for the unmitigated scenario and Medium-Low for the mitigated scenario.

Probability

The probability associated with the impacts without any mitigation, is definite. With mitigation and taking the nature of the potential impacts on the proposed Power Station and power line site into consideration, the probability can be reduced to Low.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.4.1.2 *Tabulated Summary of The Assessed Impact – Loss of Habitat, Destruction of Animals and Plants and General Disturbance of Biodiversity – Power Station and Power Line Sites*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**H**	**M**
Mitigated	**L**	**M**	**M-L**	**M-L**	**L**	**L**

7.4.1.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid or minimise the loss of habitat, destruction of animals and plants and general disturbance of biodiversity.

Actions

- Keep footprint as small as possible within the design brief.
- Do not clear areas that are not within the infrastructure footprint or outside the fire safety buffer of infrastructure.
- If necessary, thin out encroacher species in surrounding areas according to harvesting guidelines.
- As far as possible, do not remove large trees of any species.
- Design waste product storage, processing areas and power generation methodology to minimise pollution.
- Secondary use found for ash or safe disposal.
- Before construction starts, the proposed biomass Power Station site and power line route should be inspected by a suitably qualified person for any signs of bird nesting activity; birds that are in the process of nesting or raising chicks should not be disturbed; if possible, the timing of construction should try to avoid bird breeding seasons.
- Ongoing awareness should be promoted about the value of biodiversity and the negative impacts of disturbance, especially to breeding birds and protected flora species.

Emergency Situations

Certain instances of injury to or killing of animals and illegal harvesting of plants or collection of bird's eggs, etc. may be considered emergency situations. These will be managed in accordance with the Biomass Power Project Emergency Response Procedure.

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure.

7.4.2 Issue: Collisions and Electrocution of Birds on Power Line Structures

Severity

A collision occurs when a bird in mid-flight does not see overhead cables/conductors or other structures (i.e. proposed telecommunications tower) until it is too late to take evasive action. These impacts could take place on any part of a power line but are more likely in sections where the line crosses flight corridors or flyways, such as drainage lines or ridges. Collisions may also take place on stay wires (e.g. on poles at bend points or on transformer poles), for instance when a bird is flushed from its position on the ground. The proposed structure is likely to have (multiple) stay wires at bend points. Collisions may take place even during the construction phase, once the conductors have been strung but not energised, but occur mainly during the operational phase. The construction of power lines may also provide new perches for raptors on towers, attracting such birds to the area.

An electrocution occurs when a bird is perched or attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components. The clearances on the proposed steel monopole structure are relatively large, which would reduce the risk of electrocutions; however, as the structure would be permanently earthed, a large bird (such as a raptor) perched on the insulator could run the risk of simultaneously touching the pole and a live component and thereby be electrocuted, especially if in the case of a steel pole, or if the bird or the pole is wet.

Should a temporary distribution line be constructed for the construction power supply, a large bird sitting on a pole or an associated earthed transformer or switchgear structure would be at a higher risk to electrocution if it were to touch two or more live components (or a live and an earthed component) simultaneously, especially if the structure and/or bird is wet.

Collisions with power line and other overhead structures and electrocutions may result in bird mortalities/injuries.

Priority bird species that may potentially be impacted by collisions include Martial Eagle, Tawny Eagle, Booted Eagle, Red-footed Falcon, Black-necked Grebe and Damara Red-billed Hornbill. The Martial Eagle, Tawny Eagle, Booted Eagle and Red-footed Falcon may also potentially be impacted by electrocutions.

Due the fact that the priority bird species are all locally rare or rare-uncommon and the fact that the proposed power line length is relatively short (approximately3 km maximum), the overall severity is Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

The duration of the impacts on birds is rated as Medium in both the unmitigated and mitigated scenarios

Spatial scale

The spatial scale is fairly widespread, beyond the site boundary but local, therefore rated as Medium.

Consequence

The consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of collisions or electrocutions taking place is unlikely and therefore Low, even without mitigation.

Significance

The significance of this potential impact is Low in both the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.4.2.1 *Tabulated Summary of the Assessed Impact – Collisions and Electrocution of Birds on Power Line Structures*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**L**	**L**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.4.2.2 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to avoid the impacts of birds due to collisions and electrocutions on power lines and other relevant structure.

Actions

For the powerline structure, marking the new power line and any stay wires as a mitigation for bird collisions is not recommended at this stage due to the potential impacts being Low (even without mitigation).

- Any telecommunications structures (e.g. masts/towers) constructed in the area should be mitigated, as recommended below:
  - Should the communication mast structure include stay wires, such wires should be marked with standard "vibration dampers" in alternating black and white, to increase visibility. The entire length of at least all the outer stay wires of the structure should be marked.
  - While subscribing to mandatory (Civil Aviation Authority) aviation requirements, attempts should be made to reduce the impact of necessary light emanating from telecommunication structures as far as possible.
- On the proposed structure for the power line, if this is technically and economically feasible, a braced or slanting insulator, rather than a standard/horizontal post insulator, would help to deter perching by large birds.
- Using a delta/triangular design for stringing the conductors of this structure would reduce the electrocution risk, as the conductors would be further apart compared to a vertical configuation of the conductors.
- In the case of any wooden distribution pole structures used for a temporary/construction power supply, including poles used for transformer and/or switchgear structures:

- The earth wire on each power line pole should be "gapped", i.e. an air space safety gap should be included in the earth wire running along the pole. The gap should be wide enough to avoid being permanently active, but close enough to allow lightning strikes to bridge it.
- Any stay wires on wooden power line poles should be "gapped" similarly, by means of an insulator.
- "Jumper" wires on poles should be offset vertically, to increase the distance between these live components.
- Transformer structures should be designed in such a way that they are not attractive as bird perches/nesting sites. Selected live components should be insulated e.g. using black PVC piping or low-density polyethylene pipe. On any strain structures where "jumper" wires are used in a horizontal configuration, the two outer jumpers should be suspended below the cross arm and the third/centre jumper should be insulated, or all jumpers insulated.

- Bird monitoring is considered essential.

Emergency situations

None identified.

7.4.3 Issue: Failure to Achieve Savanna Ecological Restoration Goals in the Harvesting Area

7.4.3.1 *Assessment of Impact*

Severity

Utilising the woody biomass for energy production seems like a logical and sensible way to address two different aspects: contributing to Namibia's goal to become self-sufficient in energy production while simultaneously improving agricultural production through the improvement of rangeland condition (MAWF 2012). The proposed Biomass Power Project therefore occurs within this context of rangeland dynamics, with an underlying implicit benefit of restoration of savanna structure, function and composition. Selective bush harvesting of encroached areas should improve the diversity and abundance of animals, provided that no dispersal or population regulation restrictions prohibit low density or locally extinct species to inhabit the newly created habitat. How the open structure created by harvesting is maintained, will determine how long these perceived benefits last.

A potential positive impact of biomass harvesting is therefore an increase in biodiversity and in the ecological integrity of the savanna ecosystem, following bush thinning operations (i.e. implemented a bush-thinning approach, rather than bush-clearing).

However, although the removal of woody biomass has the potential to greatly improve savanna structure, function and composition, this will only occur if key management principles are followed. These include clear accountability, adherence to basic ecological principles and adherence to existing guidelines.

Because of the structure of the project, with a single user i.e. NamPower's proposed Biomass Power Station being supplied by a number of suppliers, responsibilities at the regional scale is not clear and this increases the risk that the project will fail ecologically.

Poor management due to lack of ownership of responsibility for ecological outcomes is likely to result in poor outcomes and an increased risk that ecological goals will not be achieved.

The result can be any of a range of outcomes, from no change in the status quo to specific problems such as proliferation of problematic species and weeds favoured by disturbance, such as Gifblaar (*Dichapetalum cymosum*) in Kalahari Woodlands zone, or even, paradoxically, a worsening of bush encroachment if aftercare is not done properly. There could also be decreased productivity and diversity as a result of poor practice and poor aftercare.

This is a potentially cumulative impact due to the proliferation of bush to energy projects, such as Ohorongo and other possible bush harvesting activities in the area.

Taking the above into consideration, the overall severity is High negative in the unmitigated (and poor management) scenario. In the mitigated scenario, the severity would be High positive.

Duration

The duration of the impacts is long term.

Spatial scale

Biodiversity processes are not confined to the proposed harvesting area and therefore the spatial scale of impacts would extend beyond the boundary of the harvesting area. The spatial scale is therefore rated as Medium in the unmitigated and mitigated scenarios.

Consequence

The determining consequence is High negative in the unmitigated scenario and High positive in the mitigated scenario.

Probability

The probability that savanna ecological restoration goals in the harvesting area will not be achieved is likely in the unmitigated scenario. Similarly, the savanna ecological restoration goals are likely to be met in the mitigated scenario.

Significance

The significance of the potential impacts associated with achieving the savanna ecological restoration goals in the harvesting area, or not, is High negative in the unmitigated scenario and High positive in the mitigated scenario. SLR's confidence level is low to moderate for this significance rating due to the unclear ownership of management of the harvesting activities; non-aligned or competing land management objectives of land owners; unclear financial incentives regarding the harvesting and aftercare activities, uncertainty of post-harvesting follow-up.

7.4.3.2 *Tabulated Summary of the Assessed Impact – Failure to Achieve Savanna Ecological Restoration Goals in the Harvesting Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**M**	**H**
Mitigated	**H+**	**H**	**M**	**H**	**M**	**H+**

7.4.3.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the management and mitigation measures is to ensure savanna ecological restoration goals in the harvesting area are achieved.

Actions

- Mitigating this potential impact involves the definition and implementation of measures to decrease the risks of failure to achieve savanna restoration. Because of the complexity of the task, specific recommendations about the structure or function of the measures are not provided. However, the critical characteristics are provided below:
    - Clear authority and a governance structure has to be established, with some form of central supervision and accountability. Ideally this should be vested in NamPower itself, but a number of other possible options have emerged over the last few months, including an industry body.
    - Regardless of that, NamPower could unlock all the potential of this project by appointing an Environmental Manager who can play various roles to ensure that the overall risk of failure declines, including auditing, regular training, monitoring and being a champion for responsible management. We would prefer to recommend this, but because of the rapid development of the biomass and charcoal sectors and expected impacts of possible changes in European import requirements, we simply point out here that this will be a good solution.
    - The overall management shall be based on an “Adaptive Management” approach, including explicit ecological goals and science standards.
      Adaptive Management entails a continuous assessment of the condition of savanna structure against the promoted ecological goals and a decision-making process where management actions are changed (“adapted”) to reflect the current and expected future conditions in such a way as to maintain progress towards goals.
    - Alignment with FSC standards, although actual certification is not required. By aligning and implementing the FSC standards would allow for industry best practices to be complied with. Implementing FSC standards would require displaying long term commitment by famers/harvesters that supply the project with biomass, which may be the required model to achieve central supervision and accountability.
    - Regular training of harvesters and landowners on the ecological principles that underlie savanna dynamics (see Biodiversity Report and the Biodiversity Baseline Section in the EIA Report), the important species and ecological features/functions, specific cutting guidelines and aftercare.
- Develop Site Specific Harvesting Plans for harvesters and landowners.
- Monitor the adherence of harvesters and landowners to the site-specific harvesting plans.

Notes:

Adaptive Management Structure: Adaptive management entails a continuous assessment of the condition of savanna structure against ecological goals and a decision-making process where management actions are ‘adapted’ i.e. altered, to reflect the current and expected future conditions in such a way as to maintain progress towards goals. Implicit in this structure is the definition of measurable ecological goals and a monitoring programme.

Emergency situations

None identified.

7.4.4 Issue: Large Scale Loss of Protected Woody Species, Including Fruit Bearing, Iconic, and Timber Species

7.4.4.1 *Assessment of Impact*

Severity

One of the important environmental goals of the proposed Biomass Power Project is to use the biomass harvesting process as a springboard to convert bush encroached land in productive and diverse rangelands. Intentional bush farming will not be implemented. In any bush harvesting operation there is a high risk of felling protected or desirable plants such as palatable and evergreen trees and shrubs (SEA, 2016). Large trees, even dead ones, have important key stone functions in savannas as nesting and perching sites for several birds of conservation importance, as well as important ecological services related to nutrient cycling and providing habitat niches for specify organisms. Evergreen shrubs and trees offer browse during the late dry seasons for browsers such as kudu, eland, giraffe and goats.

Areas with a high occurrence of protected plants evenly distributed among encroacher species has a higher probability of losing protected plants than harvesting operations in monocultures of the target encroacher species. Also, very dense thickets will impede visibility, resulting in recognition rates of desirable species. The Biodiversity Specialist Team's observations, corroborated by the Tree Atlas distribution data of protected tree species, suggest that such unwanted mixtures are often encountered in the proposed harvesting area.

Surviving desirable and protected species may also be unintentionally killed or damaged during aftercare control in mixtures, especially where soil applied arboricides are used.

Therefore, the following potential impacts might occur as a result of the harvesting activities:

- Loss of individuals and populations of woody plant species that are formally protected in Namibia, or are endemic and thus experience greater risks, or are sparsely distributed throughout their range, or are simply iconic members of intact and healthy savannas.
- Loss of individuals and populations of protected or endemic succulent, shrub and herbaceous plant species because of damage by the mechanical harvesting process.

Due to the proliferation of bush to energy projects, i.e. Ohorongo and others, cumulative losses over much of the range of some species in Namibia, particularly broadleaved trees need to be considered.

This is a cumulative impact due to the proliferation of bush to energy projects, such as Ohorongo and other possible bush harvesting activities in the area. Therefore, cumulative losses over much of the range of some species in Namibia, particularly broadleaved trees must be considered.

Taking the above into consideration, the overall severity is rated as High in the unmitigated scenario. In the mitigated scenario, the severity reduces to Low as the potential impacts are avoided.

Duration

The duration of the impacts is long term.

Spatial scale

The spatial scale is fairly widespread, beyond the harvesting areas boundary due to the cumulative nature of the impact, therefore it is rated as Medium.

Consequence

The determining consequence is High negative in the unmitigated scenario and Medium in the mitigated scenario.

Probability

The probability of large scale loss of protected woody species is High-Medium in the unmitigated scenario, reducing to Medium in the mitigated scenario.

Significance

The significance of the potential impacts associated with the large scale loss of protected woody species is High in the unmitigated scenario and medium in the mitigated scenario. SLR's confidence level is moderate for this significance rating due to the unclear ownership of management of the harvesting activities; non-aligned or competing land management objectives of landowners; unclear financial incentives regarding the harvesting and aftercare activities, uncertainty of post-harvesting follow-up.

7.4.4.2 *Tabulated Summary of the Assessed Impact – Large Scale Loss of Protected Woody Species*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**H-M**	**H**
Mitigated	**L**	**H**	**M**	**M**	**M**	**M**

7.4.4.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the management and mitigation measures is to avoid large scale loss of protected woody species during the harvesting activities.

Actions

- Avoid harvesting of the no-go areas.
- Develop Site Specific Harvesting Plans for harvesters and landowners.
- Harvesters should be encouraged to follow biomass harvesting guidelines (see the EMP in Appendix 15). It is important not to over clear: tree equivalents/ha that should remain after thinning should follow the recommended rainfall-TE guidelines per dominant encroacher species.
- Only use harvesting methods and/or machinery that are able to selectively harvest encroacher bush while avoiding damage to desirable species.
- Regular training events where all harvesting contractors, land owners, bush cutters and machine operators are instructed about which woody plants to target, which ones to avoid and how to calculate TEs/ha.
- Supervision to prevent cutting of non-target plants.
- Long-term monitoring of population trends/health of valuable species to also include the post-harvest management efficiency.

Emergency situations

None identified.

7.4.5 Issue: Loss of and Disturbance of Animals in Harvesting Area

7.4.5.1 *Assessment of Impact*

Severity

Activities associated with the harvesting process and transport of biomass on site and to the proposed Biomass Power Station site could lead to direct killing and maiming of animals, decreased population sizes and disruption of animal activities notably that relate to breeding, due to accidents; disturbance of animals during operations via human presence, noises, smells and movement of machinery; increased poaching and illegal capture of animals.

Poaching is also likely to increase with the additional people that work and live close to animals, birds including chicks or eggs, and plants of value, bush meat or illegal trade. These include common game species such as small antelope species, warthog, kudu, oryx and eland, but also species of conservation concern such as pangolins, tortoises and leguaans and several birds. In addition, the harvesting area is adjacent to three national parks. The proximity of the Etosha and Waterberg National Parks carries the additional risk of harvesters assisting rhino and elephant poaching rings by supplying local information and offering ways for poachers and goods to be transported.

At least 15 priority bird species are considered potentially at risk to the negative impacts of the biomass harvesting and transportation operations. Those at higher risk include White-backed Vulture, Lappet-faced Vulture and other raptors that nest in large trees; near-endemic cavity nesters; and ground-nesters.

Vultures occupy a nest site for an extended period (6-7 months) over the full breeding cycle and are particularly at risk to disturbance at this time. Cavity nesters, such as hornbills, are also at risk to disturbance as the female is sealed up inside the nest with the chicks for more than a month, while undergoing moult at this time, and the pair may occupy the site for up to three months in total.

The presence of people, vehicles and the operating machinery may potentially disturb animals, habitats, notably nesting vultures and raptors, but also other animals including amphibians, reptiles and mammals.

Taking the above into consideration, the overall severity is Medium to High in the unmitigated scenario. In the mitigated scenario, the severity would reduce to Medium to Low.

Duration

The duration of the impacts would be for the life of the harvesting activities but could extent to long term in the unmitigated scenario as disturbance could cause the birds to leave the area permanently or animals being killed. In the mitigated scenario, the impacts are avoided/ minimized and the duration of impacts rated as Medium to Low.

Spatial scale

Biodiversity processes are not confined to the proposed harvesting area and therefore the spatial scale of impacts would extend beyond the boundary of the harvesting area. The spatial scale is therefore rated as Medium in the unmitigated and mitigated scenarios.

Consequence

The determining consequence is High to Medium in the unmitigated scenario and Medium to Low in the mitigated scenario.

Probability

The probability of loss of and disturbance of animals during the harvesting and associated activities are rated as High to Medium in the unmitigated scenario and Medium to Low in the mitigated scenario.

Significance

The significance of the potential impacts is therefore High to Medium in the unmitigated scenario and Medium to Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.4.5.2 *Tabulated Summary of the Assessed Impact – Loss of and Disturbance of Animals in Harvesting Area*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H-M**	**H-M**	**M**	**H-M**	**H-M**	**H-M**
Mitigated	**M-L**	**M-L**	**M**	**M-L**	**M-L**	**M-L**

7.4.5.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the management and mitigation measures is to avoid as far as possible or minimize loss of and disturbance of animals in harvesting area.

Actions

- Do not accept wood that originated from the no-go areas or from the buffer zone along the National Parks (should this be enforced by MET).
- Develop Site Specific Harvesting Plans for harvesters and landowners:
  - See the map in Figure 6-38 for a regional-scale indication of the location of sensitivity zones: this is a first-level filter to indicate the relative sensitivity of a specific harvesting unit/farm. For each harvesting unit, a detailed, site-specific map should be drafted by the landowner or harvester, focusing firstly on the presence and spatial organisation of important ecological processes e.g. drainage lines, and habitat features e.g. large old trees for nesting, and secondly on the location and density of important tree species (see Biodiversity Report in Appendix 6.1).
  - These site-level sensitivity zones should indicate where harvesting should be either avoided i.e. no-go zones, or carefully applied following cutting rules as defined in Appendix 6.1. Ensure adherence to rules in this regard.
- Give preference to harvesting methods that allow smaller animals to move away i.e. slow moving.
- Harvesters should be encouraged to assign clear responsibilities and control over field personnel at all times.

- Harvesters should be encouraged to educate field personnel to respect wildlife.
- Anti-poaching measures should be strictly enforced.
- Regulations and strict adherence to speed and traffic rules.
- Ensure swift law enforcement in poaching cases by reporting immediately to the police and to community anti-poaching organisations.
- Restrict driving at night where possible.
- Enforcing a buffer zone around Etosha and Waterberg National Parks in liaison/agreement with MET.

Emergency situations

Certain instances of injury to or killing of animals and illegal harvesting of plants or collection of bird's eggs, etc. may be considered emergency situations. These will be managed in accordance with the relevant emergency response procedure.

7.4.6 Cumulative Biodiversity Impacts

Several impacts may have negative cumulative impacts. These include (1) air pollutants from other sources that combine with that of Otjikoto Power Station to exceed safe thresholds, thereby affecting habitat quality at the Power Station and surrounding area, (2) the failure to achieve restoration goals, which will negatively affect biodiversity beyond the harvesting footprint areas, especially if combined with other failed bush harvesting/control efforts in the study area, and may negatively affect ecological processes that operate at the larger scale e.g. metapopulation dynamics, (3) large scale loss of cohorts of protected, rare, iconic and timber species which could negatively impact reproduction, especially if combined with other woody harvesting/control efforts depleting these species in the study area, (4) disturbance of soil which leads to increased soil erosion also effecting downstream and downwind areas, and (5) arboricide after effects that potentially affect non-target plants and areas, as well as underground water resources.

A positive cumulative effect with a potentially positive outcome could occur as a result of successful restoration that leads to an increase in the productivity of rangelands in harvested areas and on plant and animal diversity and population sizes beyond the harvest areas. This could occur as a result of improved connectivity of open savanna populations (plants and animals) and increased resilience to disturbances e.g. buffering of drought effects for grazers due to increased and less variable forage production in restored area.

Significant amounts of wood are currently being harvested by the charcoal and firewood industries in the study area (see section 7.11.5), therefore cumulative impacts (positive or negative) are likely to occur once the Biomass project becomes operational. Various factors may determine a positive cumulative outcome: Many charcoal producers are currently seeking FSC accreditation, therefore increasing the chance that these harvested areas are responsibly managed. This has the potential to result in a positive cumulative impact if this trend continues and provided that the Biomass project itself has a positive impact. Also, a greater awareness of the need for aftercare and the increasing availability of information about post-harvesting best practices are likely to result in fewer failed projects in future.

7.5 SURFACE WATER

This section is based on the Surface Water Study which was undertaken for the proposed Biomass Power Project by SLR Environmental Consulting Namibia included in Appendix 11.

With reference to Table 7-8, there are a number of pollution sources in all project phases that have the potential to negatively impact surface water sources, particularly in the unmitigated scenario. During the construction and decommissioning phases, potential surface water pollution sources will be temporary in nature, usually existing for a few weeks to a few months. Although these sources may be temporary, the potential pollution may be long term. The operational phase will present more long term potential sources that may have the potential to contaminate surface water through seepage and/or run-off.

TABLE 7-8: SURFACE WATER IMPACTS LINKED TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Relevant to first 3 months pre-commissioning stockpile: Similar to operational phase.	Increased salinization through de-bushing, impacting surface water quality. Surface water contamination as a result of hydrocarbon spills from harvesting machinery and trucks. Non environmental friendly arboricides impacting surface water quality.	-
Transport of biomass		Surface water contamination as a result of hydrocarbon spills from trucks during transportation of biomass.	-
Power Station	Surface water i.e. storm water, contamination as a result of spillages of hydrocarbons, paints, etc. during construction activities.	Surface water i.e. storm water, contamination as a result of possible pollutants, i.e. chemicals used at the Power Station, ash from the plant, sewage, etc. Contamination for surface water from hydrocarbon spills from vehicle movement during operation. Impact on surface water runoff due to new infrastructure.	Surface water i.e. storm water, contamination as a result of spillages of hydrocarbons during decommissioning activities.
Overhead power line		-	

7.5.1 Issue: Decrease in Downstream Surface Water Runoff due to the Power Station and Associated Infrastructure

7.5.1.1 *Assessment of Impact*

Severity

With reference to section 6.4.2, there is no significant contribution to downstream runoff, as there are no identified drainage lines downstream of the plant site. The severity is therefore considered Low in both the unmitigated and mitigated scenarios.

Duration

The duration of possible reduction in potential runoff is for the life of the project, therefore of Medium duration.

Spatial scale

The impact of possible reduction in potential runoff is within the site boundary, with no significant distance downstream.

Consequence

The determining consequence is Low in the unmitigated and mitigated scenarios.

Probability

It is likely that the plant will decrease the surface water runoff.

Significance

The significance of this potential impact is Low in the unmitigated and mitigated scenarios. No cumulative impacts are expected. SLR's confidence level is high for this significance rating.

7.5.1.2 *Tabulated Summary of the Assessed Impact – Decrease in Downstream Surface Water Runoff Due to the Power Station and Associated Infrastructure*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**M**	**L**	**L**	**L**	**L**
Mitigated	**L**	**M**	**L**	**L**	**L**	**L**

7.5.1.3 *Conceptual Description of Mitigation Measures*

No mitigation required.

7.5.2 Issue: Contamination of Surface Water from Pollutants at the Power Station and Associated Activities

7.5.2.1 *Assessment of Impact*

Severity

Flood water may collect and mobilise contaminants/pollutants (i.e. hydrocarbons, paints, sewage and chemicals) from numerous sources on site. At elevated pollution concentrations these contaminants can be harmful to humans if ingested and to biodiversity (see section 7.4).

However, there is little pollution likely to be transported downstream from the proposed Power Station site as no identified drainage lines exist. There are no other likely pollution sources in the surrounding area and cumulative impacts are not considered a possibility. In the unmitigated scenario, there may be possible deterioration close to site, possibly small distance downstream, but there are no identified drainage lines or any main river system (refer to section 6.4.2) therefore this is of Medium severity.

In the mitigated scenario, most surface water run-off should be relatively clean, and the severity is reduced to Low.

Duration

The duration of potential for pollution is beyond the life of the project in the unmitigated case, i.e. High, reducing to Low in the mitigated scenario.

Spatial scale

The spatial scale of the potential unmitigated impacts will be restricted to potential surface water use which could extend beyond the site boundary, i.e. possibly a small distance downstream, but no identified drainage lines or any main river system, hence Medium. In the mitigated scenario contaminated water will be contained on site, which is a localised spatial scale.

Consequence

The determining consequence is High for the unmitigated scenario and Low for the mitigated scenario.

Probability

The likelihood that the onsite pollutants can be carried off through runoff exists, but because there are no drainage lines identified further afield from the Power Station and associated infrastructure the probability is Medium for the unmitigated scenario, which can be reduced to Low for the mitigated scenario.

Significance

The significance of this potential impact is high in the unmitigated scenario and low in the mitigated scenario. No cumulative impacts are expected. SLR's confidence level is high for this significance rating.

7.5.2.2 *Tabulated Summary of the Assessed Impact – Contamination of Surface Water from Pollutants at the Power Station and Associated Activities*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**M**	**H**	**M**	**H**
Mitigated	**L**	**M**	**L**	**L**	**L**	**L**

7.5.2.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent pollution of surface water run-off and related health impacts on third parties.

Actions

- Storm water management plan to be developed to determine the extent of contact water runoff and how to contain the polluted water on site and to divert clean water around site.
- Effective site supervision to ensure no blocking of storm water infrastructure and efficient storage of contact water. Solids removal from storm water ponds at end of each rainy season, and disposal of material at suitable waste site, such as municipal landfill sites.
- Storm water run-off would incorporate an oil interceptor as mitigation prior to discharging from site due to oil leaks from vehicles on the site road washing into the storm water attenuation system.

- One off sampling of runoff water post oil interceptor prior to discharge from site during a rain event should be undertaken to confirm containment of pollution sources. The water will be sampled for general standards for effluent discharge into the environment as given in the EMP (Appendix 14).

Emergency situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure.

7.5.3 Issue: Contamination of Surface Water from Ash Being stored at the Power Station Ending up in the Runoff

7.5.3.1 *Assessment of Impact*

Severity

With reference to section 5.5, NamPower is considering various options for the final end use/disposal of the ash from the proposed Biomass Power Station, taking the interpretations from the laboratory test results (section 4.4.4.4) into account. One of the options being considered is to dispose as waste at a new facility at the Power Station site, which is being assessed in this section. The option for taking the ash back to the harvested farms i.e. areas where bush was harvested, is assessed in section 7.5.7.

With reference to the laboratory tests conducted on ash samples from a similar project within the Namibia (see section 4.4.4.4), the ash, specifically the fly ash, is of concern with regards to surface water because of its elevated salt and metals concentrations that are often above the general Namibian Effluent guidelines as given in the Surface Water Study (Appendix 11). Open ash storage piles pose a threat in rainy season as ash material may be washed along during runoff. The severity lies in metals ending up in surface water bodies such as rivers and lakes. But, because there are no tributaries close to the site to transport the pollutants further, this therefore gives opportunity for the pollutant to be captured.

Taking the above mentioned into considerations, the severity of the impact is assessed as Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

In unmitigated scenario, the impact may be for a long-term duration and may be rated High

Spatial scale

Special scale impact is Medium as runoff may be beyond the site boundary, but local, because there are no tributaries close to the site to transport the pollutants further, and therefore giving opportunity for the pollutant to be captured.

Consequence

The determining consequence is High for the unmitigated scenario and Low for the mitigated scenario.

Probability

The likelihood that ash will impact the surface water exists especially in cases of stockpiled ash being blown by wind or transported by rainwater, the impact is deemed Medium in the unmitigated scenario, depending on the concentration and constituents of the ash.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. No cumulative impacts are expected. SLR's confidence level is high for this significance rating due to the limitation in the analytical results for the fly ash and bottom ash not being available for assessment.

7.5.3.2 *Tabulated Summary of the Assessed Impact – Contamination of Surface Water from Ash at the Power Station Ending up in the Runoff*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**M**	**H**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.5.3.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent pollution of surface water run-off from ash generated from the Power Station.

Actions

- Should NamPower decide to implement this option of ash disposal at the Biomass Power Station site:
  - The ratio of bottom ash to fly ash is probably 5:1 and therefore bottom ash is likely to be stored in bays which can be covered and the fly ash is likely to be stored in a silo which will either fed a dedicated enclosed skip or have infrastructure to load a tanker directly depending on the disposal/recovery destination. Dispose of ash on a regular basis to prevent it from piling and increasing as a threat.
  - Analysis of fly ash and bottom ash to be deposited at the plant area should be used to inform the potential constituents of concern that may be contributed by the processing of biomass material.
  - Lining of the ash facility,whether it is a temporary storage facility before disposal or final onsite disposal facility.
  - Stormwater Management Plan to be developed to prevent ash runoff in the surface water.
  - Care should be taken to ensure that aerial distribution of material from the ash dump be avoided.
  - Dispose of ash on a regular basis to prevent it from piling and increasing as a threat.
- The ash should preferably be used for alternative applications (as discussed in section 5.5) or disposed of at an approved municipal landfill, in line with their approved EMP.
- Refer to the Biomass Power Station EMP for further details.

Emergency situations

None identified.

7.5.4 Issue: Bush Harvesting Activities Causing Increased Salinization, Causing Surface Water Quality Impacts

7.5.4.1 *Assessment of Impact*

Severity

It is expected that bush harvesting results in less trees available to take up salts which results in increased salts concentrations in the soils consequently posing a threat to the ephemeral streams in the harvesting area during seasons of rainfall. The salinization deteriorates water quality in the the omiramba such as the Omatako and Owambo and close by streams (refer to section 6.4.3 and Figure 6-14). Since the deteriorated water quality cannot be remediated immediately; widespread complaints which may include the brackish taste of water or more adverse effects of 'blue baby syndrome' that may be experienced over a medium term. These levels as per EPA standards have nitrates concentrations higher than 10ppm while the WHO standards indicate that above 600mg/l sulphate concentrations in drinking water caused catharsis and diarrhoea induced dehydration. However, the Namibian drinking water guidelines has a limit of 1200mg/l where the water has health risk based on sulphate and 40mg/l for nitrate as N concentrations.

Deteriorated water quality cannot be remediated immediately but this phenomenon is increased in impact when there is overharvesting, therefore the severity of the impact is deemed only Medium as bush thinning is the approach to be employed. The severity of the impact is therefore deemed medium for the unmitigated scenario and Low with mitigation.

Duration

In unmitigated scenario, the impact may be long term (beyond the harvesting period), therefore High in the unmitigated scenario, reducing to Low in the mitigated scenario.

Spatial scale

The spatial scale of the potential unmitigated impacts is Medium as impacts may be beyond the site boundary, but local. In the mitigated scenario it would reduce to Low, due to the impacts being avoided.

Consequence

The determining consequence isHhigh for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability of overharvesting, in specifically sensitive areas, to occur and causing increased salinization and associated surface water quality impacts is possible in the unmitigated scenario. The probability reduces to Low in the mitigated scenario as these impacts can be avoided through implementing the required harvesting management and mitigation measures.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.5.4.2 *Tabulated Summary of the Assessed Impact – Bush Harvesting Activities Causing Increased Salinization, Causing Surface Water Quality Impacts*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**H**	**H**	**M**	**H**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.5.4.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent overharvesting specifically in sensitive areas and the associated potential increased salinization and surface water quality impacts.

Actions

- Bush thinning as opposed to bush clearing should be practiced, specifically in the groundwater sensitive areas.

Emergency situations

None identified.

7.5.5 Issue: Non-Environmentally Friendly Arboricides Used After Bush Harvesting Impacting on Surface Water Quality

7.5.5.1 *Assessment of Impact*

Severity

Arboricides and the foliar leaf sprays commonly used may be washed off by rain and end up in the tributaries of major ephemeral rivers, compromising the quality of the surface water and subsequently affecting aquatic life, crops and the health of third parties. During application of arboricides, spills may also occur further increasing the concentration in areas more than what is designed for application.

Since water in rivers is mobile more than it is stagnant the pollutants can be carried further from the project boundary. With reference to section 6.4.3, the omiramba such as the Omatako and Owambo and close by streams (refer to Figure 6-14) as well as Lake Otjikoto and Lake Guinas are sensitive surface water bodies.

The severity of this impact is assessed as High in the unmitigated scenario. In the mitigated scenario, surface water quality and related impacts can be avoided.

Duration

Without immediate remedial action, this impact could be long term and be felt after harvesting activities have ceased, giving rise to a High duration impact rating. With mitigation, the impact could be avoided, and the duration assessed as Low.

Spatial scale

Since water in rivers is mobile more than it is stagnant the pollutants can be carried further than the harvesting area boundary especially in areas close to harvesting area boundaries, thereby escalating the spatial impact to High in the unmitigated scenario. Even in the mitigated scenario i.e. staying 100m from surface water bodies, the arboricides may still be carried beyond site boundary by runoff depending on flow direction. However, due to the fact that environmental friendly arboricides shall be used, the spatial scale is considered Low in the mitigated scenario.

Consequence

The determining consequence is High for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability that non-environmentally friendly arboricides will negatively affect surface water quality and cause other related impacts is likely in unmitigated cases, specifically where bush harvesting activities are taking place in close proximity to the omiramba, streams and the lakes in the area. The probability is therefore ranked High. In the mitigated scenario, the possibility of surface water quality and associated impacts will be reduced to Low.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.5.5.2 *Tabulated Summary of The Assessed Impact – Bush Harvesting Activities Causing Increased Salinization, Causing Surface Water Quality Impacts*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**M**	**H**	**H**	**H**	**H**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.5.5.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impacts on surface water quality (and associated impacts) as a result of the use of arboricides.

Actions

- Use water insoluble arboricides (exclude organic salts).

- Application of arboricides to invader bush should be limited to before and after rainy season or alternatively use water insoluble Arboricides.
- Or use arboricides with short half-lives.
- Do not apply arboricides within 100m of the omiramba and close by streams.
- Use approved environmentally friendly arboricides.

Emergency situations

None identified.

7.5.6 Issue: Contamination of Surface Water From Hydrocarbon Spillages and Undetected Leakages from Harvesting Equipment and Trucks Transporting Biomass

7.5.6.1 *Assessment of Impact*

Severity

Hazardous industrial materials such as hydrocarbons (oil, grease, and lubricating oil) are expected to be used during the harvesting activities, and accidental fuel spillage and undetected leakage from harvesting machinery may occur and consequently be washed along through run-off into significant surface water sources. Hydrocarbon products that reach the surface water bodies are considered to pose serious threat. Since it is difficult to reinstate the surface water systems to their original state after pollution, the severity is therefore assessed as High in the unmitigated scenario. In the mitigated scenario, the impacts are avoided, and the severity reduces to Low.

Duration

The duration of potential for pollution is for the life of the project in the unmitigated case, i.e. Medium, reducing to Low in the mitigated scenario.

Spatial scale

Localized, within harvest boundary, except in cases where harvesting and spills are close to the edge of the harvest boundary, then pollution will be beyond the harvest boundary. The spatial scale is therefore rated as Medium in the unmitigated scenario and Low in the mitigated scenario.

Consequence

The determining consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

The probability that the spillages will occur and be transported via runoff is possible for the unmitigated scenario. With mitigation, the probability of impacts is Low.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.5.6.2 *Tabulated Summary of The Assessed Impact – Contamination of Surface Water from Hydrocarbon Spillages and Undetected Leakages From Harvesting Equipment and Trucks Transporting Biomass*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.5.6.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent pollution of surface water run-off and related health impacts on third parties.

Actions

- Regular maintenance of machinery and servicing of vehicles to prevent breakdowns and the need to repair machinery onsite.
- Ensure that the fuel transport companies have a system in place to deal with hydrocarbon spills and subsequent cleanup thereof.
- Designated refueling areas for harvesting equipment. Re-fuelling procedure to be developed.
- If any onsite refueling is planned drip trays must be provided to contain any spills.

Emergency situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure.

7.5.7 Issue: Impact On Surface Water from Ash taken back to the Harvested Farms

7.5.7.1 *Assessment of Impact*

Severity

Utilising the ash as a fertilizer on the harvested farms (i.e. area where bush was harvested) is one of the options being considered for the ash management (see section 5.5 for more details).

The ash is considered as non-hazardous. The composition of the ash from the proposed Biomass Power Station is similar to that of bushfire ash but metal concentrations can be significantly higher (generally less nutrients and higher metal content). A mix of fly and bottom ash seems to be the less harmful compound where water soluble metal and salt concentrations are mostly within Namibian General Effluent Guideline Values (see Table 7-10). The ash should be dispersed in the harvesting area and used as fertilizer and soil improver and should not be stockpiled for longer periods, because it could develop into a local surface water pollution source i.e. there is a risk that local surface water could be polluted after major rainfall events.

Taking the above mentioned into consideration, the severity is Medium in the unmitigated scenario, reducing to Low in the mitigated scenario.

Duration

The impact is potentially beyond the life of the project in the unmitigated scenario.

Spatial scale

Localized, within harvest boundary, except in cases where harvesting and spills are close to the edge of the harvest boundary, then pollution will be beyond the harvest boundary.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability that the ash will have a negative impact on groundwater is possible. Therefore, ranked Medium in the unmitigated scenario. This would be reduced to Low with mitigation.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.5.7.2 *Tabulated Summary of the Assessed Impact – Impact of Ash from The Power Station taken back to the Harvested Farms*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**L**	**M**	**M**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.5.7.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and associated activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impacts on groundwater through ash management practices.

Actions

- Ash to be dispersed and used as fertilizer at the harvested farms or used for alternative applications (as discussed in section 5.5) or disposed of at an approved municipal landfill, in line with their approved EMP.
- Not to be stockpiled for longer periods, preferably prior to the start of the rainy season.
- Not to be disposed of in riverbeds and drainage lines.
- Preferably fly ash and bottom ash composite be deposited due to the less harmful metal and salt content compared to fly ash and bottom ash alone.

Emergency situations

None identified.

7.5.8 Cumulative Surface Water Impacts

The potential cumulative surface water impacts associated with the proposed Power Station activities were considered in sections 7.4.1 to 7.4.3 above. No cumulative impacts are expected.

It is a given that harvesting machinery will need to be refueled. It is also expected that several harvesting machineries will be employed simultaneously at different locations. The refueling of the machinery may be conducted in number of ways, but the most feasible will be to have a fuel tanker accompanying each of the harvesting machinery such as bull dozer/ front end loader/ TLB etc. for ease of access and to capitalize on the time given to complete the harvesting. The risks to surface water involved with these activities include overturn and spillage from fuel tankers, using inadequate equipment such as broken fuel nozzles to transfer fuel from tanker to harvesting equipment which may lead to fuel spills or drips and the undetected fuel leakages from the stationary fuel tankers. It may also include the risks from machinery repair and maintenance.

These leakages if undetected or untreated pose a risk for surface water contamination especially in areas near drainage lines or where the sub-surface prevents quick infiltration of the pollutants. If no detailed risk assessment and mitigation is conducted and followed by the contractor, these spills will be across more than one isolated area and an accumulation of fuel spills will be an accumulation of hydrocarbons across the harvest area, which increases the risk for surface water.

7.6 GROUNDWATER

This section is based on the Groundwater Study which was undertaken for the proposed Biomass Power Project by SLR Environmental Consulting Namibia included in Appendix 11.

With reference to Table 7-9, there are a number of sources during the construction, operations and decommissioning phase of the proposed Power Station, power line and other associated infrastructure and activities that have the potential to negatively impact groundwater resources, particularly in the unmitigated scenario. In the construction and decommissioning phases these potential pollution sources are temporary and diffuse in nature, usually existing for a few weeks to a few months and although these sources are temporary in nature, the related potential pollution can be long term. The operational phase will present more long term potential sources that may have the potential to pollute water resources through long term seepage and/or run-off.

TABLE 7-9: GROUNDWATER IMPACTS – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Relevant to first 3 months pre-commissioning stockpile: Similar to operational phase.	Positive impacts of bush harvesting activities on the groundwater levels. Groundwater contamination as a result of hydrocarbon spills from harvesting machinery and trucks transporting biomass. Impact of De-bushing on groundwater (and soil) through salinization.	-

		Impact of seeping of arboricides into the underlying aquifer.	
Transport of biomass		Groundwater contamination as a result of hydrocarbon spills from trucks during transportation of biomass.	-
Power Station	Groundwater contamination as a result of spillages of hydrocarbons, paints, etc. during construction activities.	Groundwater contamination as a result of possible pollutants, i.e. chemicals used at the Power Station, ash from the plant, sewage, etc. Groundwater contamination from water treatment activities, i.e. release of brine. Impacts on water resources and other water users as a result of water abstraction for the Power Station.	Groundwater contamination as a result of spillages of hydrocarbons during decommissioning activities.
Overhead power line		-	

7.6.1 Issue: Impacts of groundwater over-abstraction (for the Power Station) on the underlying aquifer

7.6.1.1 *Assessment of Impact*

Severity

The planned site is located in a high groundwater potential area of fractured/ karstified dolomite rocks of the Tsumeb Subgroup. Three potential production boreholes were drilled and test pumped in 2019 on the Otjikoto site as part of the site investigation carried out Burmeister. Each of the boreholes yields approximately 10m^3/h and the daily demand of 5 m^3/h for a 40 MW plant capacity should be sustainably met by abstracting from one or more of the recently drilled boreholes.

An abstraction permit has to be obtained from the DWAF as the site is within a Subterranean Water Control Area.

The severity of the potential impact is therefore low because the planned site is positioned on a high groundwater potential area of fractured/ karstified rocks and drilling a new borehole or pipelining from the existing boreholes is not going to stress the aquifer in both the unmitigated and mitigated scenarios.

Duration

The impact is quickly reversible, therefore Low because the supply is sufficient.

Spatial scale

Should there be over abstraction, it would be localized and the spatial impact will be Low.

Consequence

The determining consequence is Low in the unmitigated and mitigated scenarios.

Probability

The probability of over-abstraction of groundwater for the Power Station, impacting on the underlying Tsumeb aquifer is rated as Low in both the unmitigated and mitigated scenarios, due to the fact that more than sufficient daily demand can be pumped from the aquifer without causing impacts or lowering of the water table.

Significance

The significance of this potential impact is Low in the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.6.2 Tabulated Summary of the Assessed Impact – Impacts of groundwater over-abstraction on the underlying aquifer

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**L**	**L**	**L**	**L**	**L**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.2.1 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent over-abstraction of groundwater and associated impacts on the underlying Tsumeb aquifer.

Actions

- Monitoring of the planned wells on site and flow meters must be installed to ascertain the volumes pumped per month/year.
- Abstraction permit from DWAF required.
- Process water should be recycled where possible and re-used.
- Pump testing of the existing functional borehole at the NamPower substation as an option for water supply.

Emergency situations

None identified.

7.6.3 Issue: Contamination of Groundwater from Pollutants at the Power Station and Associated Activities

7.6.3.1 *Assessment of Impact*

Severity

During the construction phase, various activities has the potential to release hazardous industrial waste e.g. used oil, hydrocarbons, concrete mixes, paints, grease, as well as lubricating oil, into the environment. The impact of the above mentioned hazardous products that reach the groundwater is considered serious, since it is difficult or impossible to reinstate the groundwater system to its original state.

Furthermore, additional onsite sewerage facilities must be constructed. Depending on the manner of disposal whether by evaporation in ponds or connecting to Tsumeb municipality sewage options septic tanks, the risk to the underlying dolomitic/limestone aquifer exists. Because of the nature of the waste and depending on the volume of waste, there exists a risk that groundwater pollution through sewage plant effluent may cause pathogenic derived diseases.

Taking the above into consideration, the severity in the unmitigated scenario is considered High, which can be reduced to Low in the mitigated scenario.

Duration

The impact is not easily reversible during life of the Power Station, and is therefore long term, ranking the duration of the impact as High in the unmitigated scenario and Low in the mitigated scenario.

Spatial scale

With the potential karstic features of the area, the pollutants may be transported to beyond the site boundary i.e. fairly widespread beyond the site following groundwater flow patterns. It would be difficult to remediate the aquifer after adsorption, but groundwater levels are deep bringing the spatial impact level to Medium in the unmitigated scenario. In the mitigated scenario the spreading of pollutant in the groundwater can be prevented.

Consequence

The determining consequence is High for the unmitigated scenario and Low for the mitigated scenario.

Probability

The chances for oil spills, and other hydrocarbons ending up in groundwater is possible, therefore the probability of the impact is ranked as Medium in unmitigated scenario. With the implementation of the management and mitigation measures, the probability will be reduced to Low. The chances that the sewage plant discharge or waste water will spill onto the ground and seep into groundwater is unlikely.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.3.2 *Tabulated Summary of the Assessed Impact – Contamination of Groundwater from Pollutants at the Power Station and Associated Activities*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**M**	**H**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.3.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent contamination of groundwater from pollutants at the Power Station and associated activities.

Actions

- Proper storage facilities which include using original containers for materials such as paints and hydrocarbons.
- Regular construction equipment maintenance to avoid breakdowns.
- Designated refuelling areas for excavators and cranes and other construction vehicles. Re-fuelling procedure to be developed with access to the locked fuel dispenser being controlled under this procedure.
- Regular sampling at monitoring boreholes, monitoring hydrocarbon contents to quickly identify change in groundwater quality for early detection.
- Set up a Groundwater Protection Plan with a procedure on disposing the waste including disposing at the approved disposal sites such as appropriate landfill sites and on a regular basis.
- Applying a dedicated storage facility for paints, grease, lubricants with an impervious concrete bund.
- If any onsite refuelling is planned drip trays must be provided to contain any spills.
- Lining of the sewage ponds.
- Compliance with the regulations of the Water Resources Management Act of 2013.
- Specific for the storage of sewage, a dedicated storage facility with an impermeable bund concrete base and a sealed wall must be constructed and storage tanks should be erected above ground.
- No discharge of untreated sewage into the environment.
- Drilling of monitoring boreholes, approximately 80m deep, and regular sampling to quickly identify changes in groundwater quality, this is to be done on boreholes upstream and downstream on the boundaries of the Power Station site. The frequency should be at least quarterly and at any time a leak is suspected. The monitoring is to include bacteriological determinants.

Emergency situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure and will be reported to MEFT and MAWF.

7.6.4 Issue: Seepage of Effluent i.e. Discharged Brine from the Water Treatment Plant Impacting the Water Quality in the Underlying Aquifer

7.6.4.1 *Assessment of Impact*

Severity

With reference to section 4.4.4.7, an onsite Water Treatment Plant is envisaged to purify water, should the groundwater supply be of substandard quality for the process, by means of reverse osmosis or other means. This is to lower the mineral content of the water from the boreholes. If this route is pursued, a side stream of rejected water containing higher mineral content will be produced that can be either discharged or evaporated and later disposed of. The blow down of the boilers will also produce a waste water stream that will require disposal, the disposal concentration of these effluents should meet the requirements given in Appendix 11 and the EMP in Appendix 14.

The possible negative impacts from the treatment of water, such as above mentioned generation and production of brines as an effluent, have the potential to cause local pollution of groundwater resources. Also recycling of waste water is expected as a large proportion of this water would potentially be used for ash quenching. Oil in the recycled water is common with treatment plants this would be skimmed off and scaling will be scraped from the bottom of the holding tanks. Wastewater is expected to be stored before being discharged, accidental spills may occur at this stages and the risk to the underlying dolomitic/ limestone aquifer exists.

Taking the above into consideration, the severity of the impact is considered High in the unmitigated scenario but would reduce to Low in the mitigated scenario.

Duration

The duration of the impact may be long term in the unmitigated scenario, as it may not be reversible during the lif of the project because retracting contamination is difficult.

Spatial scale

The impact will be beyond the site boundaries as it will be transported by groundwater which is a Medium impact. In the mitigated scenario it will reduce to Low.

Consequence

The determining consequence is High for the unmitigated scenario and Low for the mitigated scenario.

Probability

The chances that the brine or wastewater will spill onto the ground and seep into groundwater is unlikely, and therefore probability is Low in both the unmitigated and mitigated scenarios.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.4.2 *Tabulated Summary of the Assessed Impact – Seepage of Effluent i.e. Discharged Brine from the Water Treatment Plant Impacting the Water Quality in the Underlying Aquifer*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**L**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.4.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent contamination of Groundwater from water treatment activities (i.e. discharged brine).

Actions

- Waste water to be safely stored before it is disposed in the approved manner of designated disposal sites.
- Brine and contaminated water should be collected and stored in impermeable evaporation ponds or tanks. The residue should be regularly scraped up and disposed of at an appropriate site and on a regular basis to avoid it piling up or overflowing if stored in tanks.
- Compliance with the regulations of the Water Resources Management Act of 2013.
- Set up a Groundwater Protection Plan with a procedure on disposing of the waste including disposing of it at the approved disposal sites on a regular basis. The effluent must either be allowed to dry/ evaporate, and for the crystalised salts to be disposed of at a municipal landfill, or the effluent must be treated until it reaches concentrations safe for environmental discharge as stipulated in Appendix 11 and the EMP (Appendix 14).
- Regular sampling at monitoring boreholes to quickly identify changes in groundwater quality. Quarterly sampling is recommended, testing for parameters outlined in Appendix 11. The testing must be done on strategically placed monitoring boreholes, up and downstream on the Power Station site boundaries and any location deemed by environmentalist on site as necessary.

Emergency situations

Major spillage incidents will be handled in accordance with the NamPower Emergency Response Procedure and will be reported to MEFT and MAWF.

7.6.5 Issue: Leaching of Ash Constituents from the Onsite Storage/Disposal Piles, Impacting on the Underlying Aquifer

7.6.5.1 *Assessment of Impact*

Severity

With reference to section 5.5, NamPower is considering various options for the final end use/disposal of the ash from the proposed Biomass Power Station, taking the interpretations from the laboratory test results (section 4.4.4.4) into account. One of the options being considered is for it to be disposed of as waste at a new facility at the Power Station site, which is being assessed in this section. The option for taking the ash back to the harvested farms i.e. areas where bush was harvested, is assessed in section 7.6.10.

The ash from the Power Station may contain concentrate metals, salts and other elements from the original fuel materials, some unburnt carbon may also be part of the ash heap. If poorly managed, ash has the potential to harm human health and the environment. Ash constituents are unique to the fuel sources. The ash produced from wood fired boilers is known to have K and Cl ions which react to produce KCl in the ash deposits, which may be a corrosive agent. Other metals known to be associated with wood ash include Ca, Mg and Na. They form compounds with chlorides, sulphates, phosphates, and nitrates, which get washed away by runoff water.

Metals and salts can leach into groundwater and contaminate the aquifer. The leaching of contaminants into groundwater poses a higher risk in areas of shallow groundwater levels. The groundwater level below the proposed Power Station area shows a moderately deep groundwater level at approximately 30 mbgl. The contaminants could potentially be transported through fractures and fissures which may act as conduits and transfer the contaminants, beyond the plant boundary.

With reference to the laboratory test conducted on ash samples from a similar project within the Namibia (see section 4.4.4.4), the groundwater impact assessment focusses on water soluble elements comparing with the Namibian General Effluent Standard (DWAF, 2013). Table 7-10 provides the soluble concentrations of the ash samples that were analysed.

TABLE 7-10: SOLUBLE CONCENTRATIONS OF ASH

CONSTITUENT	UNIT	FLY ASH	BOTTOM ASH	BOTTOM ASH + FLY ASH COMPOSITE	BUSHFIRE ASH	NAMIBIA GENERAL EFFLUENT STANDARD
Antimony (2:1 Ext)	mg/l	0.004	0.016	<0.002	<0.002	<0.05
Arsenic (2:1 Ext)	mg/l	<0.0025	0.0028	<0.0025	<0.0025	<0.15
Barium (2:1 Ext)	mg/l	0.575	0.913	2.788	0.005	<0.20
Boron (2:1 Ext)	mg/l	20.47	0.236	2.431	4.796	<1.00
Cadmium (2:1 Ext)	mg/l	<0.0005	<0.0005	<0.0005	<0.0005	<0.05
Chromium (2:1 Ext)	mg/l	0.8848	2.077	0.2165	0.0134	<1.00
Copper (2:1 Ext)	mg/l	0.008	<0.007	<0.007	0.066	<2.00
Lead (2:1 Ext)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.10
Manganese (2:1 Ext)	mg/l	<0.002	<0.002	<0.002	<0.002	<0.40
Mercury (2:1 Ext)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.002
Nickel (2:1 Ext)	mg/l	<0.002	<0.002	<0.002	0.002	<0.30
Selenium (2:1 Ext)	mg/l	0.323	0.043	0.007	0.017	<0.05
Strontium (2:1 Ext)	mg/l	19.61	40.46	57.94	0.077	<0.10
Thallium (2:1 Ext)	mg/l	<0.003	<0.003	<0.003	<0.003	<0.01
Tin (2:1 Ext)	mg/l	<0.005	<0.005	<0.005	0.015	<0.40
Titanium (2:1 Ext)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.30
Zinc (2:1 Ext)	mg/l	0.075	0.005	0.005	<0.003	<0.05
Total Heavy metals (Ca, Cr, Cu, Hg & Pb)	mg/l	0.8928	2.09	0.2295	0.0854	<0.50
Chloride	mg/kg	17216	317	144	8952	<75 [1)]
Fluoride	mg/kg	2.8	0.6	<0.3	<0.3	<2.00
Nitrate as NO_3	mg/kg	3882.5	135.1	37.2	23.5	<88
Sulphate as SO_4 (2:1 Ext)	g/l	26.1757	1.6834	0.3164	3.886	<0.075 [2)]

1) <70 mg/l above the intake potable water quality
2) <40 mg/l above the intake potable water quality

Therefore, even though the ash is classified as non-hazardous (see section 4.4.4.4), it may contain metals that have the potential to leach into groundwater and pollute the resource. The ash may further produce compounds creating salts as described above. Poor management of ash can lead to leaching to a level of measurable deterioration, which is above the Namibian General Effluent Guideline values of the groundwater.

Taking the above into consideration, the severity of the impact is considered Medium in the unmitigated scenario but would reduce to Low in the mitigated scenario.

Duration

The duration of the impact may be long-term, beyond closure of the plant. The impact is therefore rated as High.

Spatial scale

The contaminants will be fairly widespread due to the fractured and fissured nature of the aquifer which may act as conduits and transfer the contaminants to a fairly widespread, beyond the plant boundary which rates the spatial scale impact as Medium.

Consequence

The determining consequence is Medium for the unmitigated scenario and Low for the mitigated scenario.

Probability

Without mitigation, the issue is likely to occur, but with mitigation the impact becomes unlikely and therefore ranked Low.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.5.2 *Tabulated Summary of The Assessed Impact – Leaching of Ash Constituents From The Onsite Storage/Disposal Piles, Impacting On The Underlying Aquifer*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**H**	**H**	**M**	**H**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.5.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent contamination of groundwater from water leaching from the ash.

Actions

- Analysis of fly ash and bottom ash once the plant is operational to compare with the samples analysed for the EIA.
- Should NamPower decide to implement this option of ash disposal at the Power Station site the following will apply:
    - Bunding and lining of the storage pile, designed for 1:50 year rainfall event; or a smaller bunded and lined area for the ash storage area under roof to prevent direct exposure to rainfall and runoff.
    - Analysis of ash to be conducted and recorded once the plant is operational to compare with the samples analysed for the EIA and groundwater monitoring should be done monthly.
- The ash should preferably be used for alternative applications (as discussed in section 5.5) or disposed of at an approved municipal landfill, in line with their approved EMP.
- Refer to the Biomass Power Station EMP for further details.

Emergency situations

None identified.

7.6.6 Issue: Impact of De-Bushing on the Groundwater Levels

7.6.6.1 *Assessment of impact*

Severity

De-bushing is reported to have a positive influence on groundwater recharge due to reduced evapotranspiration, where a moderate improvement, depending on the geology, will be seen and groundwater levels rise higher than usual with good rains. It is not documented how fast the water levels will rise after the de-bushing, because this is a relative phenomenon depending on; the rainfall of the area, the geology, and other users in the area, such as irrigation schemes. This will have to be studied on a specific site basis. Furthermore, because there is an associated risk to reducing groundwater quality with this water level rise (see section 7.6.6), the severity of the impact is deemed Low positive.

Duration

It is dependent on re-growth of vegetation. The positive impact on groundwater levels is short to medium term and therefore rated as Low positive.

Spatial scale

This is expected to happen beyond the harvest site boundary, but local giving a Medium positive impact.

Consequence

The determining consequence is Low positive.

Probability

The probability that this impact will cause the implied consequence is Medium positive. It is however dependent on the fact that the area harvested is maintained, i.e. effective aftercare measures implemented.

Significance

The significance of this potential positive impact is Medium positive. SLR's confidence level is moderate for this significance rating.

7.6.6.2 *Tabulated Summary of the Assessed Impact – Impact of De-Bushing on the Groundwater Levels*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L+**	**L+**	**M+**	**L+**	**M+**	**M+**
Mitigated	-	-	-	-	-	

7.6.6.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the measures to enhance the positive impacts is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective is to enhance the positive impacts of de-bushing activities on the groundwater levels.

Actions

- Soil isotope studies and other recharge assessment studies like the well-established "Chloride Method" carried out in areas prior to de-bushing and after de-bushing, will give a direct result of change in recharge.

Emergency situations

None identified.

7.6.7 Issue*:* Impact of De-Bushing on Groundwater and Soil through Salinization

7.6.7.1 *Assessment of Impact*

Severity

The overall objective of the project is not to do bush clearing but rather to undertake bush thinning to create improved grazing land and to prevent regrowth. It is expected that de-bushing will result in less trees available to take up salts, which results in increased saltsconcentrations in the soils. This may include ammonium nitrate (NH_4NO_3), sodium nitrate ($NaNO_3$) and potassium nitrate (KNO_3). The invader bush in effect has its roots down to the groundwater table when the level is shallow enough. When invader bushes are removed, the salts remain in the water and in the soils and as the water level rises due to increased recharge resulting from reduced evapotranspiration, the salts in the soil dissolve in the groundwater. This consequently poses a threat of deterioration of groundwater quality in areas of shallow water table and already increased salinity (see sensitive areas in Figure 6-24 rendering the groundwater unsuitable for humans and in severe cases also for livestock.

Duration

The impact would be long term, beyond the completion of the harvesting activities and the closure of the Power Station (if the area harvested is maintained, i.e. effective aftercare measures are implemented, and is therefore ranked as High in the unmitigated scenario and Low in the mitigated scenario.

Spatial scale

The impact would be beyond the harvesting area, therefore the impact is Medium in the unmitigated scenario and Low in the mitigated scenario.

Consequence

The determining consequence is High in the unmitigated scenario and Low in the mitigated scenario.

Probability

The increase in recharge and therefore rise in water level due to de-bushing is not well understood and cannot be quantified at this stage. It is documented that the increase in salinization due to de-bushing is possible, but only in areas where irrigation takes place on an industrial scale. This will not be the case in the areas harvested. The probability is rated as Low.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is moderate for this significance rating.

7.6.7.2 *Tabulated Summary of the Assessed Impact – Impact of De-Bushing on Groundwater and Soil through Salinization*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**M**	**H**	**L**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.7.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impact on groundwater and soil through salinization.

Actions

- Bush thinning as opposed to bush clearing shall be practiced.

Emergency situations

None identified.

7.6.8 Issue: Non Environmentally Friendly Arboricides Used After Bush Harvesting Impacting on Groundwater Quality

7.6.8.1 *Assessment of Impact*

Severity

In the process of preventing re-growth of the invader species or more aggressive colonizers that tend to establish themselves in the thinned-out areas, stem applied arboricides could be used to retard or stop the re-growth (see section 5.2). Some herbicides are soluble in water and could cause pollution to the groundwater especially if the water table is shallow.

There is a strip north of the proposed harvesting area, stretching from west to east that has very shallow groundwater, other locations with such shallow groundwater are in the Platveld surroundings, at Grootfontein and south-east of Grootfontein. This increases the potential groundwater vulnerability and poses a threat to the groundwater and to the end users. Arboricides, as with the Foliar Leaf spray, are the recommended methods of inhibiting re-growth set by DWAF as presented in the best practice guidelines for de-bushing of 2017.

Taking the above mentioned into consideration, the severity of arboricides seeping into groundwater especially at areas with shallow groundwater is considered Medium unless the chemical used is bio-friendly.

Duration

The duration of the impact is Medium, reversible overtime within the lifespan of the harvesting time through in-situ remediation techniques.

Spatial scale

Due to the fact that the groundwater is shallow at some areas, and yet other areas have fractures that may act as direct conduits for the pollution, the spatial scale is expected to be local, but beyond the harvesting area which ranks this criteria as Medium in the unmitigated scenario, reducing to Low in the mitigated scenario.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

In rainy season, the arboricides may dissolve in rainwater andis expected to eventually seep into groundwater. This is very likely to happen, and the probability is therefore High in the unmitigated scenario.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.8.2 *Tabulated Summary of the Assessed Impact – Non-Environmentally Friendly Arboricides Used After Bush Harvesting Impacting On Groundwater Quality*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**H**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.8.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impacts on groundwater though seeping of non-environmentally friendly arboricides.

Actions

- Harvesters and landowners should be encouraged to use stem/foliar applied chemicals instead of soil-applied arboricides and shall comply with FSC pesticides standards.
- Follow harvesting guidelines.
- Do not use arboricides in sensitive areas with shallow water levels of 0-20m bgl. If this cannot be avoided, the use of Arboricides with short half-lives, shall be promoted as potential aftercare application.

Emergency situations

None identified.

7.6.9 Issue: Contamination of Groundwater from Hydrocarbon Spillages and Undetected Leakages from Harvesting Equipment and Trucks Transporting Biomass

7.6.9.1 *Assessment of Impact*

Severity

Hazardous industrial materials such as hydrocarbons (oil, grease, and lubricating oil) are expected to be used during the harvesting activities, and accidental fuel spillage and undetected leakage from harvesting machinery may occur and consequently seep into groundwater especially in areas where the watertable is shallow. Hydrocarbon products that reach the groundwater are considered to pose a serious threat. Since it is difficult to reinstate the groundwater system to its original state after pollution, the severity is therefore High in the mitigated scenario, reducing to Low in the mitigated scenario.

Duration

The impact is not easily reversible but may be reversible during the life of the project.

Spatial scale

Localized, within harvest boundary, except in cases where harvesting and spills are close to the edge of the harvest boundary, then pollution will be beyond the harvest boundary. The spatial scale is therefore rated as Medium in the unmitigated scenario and Low in the mitigated scenario.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability that the spillages will occur and seep into groundwater is possible in the unmitigated scenario. With mitigated the spillages can be avoided or prevented to seep into the groundwater.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.9.2 *Tabulated Summary of the Assessed Impact – Contamination of Groundwater from Hydrocarbon Spillages and Undetected Leakages from Harvesting Equipment and Trucks Transporting Biomass*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.9.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impacts on groundwater through hydrocarbon spillages.

Actions

- Regular maintenance of machinery and fuel carriers, and servicing of vehicles to prevent breakdowns and the need to repair machinery onsite.
- Ensure that the fuel transport companies have a system in place to deal with hydrocarbon spills and subsequent clean-up thereof.
- Designated refuelling areas for harvesting equipment. Re-fuelling procedure to be developed.
- If any onsite refuelling is planned drip trays must be provided to contain any spills.
- Groundwater monitoring of nearby water sources.

Emergency situations

Major spillage incidents will be handled in accordance with the Biomass Power Project Emergency Response Procedure and will be reported to MEFT and MAWF.

7.6.10 Issue: Impact on Groundwater from Ash Taken Back to the Harvested Farms

7.6.10.1 *Assessment of Impact*

Severity

Utilising the ash as a fertilizer on the harvested farms (i.e. area where bush was harvested) is one of the options being considered for the ash management (see section 5.5 for more details).

The bottom ash and fly ash generated as waste from the Biomass Power Station is rated as non-hazardous. The composition of the ash from the Biomass Power Station would be similar to that of bushfire ash but metal concentrations can be significantly higher, generally less nutrients and higher metal content. The metal content of the fly ash/bottom ash composite waste was analysed as having total soluble metal concentrations of <0.5 mg/l, which is below the Namibian general guideline values for effluent. The salt content and pH are however above guideline values.

A mix of fly ash and bottom ash seems to be the less harmful compound where water soluble metal and salt concentrations are mostly within Namibian General Effluent Guideline Values. The ash should be dispersed in the harvested areas and used as fertilizer and soil improver and should not be stockpiled for longer periods, whereby it could develop into a local groundwater pollution source.

Taking the above mentioned into consideration, the severity is medium in the unmitigated scenario, reducing to low in the mitigated scenario.

Duration

The impact is not easily reversible but may be reversible during the life of the project.

Spatial scale

Localized, within harvest boundary, except in cases where harvesting and spills are close to the edge of the harvest boundary, then pollution will be beyond the harvest boundary. The spatial scale is therefore rated as Medium in the unmitigated scenario and low in the mitigated scenario.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability that the ash will have a negative impact on groundwater is possible this is therefore ranked as Medium in the unmitigated scenario. This would be reduced to Low with mitigation.

Significance

The significance of this potential impact is Medium in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.6.10.2 *Tabulated Summary of the Assessed Impact – Impact of Ash Taken Back to the Harvested Farms*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.6.10.3 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent impacts on groundwater through ash management practices.

Actions

- Ash to be dispersed and used as fertilizer at the harvested farms or used for alternative applications (as discussed in section 5.5) or disposed of at an approved municipal landfill, in line with their approved EMP.
- Preferably fly ash and bottom ash composite be deposited due to the less harmful metal and salt content compared to fly ash and bottom ash alone.

Emergency situations

None identified.

7.6.11 Cumulative Groundwater Impacts

Harvesting machinery will need to be refueled, it is also expected that several harvesting machineries will be employed simultaneously at different locations. The refueling of these machineries may be conducted in a number of ways, but the most feasible will be to have a fuel tanker accompanying each of the harvesting machinery for ease of access and to capitalize on the time given to complete the harvesting. The risks to groundwater involved with these activities include overturn and spillage from fuel tankers, using inadequate equipment such as broken fuel nozzles to transfer fuel from tanker to harvesting equipment which may lead to fuel spills or drips and the undetected fuel leakages from the stationary fuel tankers. It may also include the risks from machinery repair and maintenance.

These leakages if undetected or untreated pose a risk for groundwater contamination especially in areas of shallow groundwater levels. If no detailed risk assessment and mitigation is conducted and followed by the contractor, these spills will be across more than one isolated area and an accumulation of fuel spills will be an accumulation of hydrocarbons across the harvest area, which increases the risk for groundwater.

7.7 AIR QUALITY

This section is based on the Air Quality, Climate Change and Health Risk Assessment (Airshed, 2018) included in Appendix 5.

With reference to Table 7-11, there are a number of sources during all phases of the proposed project that have the potential to pollute the air. In the construction and decommissioning phases these activities will be limited to the gaseous emissions and dust from vehicles and generator exhausts and are temporary in nature and will only last a few months. The operational phase will present more long term activities with the main sources of emissions being associated with the release of SO_2, CO and NOx as NO_2 from the proposed Power Station. The carbon footprint of the Project is however assessed in section 7.12.

TABLE 7-11: AIR QUALITY IMPACTS – LINK TO PROJECT PHASES AND ACTIVITIES

<table>
<tr><th>PROJECT COMPONENT</th><th>CONSTRUCTION</th><th>OPERATIONAL</th><th>DECOMMISSIONING AND CLOSURE</th></tr>
<tr><td>Harvesting</td><td rowspan="2">Relevant to first 3 months pre-commissioning stockpile: Similar to operational phase.</td><td rowspan="2">Dust from bush harvesting activities and transportation on gravel roads causing impacts to third parties’ health and causing nuisance.
Gaseous and particulate emissions from vehicle tailpipes</td><td>-</td></tr>
<tr><td>Transport of biomass</td><td>-</td></tr>
<tr><td>Power Station</td><td rowspan="2">Exhaust fumes (vehicles, generators)
Construction / building activities causing dustfall, PM_{10} and $PM_{2.5}$</td><td>Vehicle entrained dust from paved roads
Materials handling and storage causing dust
Power Station stack emissions i.e. combustion
Exhaust fumes e.g. vehicles, generators.
Ash disposal activities.</td><td rowspan="2">Exhaust fumes from vehicles and generators.
Decommissioning activities, i.e. blasting during the demolition of infrastructure, handling and disposal of building waste causing dustfall, PM_{10} and $PM_{2.5}$</td></tr>
<tr><td>Overhead power line</td><td>-</td></tr>
</table>

Typically international criteria are referenced when no local ambient air quality criteria exist, or are in the process of being developed.

Table 7-12 summarises the relevant international ambient air quality limits, including WHO Guideline values, EU Air Quality Directive limits, US NAAQS and SA NAAQS that were established by the Air Quality Specialist and used as a basis for the assessment (refer to Appendix 5 for more details).

TABLE 7-12: INTERNATIONAL AMBIENT AIR QUALITY LIMITS[22]

Pollutant	Averaging Period	WHO Guideline Value (µg/m³)	EU Air Quality Directive (µg/m³)	US NAAQS (µg/m³)	South Africa NAAQS (µg/m³)
Sulphur Dioxide (SO_2)	1-year	-	-	-	50
	24-hour	125 (IT-1) 50 (IT-2) (a) 20 (guideline)	125 (b)	-	125 (q)
	1-hour	-	350 (b)	196 (h); 1 300 (i)	350 (r)
	10-minute	500 (guideline)	-	-	500 (s)
Nitrogen Dioxide (NO_2)	1-year	40 (guideline)	40 (b)(c)	100 (j)	40
	1-hour	200 (guideline)	200 (b)(d)	188 (k)	200 (r)
Particulate Matter (PM_{10})	1-year	70 (IT-1) 50 (IT-2) 30 (IT-3) 20 (guideline)	40 (b)(e)	-	40 (t)
	24-hour	150 (IT-1) 100 (IT-2) 75 (IT-3) 50 (guideline)	50 (b)(f)	150 (l)	75 (q)(t)
Particulate Matter ($PM_{2.5}$)	1-year	35 (IT-1) 25 (IT-2) 15 (IT-3) 10 (guideline)	25 (b)(g)	12 (m) 15 (n)	20 (q)(u) 15 (r)(v)
	24-hour	75 (IT-1) 50 (IT-2) 37.5 (IT-3) 25 (guideline)	-	35 (o)	40 (q)(u) 25 (q)(v)
CO	1-hour	30 000	-	40 000 (p)	30 000 (w)
	8-hour	10 000	10 000 (b)	10 000 (p)	10 000 (x)

Notes:

[22] Concentrations measured at ground level outside the proposed power station area

(a) Intermediate goal based on controlling motor vehicle emissions; industrial emissions and/or emissions from power production. This would be a reasonable and feasible goal to be achieved within a few years for some developing countries and lead to significant health improvement.
(b) EC Air Quality Standards (https://ec.europa.eu/environment/air/quality/standards.htm).
(c) EU 2008/50/EC Directive on Ambient Air Quality (https://www.eea.europa.eu/themes/air/air-quality-standards).
(d) EU 2008/50/EC Directive on Ambient Air Quality (https://www.eea.europa.eu/themes/air/air-quality-standards). Not to be exceeded more than 18 times per year.
(e) EU 2008/50/EC Directive on Ambient Air Quality (https://www.eea.europa.eu/themes/air/air-quality-standards).
(f) EU 2008/50/EC Directive on Ambient Air Quality (https://www.eea.europa.eu/themes/air/air-quality-standards). Not to be exceeded more than 35 days per calendar year.
(g) EU 2008/50/EC Directive on Ambient Air Quality (https://www.eea.europa.eu/themes/air/air-quality-standards). The target value has become the limit value since 1 January 2015.
(h) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Primary SO2, 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
(i) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Secondary SO2 3-hour average not to be exceeded more than once per year.
(j) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Primary and Secondary annual mean.
(k) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Primary NO2, 98th percentile od 1-hour daily maximum concentrations, averaged over 3 years.
(l) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Not to be exceeded more than once per year on average over 3 years.
(m) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Primary PM2.5, annual mean, averaged over 3 years.
(n) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Secondary PM2.5, annual mean, averaged over 3 years.
(o) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Primary and Secondary PM2.5, 98th percentile, averaged over 3 years.
(p) US National Ambient Air Quality Standards (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Not to be exceeded more than once per year.
(q) 4 permissible frequencies of exceedance per calendar year
(r) 88 permissible frequencies of exceedance per calendar year
(s) 526 permissible frequencies of exceedance per calendar year
(t) Applicable from 1 January 2015.
(u) Applicable 1 January 2016 to 31 December 2029.
(v) Applicable 1 January 2030.
(w) Not to be exceeded more than 88 times per calendar year.
(x) Calculated on 1-hour averages, not to be exceeded more than 11 times per calendar year.

Hydrogen chloride (HCl) is a non-criteria pollutant. Air quality limits for non-criteria pollutants are published by various sources, such as:

- WHO guideline values for non-carcinogens and unit risk factors for carcinogens;
- Inhalation reference concentrations US EPA in its Integrated Risk Information System (IRIS);
- Reference exposure levels (RELs) published by the Californian Environmental Protection Agency (CALEPA) and California Office of Environmental Health Hazard Assessment (OEHHA);
- Minimal risk levels (MRL) issued by the Federal Agency for Toxic Substances and Disease Registry (ATSDR); and

- Effects screening levels (ESLs) issued by the Texas Commission on Environmental Quality (TCEQ).

In the assessment of the potential for health risks use is generally made of the lowest threshold published for a particular pollutant and averaging period.

The health risk criteria (TCEQ ESLs) and Californian Reference exposure levels for hydrogen chloride (HCl) are given in Table 7-13.

TABLE 7-13: HEALTH RISK CRITERIA FOR NON-CARCINOGENIC EXPOSURES OF HYDROGEN CHLORIDE

Compound	Acute	Chronic	Reference
Hydrogen chloride	190 (µg/m³)	7.9 (µg/m³)	TCEQ ESLs
Hydrogen chloride	2 100 (µg/m³)	9 (µg/m³)	OEHHA RELs

7.7.1 Issue: Air Pollution – Power Station and Powerline Activities

7.7.1.1 *Introduction*

The Air Quality Specialist made use of a dispersion model to determine highest hourly, highest daily and annual average ground level concentrations for the operations of the Biomass Power Station. Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria.

Dispersion modelling for the construction and decommissioning phases were considered to be unrepresentative of the actual activities that will result in dust and gaseous emissions, due to the overly conservative emission rate calculation.

Emission limits are aimed to control the quantities of emissions from pollution sources[23]. Namibia does not have any emission limits or guidelines as a result, international emission standards and limits were referenced by the Air Quality Specialist, including the EU industrial directive emission limits, the IFC guidelines, as well as the SA Minimum Emission Standards (MES).

The potential for air quality impacts from the proposed Power Station is therefore assessed for three different emission limit scenarios:

1. Scenario 1: Latest (2019) plant design specifications (see section 4.4.4.5);
2. Scenario 2: Emission rates based on the World Bank Group (WBG) IFC (Table 7-14) and SA MES (Table 7-15); and
3. Scenario 3: Emission rates based on EU industrial directive emission limits (Table 7-16).

The plant design parameters and associated emission rates for all three scenarios are provide in Table 7-17. The modelling scenarios were undertaken for the 40 MW Power Station, thus two stacks were modelled i.e. two times 20 MW plants.

[23] Concentrations measured at point of release (at the source)

TABLE 7-14: GUIDELINES FOR LARGE COMBUSTION FACILITIES FOR SOLID FUELS, PLANT SIZE >50 MWTH TO <600 MWTH (IFC)

IFC guidelines for stack emissions from solid fuel boilers, emission rates in mg/Nm³ at 6% O_2 on dry gas		
Pollutant	**95% of 1-hr averages, non-degraded Airshed (a)**	**95% of 1-hr averages, degraded Airshed (b)**
NOx	500	200
SO_2	400 – 1000 (c)	400
PM	50	30

Notes:

a) Non-Degraded Airshed (national air quality standards are complied with or in their absence WHO Air Quality Guidelines are not exceeded significantly)
b) Degraded Airshed (national air quality standards are not complied with or in their absence WHO Air Quality Guidelines are exceeded significantly)
c) Targeting the lower guidelines values and recognizing variability in approaches to the management of SO_2 emissions (fuel quality vs. use of secondary controls) and the potential for higher energy conversion efficiencies. Selection of the emission level in the range is to be determined by EA taking account of environmental, community health, technical and economic considerations.

TABLE 7-15: MINIMUM EMISSIONS STANDARDS (SA MES, 2013)

Pollutant	**Unit**	**Minimum emission standards for stack emissions from solid biomass combustion installations, ≥ 50MWth, emission rates in mg/Nm³ at 10% O_2 on dry gas**	**Minimum emission standards corrected for 6% O_2 on dry gas**
		Average over 1 month	**Average over 1 month**
NO_x	mg/Nm³	750	1023
SO_2	mg/Nm³	500	682
PM	mg/Nm³	50	68

TABLE 7-16: EU DIRECTIVE FOR LARGE COMBUSTION FACILITIES FOR SOLID FUELS, PLANT SIZE >50 MWTH

IED BAT Conclusions (EU), August 2017 (>50 MWth, 6% O_2, dry)				
Parameter	**Unit**	**Annual average**	**Daily average or average over the sampling period**	**Average over the sampling period**
NOx	mg/Nm³	50-140	100-200	–
SO_2	mg/Nm³	< 10-50	< 20-85	–
Dust	mg/Nm³	2-5	2-10	–

IED BAT Conclusions (EU), August 2017 (>50 MWth, 6% O_2, dry)				
HCl	mg/Nm³	1-5	1-12	< 1

Note:

The EU Directive does not provide an emission limit for CO, but instead gives an indication as what the yearly CO emission levels are likely to be based on the Best Available Technology (BAT) provided for NOx emissions to air from the combustion of solid biomass and/ or peat. The likely achievable emission levels are given as < 30-160 mg/Nm³.

TABLE 7-17*: POWER STATION STACK PARAMETERS AND EMISSIONS CONCENTRATIONS FOR THE THREE SCENARIOS ASSESSED*

Scenario	Stack Height (m) (f)	Stack Diameter (m)	Exit Velocity (m/s)	Exhaust Vol.-Flow (m³/s)	Exit Temp (°C)	Emissions (mg/Nm³)				
						PM	SO_2	NO_x	HCl	CO
Scenario 1 (a)	75	1.75	15	36.08	125	5	600	400	300	ND
Scenario 2 (b)	75	1.75	15	36.08	125	50	683.5(d)	500	0	ND
Scenario 3 (c)	75	1.75	15	36.08	125	10	85	200	12	160 (e)

Notes:

ND is No Data

(a) Plant design specifications, based on 6% oxygen
(b) WBG IFC (IFC, 2017) and SA MES limits
(c) EU industrial directive emission limits
(d) SA MES for SO2 is 500 mg/Nm³ based on 10% oxygen, corrected for 6% oxygen
(e) CO emission levels is given as an indicated achievable yearly average level of < 30-160 mg/Nm³ based on the achievable NOx emission to air (EU, 2017).
(f) An optimum stack height was calculated as part of the plant design. This was based on Good Engineering Practice (GEP) and dispersion simulations were conducted to demonstrate the reduction in ground level concentrations (GLCs) as a result of a GEP stack design.

The dispersion modelling included PM_{10}, $PM_{2.5}$, SO_2, NOx and HCl, there is no emission limit for HF. For PM_{10} and $PM_{2.5}$, all sources associated with the biomass plant were included combustion and power generation, as well as fugitive emissions from onsite transport of raw materials to plant; storage and handling and ash disposal activities. PM from the stack was assumed to be all PM_{10} and all $PM_{2.5}$ as a conservative estimate since no particle size distribution data is available. CO was modelled for Scenario 3 only due to no data for the other two scenarios.

7.7.1.2 *Assessment of Impact*

Severity

Construction and Decommissioning phases

The main construction and decommissioning activities likely to result in noticeable impacts due to particulate emissions ($PM_{2.5}$, PM_{10} and total suspended particles (TSP) include land clearing, construction of buildings and infrastructure, blasting during the demolition of infrastructure i.e. decommissioning, handling and disposal of building waste i.e. decommissioning, and vehicle entrainment of dust from the construction site. Vehicle entrainment of dust represents a relatively large source of fugitive dust emissions during construction. The activities associated with construction may cause a lot of dust, if uncontrolled, e.g. vehicle traffic on unpaved roads.

Gaseous and particulate emissions from vehicle tailpipes are far lower and therefore of less significance in terms of their impacts.

The Air Quality Specialist calculated emissions for general infrastructure construction activities (requiring clearing of 44 ha of land). The average TSP and PM_{10} emissions have been quantified as 4.93 tpm and 1.92 tpm, which is very low. It is not expected that the PM_{10} annual average concentration would be higher than the annual limit of 40 µg/m³, but it is possible that short-term concentrations could exceed the daily limit of 50 µg/m³ for more than 3 days per year, depending on the level and intensity of activity.

Taking the above mentioned into consideration, the severity of the impact will be low to medium in the unmitigated scenario reducing to low in the mitigated scenario.

<u>Operations phase</u>

The main operational activities at the plant include the onsite transport of raw materials to plant, storage and handling, combustion, and ash disposal activities. The incremental air quality impacts are discussed below.

PM_{10}

- Simulated PM_{10} concentrations were low and well below the WHO AQG for both 24-hour averages and annual averages, for all three scenarios. Scenario 2 resulted in the highest GLCs followed by Scenario 3 with Scenario 1 (design emissions) resulting in the lowest GLCs. This is because the design emission rates for PM from the Power Station stack were much lower than the emission limits from the EU, IFC and SA MES.

$PM_{2.5}$

- Simulated $PM_{2.5}$ GLCs from all sources (point and fugitive) were low and well below the WHO AQG for both 24-hour- and annual averages for all three scenarios, at all receptors. Scenario 1 (design emissions) resulted in lower GLCs than the other two scenarios.

SO_2

- Scenario 1 (design emissions) resulted in simulated SO_2 GLCs well below the representative limits for all three averaging periods (hourly, 24-hourly and annual). When the highest GLCs at the site boundary were compared against the ambient air quality limits, these were 33% of the EC hourly limit, 42% of the WHO-IT2 and 26% of the EC annual limit. Scenario 2 resulted in the highest GLCs with Scenario 3 the lowest. All scenarios however resulted in GLCs well below the respective limits.

CO

- For CO, the second highest hourly and 8-hourly GLCs were provided for Scenario 3 only since there are no CO emissions for the other two scenarios. The simulated GLCs were well below the SA NAAQS for both averaging periods.

NO_2

- Simulated NO_2 GLCs at the various receptors for all three scenarios were well below the WHO AQG for both 1-hour and annual averages. For Scenario 1 (design emissions), the highest simulated GLCs at the site boundary were well below the guidelines at 38% (hourly) and 9% (annual average).

HCL

- Simulated GLCs for the second highest hourly and annual averages, at each receptor, were provided. The maximum GLCs from Scenario 1 (design emissions) were well below the acute ESL (190 µg/m³) and chronic ESL (7.9 µg/m³) at the Site Boundary.

Simulated GLCs, based on design emission rates for all pollutants assessed, resulted in impacts that are well below the respective ambient air quality guidelines and limits.

The severity of fugitive $PM_{2.5}$ and PM_{10} impacts due to onsite vehicle activity, storage and handling and ash disposal will be Low (with or without mitigation). The severity of $PM_{2.5}$, PM_{10}, SO_2, NO_2 and HCl impacts due to combustion is considered Medium in the unmitigated scenario[24] and Low in the mitigated scenario.

Duration

The duration will be short term for the construction and decommissioning phases, and medium term for the operational phase.

Spatial scale

The impacts due to construction and decommissioning activities are likely to be mostly localised with occasional instances of impacts extending beyond the site boundary, depending on the dispersion potential of the site and the extent of the construction/decommissioning operations.

Provided that the plant adheres to the air emission limits the PM_{10}, $PM_{2.5}$, SO_2, HCl, CO and NO_2 impacts due to the biomass combustion operations will be localised. The PM_{10} and $PM_{2.5}$ impacts due to fugitive emissions from materials handling and vehicle entrainment of dust on paved roads will also be localised (with mitigation) and local (without mitigation).

Consequence

Construction and Decommission phases

The determining consequence is Low in the unmitigated and mitigated scenarios for TSP, $PM_{2.5}$ and PM_{10}.

Operations phase

The determining consequence is Medium in the unmitigated scenario and Low in the unmitigated scenario for PM_{10}, $PM_{2.5}$, SO_2, HCl, CO and NO_2.

Probability

The probability associated with the potential air quality impacts is assessed as possible i.e. Medium in the unmitigated scenario and reduced to low in the mitigated scenario.

Significance

[24] The severity of impacts due to uncontrolled process emissions is rated "High" because of inherent problems, such as slagging and fouling and corrosion associated with grate-fired combustion of biomass fuels with high chlorine and high ash contents.

The significance of this potential impact is medium in the unmitigated scenario and low in the mitigated scenario for all project phases for PM_{10}, $PM_{2.5}$, SO_2, HCl, CO and NO_2. SLR's confidence level is high for this significance rating.

7.7.1.3 *Tabulated Summary of the Assessed Impact – Air Pollution – Power Station and Powerline Activities*

Construction and Decommission phases (TSP, PM_{10} & $PM_{2.5}$)

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**L**	**L**	**L**	**M**	**M**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

Operations phase (PM_{10}, $PM_{2.5}$, SO_2, HCl, CO and NO_2)

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**L**	**M**	**M**	**M**
Mitigated	**L**	**M**	**L**	**L**	**L**	**L**

7.7.1.4 *Cumulative SO_2 Impacts*

The cumulative SO_2 impact due to the proposed biomass Power Station and DPMT smelter activities (see section 6.10) may be understood by studying annual average SO_2 impacts due to the respective facilities. The SO_2 annual average impacts due to DPMT smelter activities, as presented in a previous air quality specialist study for the proposed Tsumeb smelter expansion project, show that three receptors are likely to fall within the area of exceedance of the SA NAAQS of 50 µg/m^3. The DPMT smelter impacts represented a worst-case scenario, with 76% conversion efficiency of the acid plant. It is expected that the acid plant would reach between 90 and 95% efficiency rate on average.

Since the simulated SO_2 annual average ground level concentrations for all three scenarios were negligible in magnitude they are not expected to cause a significant increase to the baseline concentrations. It may be concluded that although the airshed in the study area is degraded with respect to SO_2, the proposed Power Station activities will not result in further deterioration of the ambient air quality.

7.7.1.5 *Conceptual Description of Mitigation Measures*

The air quality impact assessment for the proposed Power Station, based on design emission rates for all pollutants assessed and with a 75m stack height which would provide good air dispersion without building influences, showed low impacts that are well below the respective ambient air quality guidelines and limits. Based on this, additional Best Available Techniques (BAT) is regarded not necessary. It can be concluded that the current plant design with a stack height of 75m would result in potential low significance health impacts offsite, and at the surrounding receptors. For this reason, and taking into consideration the socio-economic and ecological conditions of the country, the emission limits may be based on the plant design and not the more stringent EU industrial directive emission limits.

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations that are within the relevant ambient air quality limits at nearby AQSRs. Although the impact assessment for the proposed Power Station showed low impacts, it is advisable to adopt good practice control measures onsite to avoid dust generating problems.

Actions

- The plant should be designed for a 75m stack height[25], which would provide good air dispersion without building influences to ensure minimal ground level impacts.
- The plant should be designed to meet the WBG IFC and SA MES emission limits.
- Although the impact assessment for the proposed power plant showed low impacts, it is advisable to adopt good practice control measures onsite to avoid dust generating problems. Sweepers can be employed to clean paved road surfaces within the project area; various dust control techniques are available to reduce windblown dust due to dust spillage, material storage and open areas; wet suppression may be used to suppress the formation of airborne dust due to materials handling and limiting the drop height from which tipping occurs would reduce the potential for the entrainment of fines by the wind.

Emergency situations

None identified.

7.7.2 Issue: Air Pollution – Harvesting and Associated Activities

7.7.2.1 *Introduction*

The Air Quality Specialist decided to model the harvesting activities as an area source. The size of the area was determined by taking into account the total extractable wood in tonnes dry mass per hectare i.e. 12.65 t/ha. The number of harvesting teams operating at any one time, i.e. 12 for the 40 MW Biomass Power Station, and the number of weeks in a year in which biomass harvesting will take place, i.e. 40 (refer to section 4.4.2.7).
Materials handling at the collection point and biomass storage area, as well as the wood chipper were modelled as volume sources. Sections of paved and unpaved roads were modelled as area sources to determine their respective impact areas.

Two scenarios were modelled, namely:
<u>Biomass Harvesting Scenario 1</u>: Biomass harvesting area modelled on flat terrain.
<u>Biomass Harvesting Scenario 2</u>: Biomass harvesting area modelled on hilly terrain.

[25] Should NamPower's Technical advisers or EPC Contractor propose other emission control technologies and a different stack height during the detail design stage of the project, the Air Quality Study needs to be revised to incorporate these possible changes to the plant design specifications to ensure the potential impacts (relating to the GLCs) remain similar to those assessed in the EIA.

It was decided to select two biomass harvesting areas, using a combination of terrain data to identify flat and hilly terrain, and a map of areas with slopes greater than 12.5% to exclude them from consideration.

Profiles corresponding with simulated ambient PM_{10}, $PM_{2.5}$, SO_2 and NO_2 ground level concentrations for the harvesting and associated activities. From these profiles, the Air Quality Specialist determined the distance travelled from the first point, at the source, to the last point at a specified distance, and the elevation or ground level concentration (refer to Appendix 5 for the various profiles). The profiles were used to estimate the distance from the source at which the target limit for each pollutant is predicted to be met.

7.7.2.2 *Assessment of impact*

Severity

Operational activities related to biomass harvesting include the felling of trees and bush, stacking and gathering for sun-drying of felled bush, in-field wood chipping while blowing the chips into a shuttle trailer, shuttling of the chips to the transferring point, transferring the chips onto the public road transporting vehicle, and transporting the chips to the Power Station. In general, simulated impacts due to Scenario 1, flat terrain, were higher in magnitude than Scenario 2, hilly terrain,.

<u>Biomass Harvesting: Scenario 1 – Flat Terrain</u>

PM_{10}

- Highest modelled daily PM_{10} concentrations for Scenario 1 were within the WHO Guideline of 50 µg/m³ for all source contributions. The total PM_{10} impacts due to biomass harvesting, excluding secondary transport, were also within the WHO Guideline.

$PM_{2.5}$

- Highest modelled daily $PM_{2.5}$ concentrations for Scenario 1 were within the WHO Guideline for all source contributions, and the total $PM_{2.5}$ impacts due to biomass harvesting, excluding secondary transport, were also within the WHO Guideline.

SO_2

- Highest modelled hourly SO_2 concentrations for Scenario 1 due to wood chipping operations were within the EC Directive of 350 µg/m³.
- Highest modelled daily SO_2 impacts for Scenario 1 due to wood chipping operations were within the WHO IT-2 of 50 µg/m³.

NO_2

- Highest modelled hourly NO_2 concentrations for Scenario 1 due to wood chipping operations were predicted to meet the WHO Guideline of 200 µg/m³ at approximately 200 m from the source.
- Highest modelled hourly NO_2 concentrations for Scenario 1 due to biomass harvesting operations were within the WHO Guideline of 200 µg/m³.

<u>Biomass Harvesting: Scenario 2 – Hilly Terrain</u>

PM_{10}

- Highest modelled daily PM_{10} impacts for Scenario 2 were within the WHO Guideline of 50 µg/m³ for all source contributions. The total PM_{10} impacts due to biomass harvesting, excluding secondary transport, were also within the WHO Guideline.

$PM_{2.5}$

- Highest modelled daily $PM_{2.5}$ impacts for Scenario 2 were within the WHO Guideline for all source contributions, and the total $PM_{2.5}$ impacts due to biomass harvesting, excluding secondary transport, were also within the WHO Guideline.

SO_2

- Highest modelled hourly SO_2 impacts for Scenario 2 due to wood chipping operations were within the EC Directive of 350 µg/m³.
- Highest modelled daily SO_2 impacts for Scenario 2 due to wood chipping operations were within the WHO IT-2 of 50 µg/m³.

NO_2

- Highest modelled hourly NO_2 impacts for Scenario 2 due to wood chipping operations were predicted to meet the WHO Guideline of 200 µg/m³ at approximately 130 m from the source.
- Highest modelled hourly NO_2 impacts for Scenario 2 due to biomass harvesting operations were within the WHO Guideline of 200 µg/m³.

Transport of Wood Chips

- The highest daily modelled PM_{10} impacts due to a 1 km section of unpaved road were predicted to meet the WHO Guideline of 50 µg/m³ at approximately 60 m from the source. The highest daily modelled PM^{10} impacts due to a 1km section of paved road were within the WHO Guideline.
- The highest daily modelled $PM^{2.5}$ impacts were within the WHO Guideline of 25 µg/m³ for both unpaved and paved roads.

Taking the above into consideration, the severity of particulate and NO_2 impacts due to biomass harvesting is Low in both the unmitigated and mitigated scenarios. The severity of particulate, NO_2 and SO_2 impacts due to wood chipping is Medium in the unmitigated scenario and Low in the mitigated scenario. PM_{10} and $PM_{2.5}$ impacts due to materials handling and vehicle entrainment of dust is Medium in the unmitigated scenario and Low in the mitigated scenario.

Duration

The duration will be Medium.

Spatial scale

For biomass harvesting, the impacts due to bush felling and materials handling will be localised. However, for wood chipping the potential exists for PM_{10}, SO_2 and NO_2 impacts to be more widespread. The potential also exists that PM_{10} impacts due to vehicle entrained dust on unpaved roads may be more widespread.

Consequence

The determining consequence is Medium in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability associated with the potential air quality impacts is assessed as possible i.e. Medium in the unmitigated scenario and reduced to Medium to Low in the mitigated scenario.

Significance

The significance of this potential impact is Low in the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.7.2.3 *Tabulated Summary of the Assessed Impact – Air Pollution – Harvesting and Associated Activities*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**M**	**M**	**M**	**M**
Mitigated	**L**	**M**	**L**	**L**	**M-L**	**M-L**

7.7.2.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations that are within the relevant ambient air quality limits at nearby AQSRs. Although the impact assessment for the proposed Power Station showed low impacts, it is advisable to adopt good practice control measures onsite to avoid dust generating problems.

Actions

It is recommended that sensitive areas within harvest zones be identified via field inspection prior to commencement of felling operations and that setback distances be determined between harvest zones and sensitive populations, taking into account the topography and prevailing wind directions. Harvest intensity should be reduced close to sensitive land uses, harvesting blocks should be kept small i.e. done in patches, with vegetation kept in between, and vegetation buffers should be retained between harvesting activities and sensitive receptors to reduce the potential of windblown dust from open areas.

Water sprays can be used on unpaved roads to suppress fugitive dust due to vehicle entrainment. The entrainment of material can be reduced by restricting traffic volumes and reducing vehicle speeds.

<u>Recommended Evaluation Distances for Biomass Harvesting Activities</u>

Evaluation distances provide an envelope around an activity or multiple activities within which environmental risks need to be assessed against current knowledge, technologies and practices (Australian EPA, 2016).

The following may be considered sensitive land uses:

- Caravan parks;
- Childcare centres;
- Community centres;
- Consulting rooms;

- Educational institutions;
- Hospitals;
- Hotels and motels;
- Nursing homes and retirement villages;
- Parklands, recreation areas and reserves;
- Residential dwellings and associated private outdoor recreational areas;
- Tourism accommodation; and
- Residential zones.

The recommended evaluation distance for biomass harvesting, is 200 m.

The profiles created in Appendix 5 may also be used to determine setback distances between harvesting areas and residential areas. The biggest setback distance indicated for wood chipping activities was for NO_2, viz. 200 m for flat terrain, and 130 m for hilly terrain. Vegetation buffers should be retained in areas that fall within these respective setback distances to reduce the potential for windblown dust.

Emergency situations

None identified.

7.7.3 Cumulative Air Quality Impacts

Neighbouring sources of air pollution which may contribute to cumulative air quality conditions were identified, and the regional dispersion potential and physical environment of all potential sites were described. Refer to section 6.10.2.2 for the existing ambient air pollution concentrations in the area.

The contaminant of greatest concern in the study area, relating to the proposed power station, was identified as SO_2, due to the presence of the Tsumeb Smelter in the near vicinity of the proposed project. Refer to section 7.12 for the quantitative assessment of the incremental risk to the ambient population as a result of the proposed Project on SO_2.

7.8 NOISE

The information in this section was sourced from the noise specialist study (refer to Appendix 7).

With reference to Table 7-18, there are a range of construction, operation and decommissioning project activities that have the potential to generate noise, disturbance and nuisance, and cause related noise impacts at sensitive receptors.

TABLE 7-18: NOISE IMPACT – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Vehicle movement and machinery used for bush thinning activities relating to the 3 month pre-commissioning stockpile.	Vehicle movement and machinery used for bush thinning activities, including: Felling, stacking, feeding, chipping and shuttling.	-

Transport of biomass		Increased vehicular movements associated with the transport of the wood chips to the Power Station.	-
Power Station	Site preparation & establishment. General construction activities. Earthworks for all surface infrastructure. Construction of foundations. Equipment maintenance. Access road construction. Vehicle movement. Generators. Other support services and amenities.	General site management activities. Off-loading of biomass. Materials handling. Equipment maintenance. Vehicle movement. Power Station operations. Waste management. Water management (pumps). Support services and amenities.	Demolition. General decommissioning and rehabilitation activities. Earthworks. Vehicle movement. Support services and amenities.
Overhead power line		-	

General noise disturbance can be defined as an increase in ambient noise levels and can be quantified and assessed based on estimated or measured sound levels, expressed in decibels (dB), which is compared to baseline noise levels. There are currently no regulations concerning environmental noise in Namibia.

Therefore, predicted noise levels have been assessed against the following guidelines:

- **<u>Construction noise:</u>**
  - IFC and World Bank guidelines - Environmental, Health and Safety (EHS) Guidelines (General guidelines)
  - British Standard BS5228:2009+A1:2014 – Code of Practice for Noise and Vibration Control on Construction and Open Sites –Part 1: Noise
  - Considering the setting and context of the proposed development, the noise criterion adopted for the assessment of construction noise is a fixed noise limit of 70dB (LA_{eq}[26]) with respect to weekday and Saturday daytime working.

- **<u>Operational noise i.e. Power Station and harvesting activities:</u>**
  - IFC and World Bank Guidelines – Environmental, Health and Safety (EHS) Guidelines (General Guidelines)
  - The guidelines provide noise criteria which should not be exceeded, whereby noise impacts should not exceed the levels presented in Table 7-19.
  - EHS Guidelines for Thermal Power Stations. The guidelines are related to the General EHS Guidelines and are therefore also based on recommended ambient noise levels presented in Table 7-19.

[26] The A-weighted equivalent sound pressure level (in dBA)

- World Health Organisation Guidelines – Guidelines for Community Noise & Night Noise Guidelines for Europe:
    - Recommend guideline noise levels regardless of the current noise environment. The former are referred to as the IFC and World Bank guidelines, with respect to acceptable indoor noise levels.
    - The WHO suggests suitable noise levels for indoor living areas during the daytime and night-time periods, and these levels are set regardless of the noise type or noise source, i.e. 'benchmark' levels. It advises on the minimum levels of noise before critical health effects, including annoyance, occur. In this regard, the WHO guidelines state:
        - *"In dwellings, the critical effects of noise are on sleep, annoyance and speech interference. To avoid sleep disturbance, indoor guideline values for bedrooms are 30dB LAeq,8h for continuous noise and 45dB LAFmax for single sound events; and*
        - *To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55dB LAeq,16h for a steady, continuous noise."*

- **Transport noise:**
    - The Design Manual for Roads and Bridges (DMRB[27]) - Noise and Vibration states that *"a change in noise level of 1dB is equivalent to a 25% increase or 20% decrease in traffic flows, assuming all other factors remain unchanged"*. DMRB also provides advice on the magnitude of impacts associated with increases in traffic flows and associated noise levels. It is stated that *"a change in road traffic noise of 1dB $L_{A10,18hr}$ in the short term e.g. when a project is opened, is the smallest that is considered perceptible"*. In the long term, a 3dB change is considered perceptible.

TABLE 7-19: IFC/WORLD BANK NOISE LEVEL GUIDELINES

Receptor	One Hour (L_{Aeq} dB)	
	Daytime 07.00 – 22.00	**Night-time 22.00 – 07.00**
Residential; institutional; educational	55	45
Industrial; commercial	70	70
NOTEs: Guideline values are for noise levels measured out of doors. (*Source: Guidelines for Community Noise, World Health Organisation (WHO), 1999*) For acceptable indoor noise levels for residential, institutional and educational settings refer to WHO (1999)		

7.8.1 Issue: Noise Pollution – Power Station and Power Line Site and the Immediate Landscape

7.8.1.1 *Introduction*

The noise specialist has assumed a list of the likely construction equipment for construction activities within the site, as summarised in Table 7-18, which will also apply to the decommissioning phase. Predictions of construction noise have been based on the corresponding 10 m sound power or sound pressure levels (SPL). The

[27] The Highways Agency (November 2011), *Design Manual for Roads and Bridges, Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 7 HD 213/11 – Revision 1 Noise and Vibration*

predicted construction noise levels have assumed the full time, concurrent use for all plant for each stage of construction. In all cases, it is likely that plant would operate for much shorter periods and not all activities would occur at the same time, resulting in lower noise levels. The assessment therefore presents a worst case scenario for construction noise levels.

The operations of the Power Station would include multiple noise sources and buildings, with the most significant elements of the plant assumed to be as follows:

- Combustion fans, boiler cleaning devices and bag filter cleaning system (compressed air);
- Turbine and generator set;
- Air cooled condenser;
- Wood chipper; and
- Screen and magnetic separator.

7.8.1.2 *Assessment of Impact*

Severity

Table 7-20 presents the highest noise levels expected from the simultaneous operation of all anticipated plant during each of the assumed stages of the construction phase. However, not all noise sources would be operational at the same and, as such, actual noise levels are likely to be lower than those predicted.

The predicted noise levels represent those during the daytime period only, as construction would be restricted between the daytime hours of 07.00 and 19.00 Monday to Friday, and between the hours of 07.00 and 13.00 on Saturdays.

TABLE 7-20: CONSTRUCTION NOISE PREDICTIONS, DB L_{AEQ}

NSR ID	NSR Name	Site Preparation & Enabling	Foundations & Substructure	Structure
NSR01	Homestead / Cattle farm	47	45	45
NSR02	Game farm	30	29	30

The predicted noise levels, due to the construction phase of the Power Station and as presented in Table 7-20, are shown to be below the BS5228-1:2009+A1:2014 limit of 70dB L_{Aeq} for daytime. This is applicable for all assumed stages of the construction phase.

In terms of construction traffic, by comparing the no-go and project scenarios, the increase in construction traffic, all vehicles, would be significantly less than 25%. Changes to the existing noise levels would therefore be less than 1dB with reference to the guidance of DMRB.

The predicted noise levels, due to the operation of the Power Station, are presented in Table 7-21 for the closest receptors. These noise levels are assumed to be the highest to occur, due to the simultaneous operation of all the identified noise sources for a 40MW Power Station. However, not all noise sources would be operational at the same time and, as such, the actual noise levels are likely to be lower than those predicted. The assessment therefore presents a worst case scenario for operational noise levels.

The predicted noise levels represent those during both the daytime and night-time periods, as the Power Station would operate on a 24/7 basis.

TABLE 7-21: IDENTIFIED OPERATIONAL NOISE SOURCES

NSR ID	NSR Name	Predicted Noise Level, dB L_{Aeq}
NSR01	Homestead / Cattle farm	44
NSR02	Game farm	24

The predicted noise levels, due to the operation of the Power Station and as presented in Table 5-5, are shown to be below the IFC and World Bank guideline of 55dB L_{Aeq} for daytime and 45dB L_{Aeq} at night-time at the closest receptors.

Taking the above into consideration, the severity is Low in the unmitigated and mitigate scenarios.

Duration

The duration of the construction and decommissioning phase impacts is short-term in both the unmitigated and mitigated scenarios. The duration of the operational phase impact is Medium, for the life of the project. This applies to the unmitigated and mitigated scenarios.

Spatial scale

The impact will extend beyond the project site boundary in the unmitigated and mitigated scenarios for all project phases, therefore will have a Medium spatial scale.

Consequence

The consequence is Low for both the unmitigated and mitigated scenarios for all project phases.

Probability

The probability of the negative impacts occurring is considered to be Low.

Significance

The significance of this potential impact is Low in both the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.8.1.3 *Tabulated Summary of the Assessed Impact – Noise Pollution – Power Station and Power Line Site and the Immediate Landscape*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**L / M***	**M**	**L**	**L**	**L**
Mitigated	**L**	**L**	**M**	**L**	**L**	**L**

*low for construction phase and medium for operations phase

7.8.1.4 *Cumulative Noise Impact*

With reference to section 6.9, it can be seen that the existing ambient noise levels at the closest receptors are already close to or in excess of the IFC and World Bank daytime and night-time noise limits (of 55dB and 45dB L_{Aeq} respectively).

It has been shown that the predicted noise levels from the operation of the plant would not exceed the recommended limits within the EHS Guidelines, similarly the cumulative impact of the plant, i.e. in combination with the existing ambient noise levels, would not be significant. The EHS Guidelines state that there should not be more than a 3dB increase to the existing noise levels at the nearest receptors.

Therefore, the contribution of operational noise from the plant would have a negligible effect, i.e. there would be no significant increase in the existing ambient noise levels during both the daytime and night time periods. This is therefore compliant with the EHS Guidelines, whereby the increase is required to be less than 3dB.

7.8.1.5 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Powerline EMP (Appendix 14).

Objective

The objectives of the management and mitigation measures are to prevent an unacceptable increase in disturbing noise and limit nuisance noise at sensitive receptors as far as practically possible.

Actions

Construction phase:

With respect to noise reduction and control strategies during construction, the EHS Guidelines recommend the following:

- Planning activities in consultation with local communities so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance;
- Using noise control devices, such as temporary noise barriers and deflectors for impact and blasting activities, and exhaust muffling devices for combustion engines; and
- Avoiding or minimising project transportation through community areas.

The adoption of Best Practicable Means (such as those recommended above through the EHS Guidelines) is usually the most effective means of controlling noise from construction sites. Experience has shown that by implementing these measures, typical noise levels from construction activities can be reduced by 5dB or more. Furthermore, problems concerning noise from construction works can sometimes be avoided by taking a considerate and neighbourly approach with local residents.

Notwithstanding the above, noise monitoring would be undertaken during the construction phase to verify construction noise levels, as recommended by the IFC and World Bank EHS Guidelines.

Operations phase:

The Power Station will need to ne designed to comply with the IFC and World Bank guidelines.

Notwithstanding the above, noise monitoring would be undertaken during operation of the Power Station to verify operational noise levels, as recommended by the IFC and World Bank EHS Guidelines.

Emergency situations

None identified.

7.8.2 Issue: Noise Pollution – Harvesting, Transportation of Biomass and Associated Activities

7.8.2.1 *Introduction*

At this stage, the exact equipment and locations for harvesting have not been defined. It has therefore not been possible to define the location of the closest NSRs for harvesting, as the exact location(s) for this activity are yet to be defined. However, the specifics of this activity would be determined with cognisance to the relevant environmental standards and requirements including noise.

The impact of traffic associated with the harvesting and transport related activties has been referenced to the baseline conditions in the traffic impact assessment. This is detailed in Table 7-2 for both the baseline year of 2022 and Year 20 in 2042, and for both heavy vehicles and all traffic.

7.8.2.2 *Assessment of Impact*

Severity

Noise levels due to harvesting activities would be designed and sited within the overall harvesting area to comply with the IFC and World Bank guideline of 55dB L_{Aeq} for daytime (harvesting would not be undertaken at night). Indicatively, this would be achieved based on a combined sound power level of 113dB(A) from all harvesting related plant and activities, at a distance of 200m from the closest receptor.

According to DMRB, *"a change in noise level of 1dB is equivalent to a 25% increase or 20% decrease in traffic flow"*. By comparing the no go and project scenarios (Table 7-2), the increase in traffic for all vehicles would be less than 25% for both the base year of 2022 and Year 20 in 2042. Changes to the existing noise levels would therefore be less than 1dB with reference to the guidance of DMRB.

Taking the above into consideration, the severity is Low in the unmitigated and mitigate scenarios.

Duration

The duration of the overall harvesting and transportation activities is for the life of the project. However, the harvesting in a specific area will be short term, i.e. less than the overall life of the project.

Spatial scale

The impact will extend beyond the site boundary of the harvesting and transport activities in the unmitigated and mitigated scenarios, therefore will be Medium with regards to spatial scale.

Consequence

The consequence is Low for both the unmitigated and mitigated scenarios.

Probability

The probability of the negative impacts occurring is considered Low.

Significance

The significance of this potential impact is Low in both the unmitigated and mitigated scenarios. SLR's confidence level is high for this significance rating.

7.8.2.3 *Tabulated Summary of the Assessed Impact – Noise Pollution – Harvesting, Transportation of Biomass and Associated Activities*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**M**	**M**	**L**	**L**	**L**
Mitigated	**L**	**M**	**M**	**L**	**L**	**L**

7.8.2.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting EMP (Appendix 15).

Objective

The objectives of the management and mitigation measures are to prevent an unacceptable increase in disturbing noise and limit nuisance noise at sensitive receptors as far as practically possible.

Actions

- Noise levels, due to harvesting activities, must be designed and sited within the harvesting area to comply with the IFC and World Bank guideline of 55dB LA_{eq} for daytime.
- Conduct harvesting-related activities, at a minimum distance of 200m from the closest receptor.

Emergency situations

None identified.

7.8.3 Cumulative Noise Impacts

The noise impact assessment relating to the proposed Power Station, in section 7.8.1 above, was conducted on a cumulative basis, taking the current (baseline) noise conditions, as well as expected noise generation from the proposed project activities into consideration.

Also, baseline noise levels within the harvesting area were not undertaken due to the significant size of the area. However, with reference to the noise impact assessment relating to the harvesting and transportation activities of the biomass (section 7.8.2), the potential cumulative impacts from these activities are not expected to contribute significantly to the background noise levels in the surrounding area. Furthermore, it is unlikely that other wood harvesting activities will be conducted, simultaneously, at or near the bush harvesting activities for the Biomass Power Project.

7.9 ARCHAEOLOGY

The information in this section was sourced from the archaeology and cultural heritage specialist study (refer to Appendix 9).

Archaeology and cultural heritage are a finite resource and as such, measures should be implemented in order to protect this resource. With reference to Table 7-17, there are several activities in all project phases that have the potential to damage archaeological resources. Potential riska that were identified include the following:

- Direct impacts from the bush clearance of the proposed Power Station site;
- Direct impacts from groundwork within the proposed Power Station site boundary prior to development;
- Indirect impacts from development on potential sacred areas of the landscape; and
- Direct impacts caused by bush harvesting actvities.

TABLE 7-22: ARCHAEOLOGY IMPACT – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Vehicle movement and machinery used for bush thinning activities relating to the 3 month pre-commissioning stockpile.	Vehicle movement and machinery used for bush thinning activities.	-
Transport of biomass		Increased vehicular movements associated with the transport of the wood chips to the Power Station.	-
Power Station	Site preparation & establishment. Earthworks for all surface infrastructure. Soil stripping and stockpiling. General construction activities. Access road construction. Vehicle movement.	General operational activities.	-
Overhead power line	Earthworks and clearing activities for the power line servitude and infrastructure.	-	-

7.9.1 Issue: Damage to Archaeological Resources – Power Station and Power Line Site and the Immediate Landscape

7.9.1.1 *Introduction*

With reference to section 6.8, there are a limited number of sites that are located within the immediate locality of the proposed Power Station site and powerline. Currently, the two sites identified are physically protected; the cairn being sited underneath an electrical pylon and in cleared open ground, and the rock outcropping possessing little or no invasive vegetation, located immediately south of the proposed Power Station site. The significance of both sites can be considered Low, although further investigation may be required in order to establish their date, provenance and symbolic significance (if any) of both sites.

7.9.1.2 *Assessment of impact*

Severity

On the basis of the archaeological assessment and study findings, the proposed project is considered to have a low archaeological sensitivity. Also, with reference to the archaeological baseline (section 6.8), there are no known archaeological sites that will be affected by the proposed project.

However, dense vegetation and difficulty of access on foot means that the survey by the archaeologist was not exhaustive. It is therefore possible that some archaeological remains will be revealed in the course of bush clearance and others construction activities. Any potential negative impact such as damage or destruction to archaeology and cultural heritage is however considered significant.

Taking the above into consideration, in the unmitigated scenario the severity is Medium. With mitigation this can be reduced to Low.

Duration

In the unmitigated scenario, the loss of archaeological sites and the related losses to the broader archaeological landscape is long term and will continue after the life of the Power Station project. With mitigation, which includes the documenting, where applicable, and preservation of sites in-situ, the duration is reduced to Low.

Spatial scale

The spatial scale is localised within the site boundary and therefore Low.

Consequence

The consequence of this potential impact is Medium in the unmitigated scenario. It reduces to Low in the mitigated scenario because the severity is reduced.

Probability

The probability of the negative impacts occurring is considered Low. This assumption is based on the low probability of encountering archaeological and cultural heritage sites, either in or immediately outside the curtilage of the proposed Power Station site.

However, since the survey was not exhaustive, and it is possible that some archaeological remains will be revealed in the course of bush clearance and others construction activities, without mitigation the probability of impact is considered Medium to Low.

Significance

The significance of this potential impact is Medium to Low in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is moderate for this significance rating due to issues of physical access with the site.

7.9.1.3 *Tabulated Summary of the Assessed Impact – Damage to Archaeological Resources – Power Station and Power Line Site and the Immediate Landscape*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**L**	**M**	**M-L**	**M-L**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Powerline EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent the unacceptable loss of archaeological resources.

Actions

- NamPower and their contractors should liaise with archaeologists and cultural heritage professionals before and during the bush removal/groundworks regime in order to ensure that all encountered archaeology and cultural heritage is assessed, recorded and mitigated;
- It is recommended that contractors working on the site are made aware that under the National Heritage Act any items protected under the definition of heritage found in the course of development should be reported to the National Heritage Council.
- NamPower will ensure that all archaeology and cultural heritage procedures recognised by the National Heritage Council of Namibia (NHC) are complied with for all activities related to the construction of the Biomass Power Station and construction and reallocation of the transmission lines.

Emergency situations

- If there are any chance finds of archaeological sites that have not been identified during the bush clearance and others construction activities, NamPower and their contractors will follow its chance find procedure. The key component of which is to ensure that the site remains undisturbed until a specialist archaeologist or cultural heritage professional has assessed the site, assessed the potential damage, advised on the necessary management steps, and advised on the requirements for authority consultation and permitting.
- Ensure that all archaeology and cultural heritage is recorded and persevered in situ and to provide archived field data to the National Heritage Council of Namibia (NHC).

7.9.2 Issue: Damage to Archaeological Resources – Harvesting Activities

7.9.2.1 *Introduction*

Potential impacts to archaeological resources in the harvesting area may be caused by damage or destruction to archaeologically shallow ephemeral subsurface or surface sites during the harvesting regime; however, the precise location of such sites in currently unknown. Such impacts would result in an adverse and permanent effect on the archaeological sites, and therefore a mitigation strategy to include archaeological advice to bush harvesters when undertaking fieldwork is required.

With reference to section 6.8, of the 67 sites identified in this search, the majority are potential farms and settlements of the historic rather than prehistoric period, although some of the possible old enclosures identified may have an earlier history than the other sites identified. Geological categories presenting the highest potential for settlement and farming activity are found within the Quaternary & Tertiary and Namibian (Otavi) formations, which are characterised with better groundwater conditions, and bedrock consisting of Dolomite, limestone, Aeolian sandstone and Kalahari Sandveld. In contrast to this it has been demonstrated that the Jurassic (Stormberg), Namibian (Mulden) and Namibian (Nosib) geological formations present lower potential for settlement, due to overall poorer groundwater availability however, local conditions can provide sufficient water for some smaller and potentially earlier settlements and traditional farmsteads. In addition to the sites identified, it is presumed that many of the existing farmsteads not included here are over 50 years old and that many of these will have within their building stock and farmland, features of cultural significance.

The remote survey results can be used to help with predictive modelling of historic sites in that most archaeological sites are related to areas with high or moderate groundwater potential. Water sources would be an essential prerequisite for settlement or farming activities. In addition, certain types of geology appear to be favoured locations for historic sites, with the majority of identified old farms and old enclosures located within the Kalahari Sandveld in the northern part of the search area. The remaining sites are located within areas of Dolomite, limestone and aeolian sandstone. A broad band of this geology runs west – east through the centre of the harvesting area, and also in the southern part.

The size of the bush harvesting area being far too large for conventional field survey to be undertaken. Therefore, the approach using satellite imagery has been adopted to enable some preliminary identification of potential archaeological sites as a sample of the total area. The results should help in predictive modelling and targeting mitigation measures during the bush harvesting campaign, however, there are categories of archaeological remains e.g. burial sites and rock shelters, which will not be identified with this method of remote survey. Therefore, great care will need to be taken to identify and record archaeological sites during the bush harvesting process.

7.9.2.2 *Assessment of Impact*

Severity

The severity of the effect on archaeology and cultural heritage from bush harvesting is currently unknown; however, the predictive modelling exercise (see section 6.3 and Appendix 9) suggests that sites may be found as the bush harvesting area extends away from the Power Station site. Less impact should occur during bush harvesting when encountering above ground structures such as buildings, boundaries and stone structures. It is envisaged that such structures will be identified either before or during the bush harvest regime. Any newly discovered sites should be fully investigated and mitigated accordingly (based on National Heritage Council of Namibia (NHC) guidance).

On the basis of the archaeological assessment and study findings, including the predictive modelling exercise, in the unmitigated scenario the severity is medium. With mitigation this can be reduced to Low.

Duration

In the unmitigated scenario, the loss of archaeological sites and the related losses to the broader archaeological landscape is long term and will continue after the harvesting and associated catties. With mitigation, which includes the documenting, where applicable, and preservation of sites in-situ, the duration is reduced to Low.

Spatial scale

The potential impacts would be within the area where harvesting will take place. However, due to the fact that the total harvesting area is relatively large the spatial scale is considered to be Medium. Farms within 100 km of the Power Station in certain areas will be considered for bush thinning and within these farmlands ther ecould be significant archaeology and cultural heritage value.

Consequence

The consequence of this potential impact is High in the unmitigated scenario. It reduces to Low in the mitigated scenario because the severity is reduced.

Probability

Based on the predictive modelling exercise, the probability of potential impacts occurring is Medium in the unmitigated scenario. In the mitigated scenario, archaeologists will be made ware of potential encounters with new and ephemeral archaeology and cultural heritage and the correct measure taken to present impacts reducing the probability to Low.

Significance

The significance of this potential impact is High in the unmitigated scenario and Low in the mitigated scenario. SLR's confidence level is moderate for this significance rating due to the significant size of the harvesting area, where exactly harvesting will take place and the fact that the precise location of potential archaeological sites is currently unknown.

7.9.2.3 *Tabulated Summary of the Assessed Impact – Harvesting Activities*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**M**	**H**	**M**	**H**
Mitigated	**L**	**L**	**M**	**L**	**L**	**L**

7.9.2.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 15).

Objective

The objective of the mitigation measures is to prevent the unacceptable loss of archaeological resources.

Actions

- It is recommended that bush harvesting contractors are made aware that under the National Heritage Act 27 of 2004 any items protected under the definition of heritage found in the course of development should be reported to the National Heritage Council.
- During fieldwork the harvesting teams will consult a recognised archaeologist if any archaeological or cultural heritage sites are discover. These sites will be afforded immediate protection and later mitigated.
- NamPower and their harvesting contractors will ensure that all archaeology and cultural heritage procedures, as required by the National Heritage Act 27 of 2004 are complied with.

Emergency situations

- If there are any chance finds of archaeological sites during the harvesting activities, the harvesting contractors will follow a chance find procedure. The key component of which is to ensure that the site remains undisturbed until a specialist archaeologists or cultural heritage professional has assessed the site, assessed the potential damage, advised on the necessary management steps, and advised on the requirements for authority consultation and permitting.

- Ensure that all archaeology and cultural heritage is recorded and/or persevered in situ and to provide archived field data to the National Heritage Council of Namibia (NHC).

7.9.3 Cumulative Archaeology Impacts

The assessments relating to the potential damage to archeological resources in the above sections (7.9.1 to 7.9.2) were conducted on a cumulative basis, taking the baseline conditions into consideration.

Currently little information about the controlling activities relating to archoalocail sites exists in the study area, making it difficult to assess potential cumulative impacts related to large scale wood extraction or bush control unrelated to the proposed Biomass Power Project. A GIZ funded Bush Information System is underway that aims to monitor all bush utilization and bush control activities in Namibia, which will be useful in this regard.

7.10 VISUAL

The information in this section was sourced from the visual specialist study (refer to Appendix 8).

Areas and sites considered potentially sensitive to project activities are, tourist facilities, public roads and residential areas.

Visual impacts will be caused by activities and infrastructure in all project phases as outlined in Table 7-23. The activities associated with the proposed project, will be visible during the day, to varying degrees from varying distances around the project site i.e. proposed Power Station and power line infrastructure, and the harvesting activities. During construction of infrastructure within the Power Station site, visibility will be influenced by the increase in activities, removal of vegetation, exposure of earth and the construction of the tall elements such as the furnace and stack. During the operation and decommissioning phases the visual qualities of the Power Station site will be influenced by the success and effectiveness of rehabilitation measures.

Visibility of the harvesting activities will be disbursed across the extended study area but will mostly be contained to a specific area or farm during any given period of harvesting. Harvesting activities will only take place during the daytime.

The intensity of the visual impact is determined using visibility, visual intrusion, visual exposure and viewer sensitivity criteria. When the intensity of impact is qualified with spatial, duration and probability criteria the significance of the impact can be predicted.

TABLE 7-23: VISUAL IMPACT – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Bush thinning activities. Increased vehicular movements associated with the transport of the wood chips to the Power Station - 3 month pre-commissioning stockpile.	Moving equipment and workers to the specific harvesting area.	-
Transport of biomass		Bush thinning activities.	-

		Increased vehicular movements associated with the transport of the wood chips to the Power Station.	
Power Station	Site preparation & establishment. Earthworks for all surface infrastructure. Soil stripping and stockpiling. General construction activities. Scaffolding & cranes Access road construction. Vehicle movement.	General operational activities. Transport systems. Power generation plant, particularly stacks. Waste management. Support services and amenities.	Site preparation and establishment. General demolition and rehabilitation activities. Earthworks. Scaffolding & cranes. Waste management. Vehicle movement.
Overhead power line		Power line infrastructure.	

The proposed project could therefore result in the following potential negative visual impacts:

<u>Power Station and Overhead Power Line:</u>

- Visual resource impacts would result from the construction activities and physical infrastructure relating to the proposed Power Station and overhead power line, being seen from sensitive viewpoints and from effects to the scenic values of the landscape.

<u>Bush Harvesting Activities and Transportation of Biomass to The Plant:</u>

- Visual resource impacts would result from the bush thinning activities as well as an increased in vehicular movements activities being seen from sensitive viewpoints and from effects to the scenic values of the landscape.

During the Scoping Phase of the EIA, I&APs haven't raised the issue of potential visual impacts on their residential properties, farms or tourist roads. This, along with the fact that for the most part, project activities will not be visible from a great number of sensitive viewing areas at any given point in time due to the nature of the study area i.e. flatness of terrain and that it is covered with 5 – 10m high vegetation that would effectively block views to an activity, suggests that visual sensitivity of the project is low.

7.10.1 Issue: Visual Impact – Power Station and Power Line

7.10.1.1 *Introduction*

Sensitive public views to the proposed Power Station and power line site would be experienced by people traveling along the TR 1/10 west of Tsumeb. This is a national road that connects the southern and eastern parts of the country to the Etosha National Park and other tourism facilities west of the project site. However, most of these viewing points from the road, are from a relatively low vantage point. The combination of flat terrain and treed savannah (i.e. views are from ground level where the vegetation would screen views) therefore blocks most views to the proposed Power Station's facilities. There are no tourist amenities within the study area i.e. 5 km radius about the Power Station site. Three homesteads are located to the east, south east and north east of the project site (refer to Figure 6-45) but none of these would have views to the Power Station site due to the screening effects of existing bush.

The 'zone of potential influence' for the proposed Power Station and overhead power line was established at 5 km. Over 5 km the impact of the proposed Project and associated infrastructure would have reduced due to the diminishing effect of distance, atmospheric conditions and the effects of dense bush on visibility. Also, at this distance the Power Station's features would recede into the background of views, thus being 'absorbed' into the landscape setting.

7.10.1.2 *Assessment of Impact*

Severity

In determining the visibility of the Power Station, the heights of the various project components were used by the Visual Specialist. The offset used to generate the viewshed (refer to Figure 6-47 for the viewshed analysis), was set at 25 m as the site is located within an area that is surrounded by bush, approximately 5- 10 m in height, which would effectively screen views to the lower aspects of the Power Station and its associated activities. Visibility of the Power Station activities, including the proposed powerline from sensitive viewing areas is considered low.

Table 7-24 indicates the potential exposure of the various sensitive viewing areas to the Power Station and associated activities. Distance from a viewer to a viewed object or area of the landscape, influences how visual changes are perceived in the landscape. Generally, changes in form, line, colour, and texture in the landscape become less perceptible with increasing distance. It must be realized that although the exposure ratings given below would contribute to the intensity of impact, the screening effect of existing vegetation must be considered. Visual exposure, which relates only to people using the TR 1/10 national road, is considered to be Moderate as only the upper portions of the Power Station would be seen briefly in foreground and middle-ground views.

TABLE 7-24: POTENTIAL EXPOSURE OF THE VARIOUS SENSITIVE VIEWING AREAS

	Foreground view of the Power Station site i.e.0 – 800m from Project Site – High exposure	Middleground view of the Power Station site i.e. 800m to 3,0km from Project Site – moderate exposure	Background view of the Power Station site i.e. 3,0km to 5,0km from Project Site – low exposure
Sections of the B2 national road which runs south of the project site.	**X**	**X**	**X**
Homesteads to the east of the project site – refer to Figure 10. None of these would have a view towards the site due to the screening effect of existing bush and their topographic elevation relative to the site.	**-**	**-**	**-**

Considering the before (current situation) and after scenarios, the proposed project activities will have minimal visual intrusion (i.e. how well the project fits with or disrupt / enhance the ecological and cultural aesthetic of the landscape as a whole) effects on sensitive viewing areas along the TR 1/10.

The visual intrusion of Power Station, overhead powerline and associated infrastructure is predicted to result in a minimal change to existing landscape characteristics resulting in a minor change to key views

The impact of lights at night is potentially a very sensitive issue and the impact of lighting would be of concern for the duration of the operational phase of the project. During decommisioning all lights associated with the project would be removed.

The negative effect of night lighting against a relatively dark sky could be annoying to tourists and residents visiting the study area and travelling in a westerly direction when the Power Station's lights would be viewed against a dark night sky. East of the study area however, there is an increasing light pollution problem, as Tsumeb and its associated urban and mining areas expand. The Power Station will contribute in a minor way to the negative effect of pollution caused by lights that would protrude above the horizon line and be visible from the TR 1/10 national road.

Taking the above discussion into consideration, the severity in the unmitigated scenario and mitigated scenario is assessed as Low.

Duration

The duration of the visual impact is mostly contained to travellers using the TR 1/10, which will be of short duration i.e. the time it takes to drive past the site. There will be no visual impact of long duration i.e. on residential or tourist facilities that would have a permanent view of the Power Station project site.

Spatial scale

The spatial scale will extend beyond the site boundary. This applies to both the unmitigated and mitigated scenarios.

Consequence

The determining consequence is Low in the unmitigated and mitigated scenarios.

Probability

The probability of the impacts occurring is considered to be Low.

Significance

The significance of this potential impact is Low in the unmitigated and mitigated scenarios. SLR's confidence level is High for this significance rating.

7.10.1.3 *Tabulated Summary of the Assessed Impact – Visual Impact of the Power Station and Power Line*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**L**	**M**	**L**	**L**	**L**
Mitigated	**L**	**L**	**M**	**L**	**L**	**L**

7.10.1.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to avoid negative visual impacts.

Actions

<u>Planning and site development</u>

With the construction of the Power Station and its associated infrastructure, the minimum amount of existing vegetation and topsoil should be removed. Wherever possible the natural vegetation should be retained and incorporated into the site rehabilitation especially in line of sight from sensitive viewers from the TR 1/10 road. All top-soil that occurs within the proposed footprint of an activity must be removed and stockpiled for later use (see section 7.3.1).

<u>Earthworks</u>

- Earthworks should be executed in such a way that only the footprint and a small construction buffer zone around the proposed activities is exposed. In all other areas, the natural occurring vegetation, more importantly the indigenous vegetation should be retained, especially along the periphery of the site. Dust suppression techniques should be in place at all times during all phases of the project, where required.

<u>Landscaping and ecological approach</u>

- Should new vegetation be introduced to the site, an ecological approach to rehabilitation and vegetative screening measures, as opposed to a horticultural approach to landscaping should be adopted. For example, communities of indigenous plants enhance biodiversity and blend well with existing vegetation. This approach can significantly reduce long term costs as less maintenance would be required over conventional landscaping methods as well as the introduced landscape being more sustainable.

<u>Structures and associated infrastructure</u>

- Paint buildings and structures with colours that reflect and compliment the natural colours of the surrounding landscape. To further reduce the potential of glare, the external surfaces of buildings and structures should be articulated or textured to create interplay of light and shade.

<u>Lighting</u>

- Light pollution has the potential to be easily remedied. Simple changes in lighting design and installation, yield immediate changes in the amount of light spilled into the atmosphere.

Emergency situations

None Identified.

7.10.2 Issue: Visual Impact – Harvesting, Transportation of Biomass and Associated Activities

7.10.2.1 *Introduction*

Views to bush harvesting (i.e. thinning) activities will be mostly from private viewing points on the selected farms and would also be contained to a small radius about the activity due to the combination of mostly low vantage points, flat topography and dense bush harvesting activities will not take place in elevated positions such as on the slopes of hills as mentioned in section 4. The exact location of the harvesting areas is not known and therefore specifics around potential impacts are unable to be quantified.

Transportation of the biomass to the plant will result in an increase in vehicular movements being seen from sensitive viewpoints i.e. along the roads, at the harvesting sites and the Power Station site and from effects to the scenic values of the landscape.

7.10.2.2 *Assessment of Impact*

Severity

Visibility of the harvesting activities will be disbursed across the extended study area and will mostly take place on flattish terrain and will be contained to a specific area during any given period of harvesting. Activities will only take place during the daytime.

The bush areas in which the biomass will be harvested is generally 5 – 10 m in height, which is higher than the equipment used in the harvesting activities. Therefore, most ground level views to the activities will be screened with only elevated views from adjacent hills would see the operation.

The study area is too extensive and as yet not sufficiently defined to have carried out a systematic analysis in a similar manner to that undertaken for the Power Station. Also, in assessing the impact of these activities, the rating is focussed on the activity at any given period in time i.e. the harvesting will not occur simultaneously over extensive areas. The rating also assumes that consultation will take place with affected parties i.e. landowners, prior to the harvesting activities and that specific areas will be determined by the harvesters where strict adherence to the requirements included in the harvesting EMP will be implemented.

The Visual Specialist assessed that the impact intensity (visibility, visual exposure and visual intrusion) of these activities and the transport of the biomass to the Power Station site, will be Low.

Taking the above discussion into consideration, the severity in the unmitigated scenario (and mitigated scenario) is assessed as low.

Duration

The duration of the visual impact relates only to harvesting activities in any given area.

Spatial scale

The spatial scale will be limited to the site boundar' i.e. specific harvesting area at any given period in time.

Consequence

The determining consequence is Low in the unmitigated and mitigated scenarios.

Probability

The probability of the impacts occurring is considered to be Low.

Significance

The significance of this potential impact is Low in the unmitigated and mitigated scenarios. SLR's confidence level is High for this significance rating.

7.10.2.3 *Tabulated Summary of the Assessed Impact – Visual Impact of the Power Station and Power Line*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**L**	**L**	**L**	**L**	**L**	**L**
Mitigated	**L**	**L**	**L**	**L**	**L**	**L**

7.10.2.4 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Powerline EMP (Appendix 14).

Objective

The objective of the mitigation measures is to avoid negative visual impacts.

Actions

Harvesting operations should prevent and minimize negative visual impacts through consultation with local communities and landowners about the extent and timing of activities. The operational procedures should take into consideration the proximity to public viewpoints when scheduling and allocating bush areas to be thinned.

A 500 m buffer zone i.e. where harvesting activities should not occur, unless otherwise mutually agreed to with the landowner should be recognised around sensitive tourist and or residential sites. Given this buffer and the general density of the existing bush, most ground level views to the operation would be screened or at least partially screened.

Good housekeeping rules must also apply, i.e. no undue damage is done to vegetation that should not be harvested.

Harvesting activities to take place only on land with a slope of less than 12 degrees.

Emergency situations

None Identified.

7.10.3 Cumulative Visual Impacts

The impact of the existing substation and powerlines that converge with roads and the existing railway line have resulted in a general degeneration of the landscape and have had a negative effect on the quality of the visual environment. The physical presence of the proposed Power Station will increase the visibility and visual instruction of infrastructural activities in the area and contribute to a negative impact on the landscape aesthetics. However, with effective mitigation (as described in 7.10.1), the cumulative impact could be retained at Low.

Harvesting activities will take place within the delineated study area and may occur in an area where other activities, not associated with the project, are occurring i.e. harvesting for charcoal purposes. In the event that this should happen, there would be a cumulative increase in impact due to the simultaneous occurrence of project and non-project activities. However, currently little information about the scale of other wood harvesting/controlling activities exists in the study area, making it difficult to assess potential cumulative impacts related to large scale wood extraction or bush control unrelated to the proposed Biomass Power Project

7.11 SOCIO-ECONOMIC

The information in this section was sourced from the socio-economic specialist study (refer to Appendix 10).

With reference to Table 7-25, the activities associated with the proposed Biomass Power Project will have socio-economic impacts in all phases. Some of these are considered to be positive impacts and others are considered to be negative impacts. The separate groups of impacts are discussed below and must be read in the context of the baseline information included in Section 6-12.

TABLE 7-25: SOCIO-ECONOMIC IMPACTS – LINK TO PROJECT PHASES AND ACTIVITIES

PROJECT COMPONENT	CONSTRUCTION	OPERATIONAL	DECOMMISSIONING AND CLOSURE
Harvesting	Relevant to first 3 months pre-commissioning stockpile: Similar to operational phase.	Creating business opportunities, job creation and skills development. Economic impacts of the Power Station and fuel supply. Impacts on current biomass users. Land productivity improvements. Farming community's safety, health and security.	-
Transport of biomass		Creating business opportunities.	-
Power Station	Community resilience and population influx during construction. Community's safety, health and security. Creating business opportunities, job creation and skills development.	Economic impacts of the Power Station and fuel supply. Creating business opportunities, job creation and skills development. Hazardous infrastructure impacting third parties' safety.	Economic impacts Job losses.
Overhead power line		-	

7.11.1 Issue: Hazardous Excavation and Infrastructure that Could Impact Safety of Third Parties

7.11.1.1 *Introduction*

Hazardous excavations and infrastructure include all structures into or off which third parties and animals, can fall and be harmed. Due to the nature of the proposed project, hazardous excavations and infrastructure will occur from construction through operation to decommissioning. In the construction, operational and decommissioning phases these hazardous excavations and infrastructure are usually temporary in nature, usually existing for a few weeks to a few months. It is not anticipated that any long term hazardous excavations or structures will be created during the operational phase. The closure phase will not present any temporary or permanent hazardous excavation as all infrastructure will be removed during the decommissioning phase of the project.

7.11.1.2 *Assessment of Impact*

Severity

In the unmitigated scenario, in all relevant project phases, most of the identified hazardous excavations and infrastructure present a potential risk of injury and/or death to both animals and third parties. Due to the site's proximity i.e. approximately 7 km to Tsumeb and people staying in close proximity to the site (refer to section 6.12.9), this risk is further extended to residents and, particularly children wandering to the site out of curiosity. This is a potential Hgh severity impact. With mitigation, potential impacts to third parties can be avoided.

Duration

In the context of this assessment, death or permanent injury is considered a long term, permanent impact.

Spatial scale

For the most part, the direct impacts will be located within the infrastructure footprint, but the indirect impacts will extend to the communities to which the people or animals belong.

Consequence

In the unmitigated scenario, the consequence of this potential impact is High and in the mitigated scenario it reduces to Low.

Probability

The proposed Biomass Power Station site, being relatively close to Tsumeb, may attract curious third parties. In the unmitigated scenario, it is possible that the hazardous excavations and infrastructure will present a risk to unaccompanied third parties during construction, operational and decommissioning phases.

The proposed mitigation measures will focus on infrastructure safety and on limiting access to third parties and animals which reduces the probability of the impact occurring.

Significance

In the unmitigated scenario, the significance of this potential impact is High. In the mitigated scenario, the significance of this potential impact is Low because there will be a reduction in probability that the impact occurs. SLR's confidence level is high for this significance rating.

7.11.1.3 *Tabulated Summary of the Assessed Impact – Hazardous Excavation and Infrastructure that Could Impact Safety of Third Parties*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H**	**H**	**M**	**H**	**M**	**H**
Mitigated	**M**	**H**	**M**	**M**	**L**	**L**

7.11.1.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Power Station and Power line EMP (Appendix 14).

Objective

The objective of the mitigation measures is to prevent physical harm to third parties and animals from hazardous excavations and infrastructure.

Actions

High security fencing and security access control will be provided around the entire site. All security staff will be trained to ensure no unauthorised third parties or animals enter operational areas or other potential construction/operations areas. In addition, permanent warning signs will be in place at appropriate intervals, in appropriate languages with danger pictures to warn people of the safety risks of entering the operational area.

Information will be provided at stakeholder information meetings to educate third parties about the dangers associated with hazardous excavations and infrastructure related to the operations.

Emergency situations

If people or animals do fall into hazardous excavations or off infrastructure causing injury, the Biomass Power Project Emergency Response Procedure will be followed.

7.11.2 Issue: Economic Impacts Associated with the Biomass Power Station

7.11.2.1 *Introduction*

Construction of the Biomass Power Station will take approximately35 months to complete.

The design life of the Power Station has been calculated at 25 years but it may be able to operate for longer with refurbishment.

There is a high fixed cost for any power plant, irrespective of size, but the 40MWe plant can gain from economies of scale which makes it more cost effective than a 20MWe plant. The capital cost of construction is anticipated to be sourced from foreign development banks which would be paid back in forms of interest and principle over a fifteen year period.

The operating costs (OPEX) are made up of fixed costs such as the management fees, maintenance and salaries and variable costs which include the biomass fuel cost and consumables to run the plant such as its own power consumption, chemicals etc. The removal of by-products such as ash has not been included as a variable as the plan is to store it on site.

The cost of biomass fuel depends on the quantity required, the technology used to harvest the bush, the distance the woodchips need to be transported and any transactional costs with farmers. The Cirrus Report found that at a price point of N$600/tonne, fully mechanised harvesters could generate a moderate internal rate of return (MIRR) of 12.1% compared to manual harvesting operations that could earn a MIRR of 9.9%. At this price, the power plant could generate a modest return on investment of 4.1% (Cirrus Capital, 2018).

Both a 20MWe and a 40MWe power plant will need an efficient fuel supply chain and revenue from a fixed payment capacity charge to be economically viable; in addition, a 20MWe plant will need an energy charge subsidy or a higher capacity payment to be viable. The anticipated charge for the electricity to consumers, the tariff, will be subject to regulation and will depend on the final engineering procurement and construction cost and the fuel cost. The National Integrated Resource Plan for electricity supply of 2016 gave the unit cost of energy for a 10MW biomass-based dispatchable renewable plant as N$2.07/kWh (MME, 2016). This is expected to be less for larger plants due to economies of scale.

Currently, there is no operating cost for the by-product of wood ash, which amounts to approximately 6% of the biomass fuel. Various options for the final use/disposal of the ash is being considered (ref to section 5.5.4).

7.11.2.2 *Assessment of Impact*

Severity

The Power Station will contribute positively to the Namibian economy in a number of different ways:

- The Power Station will contribute to Namibia's ability to generate electricity from its own sources, thus reducing its dependency on external suppliers. It will provide a local supply of electricity to the high consumers in the area.
- Direct benefits include the sale of electricity generated, the wages and salaries of the 300 construction workers and 65 persons employed by the Power Station, the taxes paid, and profits earned. The construction phase will not make a net contribution to GDP as the large import components estimated at 45%, outweigh other value additions (Cirrus Capital, 2018).
- Indirect benefits are the economic benefits derived from bush harvesting, converting it to woodchips and transporting them to the plant. They also include the provision of all other goods and services required to construct and operate the Power Station. A small portion of the capital cost required to construct the plant will be used to purchase inputs which are manufactured in Namibia, such as cement; these will have their own local supply chains which lead to added indirect benefits. Further indirect benefits of the Power Station are the act of bush thinning which should improve the productivity of the land, such as increasing livestock production and/or game farming and tourism activities.
- Induced economic benefits include the spending power of the construction workforce, the personnel of the biomass plant, and the bush harvesting operators, which will have a positive impact on the local economic development of Tsumeb. Local businesses in service, retail and supply industries are likely to lead to the creation of indirect jobs in the informal and formal sectors of the economy. Most Namibian employees distribute part of their income to their immediate household members and to others living elsewhere in Namibia who depend on cash remittances. When they buy Namibian goods and services, the economic benefits of the plant will spread further.
- Impact on Government Revenue will be positive including any economic activity derived as a result of plant that is likely to be taxable. Employees of the plant, and those up and down the supply chain, will be eligible to pay personal income tax and Value Added Tax (VAT) on goods and services they purchase.

Taking the above into consideration, the overall economic benefits to stimulate rural and urban economic activities i.e. severity is ranked as High positive.

Duration

The duration of the economic impacts is High as the impact on land productivity, businesses and skills developed are likely to last beyond the project lifespan.

Spatial scale

The spatial scale is High as economic impacts will be felt wherever construction and operating inputs originate, where employees have a main home elsewhere in Namibia, and where bush thinning occurs.

Consequence

The determining consequence of these positive impacts is High.

Probability

The probability of the impacts occurring is High.

Significance

The significance of the impacts is High. SLR's confidence level is high for this significance rating.

7.11.2.3 *Tabulated Summary of the Assessed Impact – Economic Impacts Associated with the Biomass Plant*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H+**	**H**	**H**	**H+**	**H**	**H+**
Mitigated	-	-	-	-	-	-

7.11.2.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Power Station and Powerline EMP (Appendix 14).

Objective

To maximise economic benefits to electrical consumers whilst maximising benefits to the local economy.

Actions

- All contractors and the Power Station's management agent should encourage the use of small and medium enterprises in supplying goods and services to the plant.

Emergency situations

- None Identified.

7.11.3 Issue: Job Creation and Skills Development Relating to all Project Components

7.11.3.1 *Introduction*

With reference to section 4.3, NamPower will appoint an engineering procurement and construction contractor and it estimates that the construction of the biomass Power Station will create approximately 300 jobs over the 35 month construction period. During operations, it is anticipated that approximately39 employees will be required to operate the 40MWe Power Station.

During the operations phase, far more additional jobs will be created indirectly through bush harvesting and processing of the wood chips (refer to sections 4.4.2.7 and 4.4.4.8).

7.11.3.2 *Assessment of Impact*

Severity

The project will create a range of jobs at the plant itself and in the harvesting and transport sectors. If land productivity improves, farmers may be able to employ more farmworkers in crop and livestock production and in their tourism activities. Job creation provides wages and salaries for those employed and their families and dependants across extended family networks. Such wages will provide families with opportunities to improve standards of living, avoid poverty, and to access better education and healthcare.

Although highly mechanised harvesting using heavy equipment can damage the soils and some remaining trees, it provides opportunities to expand the skills base for machine operators. Developing skills which are transferable between machines and across industries have beneficial impacts on those gaining the skills and the future industries which they will serve. However, the more mechanised the harvesting methods is, the more capital is required and fewer jobs are created.

The project will have positive impacts on job creation and developing transferable skills across industries and is ranked as high positive.

Duration

The duration of the impact is rated as High as most of the skills gained will lead to future employment. If profitable, the biomass producers are likely converting their operations to charcoal production as demand exceeds supply on the world market.

Spatial scale

The spatial scale is High as employees will be sourced not only locally but also regionally and nationally.

Consequence

The determining consequence of the impacts is High.

Probability

The probability of the impacts occurring is High as the project cannot operate with creating jobs.

Significance

The significance of a large number of jobs being created with associated skills development is High. SLR's confidence level is high for this significance rating.

7.11.3.3 *Tabulated Summary of the Assessed Impact – Job Creation and Skills Development Relating to all Project Components*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H+**	**H**	**H**	**H+**	**H**	**H+**

Mitigated	-	-	-	-	-	-

7.11.3.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Power Station and Power line and the Harvesting and associated activities EMPs (Appendices 14 and 15).

Objective

To maximise job creation and skills development during construction, operations and through the supply chain.

Actions

- Ensure that strategies and programmes are in place prior to construction which maximise use of the local labour force during construction and operations, where possible.
- Ensure its human resources policy is implemented which targets and encourages women for training and recruitment and supports female employees to perform well in the workplace, for the operation of the Power Station.
- Promote continuous learning programmes to diversify and upgrade skills of employees and will ensure that skills gained on the job are documented and accredited wherever possible.
- Ensure that fuel suppliers adhere to the Occupational Health and Safety precautions for bush harvesting for a range of potential impacts including HIV/AIDS infection, snake bites, scorpion stings, body injuries from thorns etc., machinery, fire and traffic accidents as detailed in government guidelines for bush thinning (MAWF, 2017).

These measures will mitigate the loss of jobs on closure of the plant.

Emergency situations

- None Identified.

7.11.4 Issue: Creating Business Opportunities in Biomass Harvesting

7.11.4.1 *Assessment of Impact*

Severity

With reference to section sections 4.4.2.7, the project will create opportunities for business development which supports government plans towards fulfilling Namibia's development goals. The severity is ranked high positive.

Duration

The duration of the positive impact is High, as once the producers are established they can produce woodchips or convert the biomass to charcoal beyond the lifespan of the project.

Spatial scale

The activities will occur within the harvesting area. The spatial scale is however rated Medium as producers would eventually operate on farms more than 50km from the plant, although transport costs will encourage producers to operate as close to the Power Station as possible, specifically during the initial years.

Consequence

The determining consequence of these positive impacts is High.

Probability

The probability of the impacts occurring is High as the project cannot operate without a fuel supply.

Significance

The significance of the impacts is High. SLR's confidence level is high for this significance rating.

7.11.4.2 *Tabulated Summary of the Assessed Impact – Creating Business Opportunities in Biomass Harvesting*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H+**	**H**	**M**	**H+**	**H**	**H+**
Mitigated	-	-	-	-	-	-

7.11.4.3 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 14).

Objective

NamPower should encourage a range of mechanised producers to operate to maximise sustainable business development in the region, which ensure a steady fuel supply.

Actions

- NamPower will interact with financing stakeholders from any early stage to ensure the availability of capital for the timeous start-up and up-scaling of biomass producers.
- The Power Station's management agent should encourage semi-mechanized woodchip producers to supply biomass.

Emergency situations

- None Identified.

7.11.5 Issues: Impact on Existing Wood Biomass Users

7.11.5.1 *Introduction*

The charcoal industry currently offtakes the largest biomass quantity in the country. Approximately 72,000 tonnes of charcoal are produced in the Tsumeb, Otavi and Grootfontein area annually, utilizing about 21% of the current biomass resource in the proposed harvesting area over the 25 year lifespan of the project (Cirrus Capital, 2019). The Namibian Charcoal Association estimates that a total of over 130,000 tonnes of charcoal were produced in 2017. This has increased from 100,000 to 120,000 tonnes recorded by the government in previous years. At a conversion rate of 5 tonnes of wood to 1 tonne charcoal, approximately 500,000 – 600,000 tonnes of biomass would have been required, contributing to de-bushing 50,000 – 60,000 hectares of land per year.

It is estimated that there are approximately 6,000 individual wood-cutters or harvesters in the charcoal industry. Most of them sub-contract to producers who are commercial, private landowners in central and northern Namibia. The harvesters chop the trees and bush with axes.

There are 10 charcoal processors who purchase up to 20,000 tonnes per annum. Almost half is exported to South Africa while some processors are involved in retail packaging for direct overseas markets in Europe (MITSMED, 2016). NNF assumed that charcoal production could increase by 25,000 tonnes per annum to supply demand from overseas (NNF, 2016).

Firewood is another use of the biomass. The current demand is estimated at 550,000 tonees per annum (NNF, 2016). It is not known how much of this is from invader bush which is less popular for firewood than the larger tree species such as mopane and camelthorn, which are both protected species).

The Ohorongo Cement factory is within the proposed harvesting area and has the production capacity to buy up to 80,000 tonnes of woodchips for its kiln, which is delivered to their premisises from four producers. They also have an additional capacity to buy up to 20,000 tonnes of charcoal fines which reduces their coal consumption, however fines are not available in the rainy season. Transport costs limit the radius of production to 70km maximum but most producers keep to a 40-50km radius.

7.11.5.2 *Assessment of Impact*

Severity

With reference to section 4.1, a 40MWe Power Station will require 200,200 tonnes (at ±70% capacity factor) of dry biomass per year. At an average yield of 12.65 tonnes per hectare, this would thin about 16,000 hectares of land per annum, equivalent to about 3 farms per annum. This will utilize under 12% of the available biomass, still leaving about 54% unharvested, available for additional users to emerge in future (see Figure 4.3).

With reference to section 7.11.5.1, the biggest current user of biomass is the charcoal industry which employs about 6,500 people in the charcoal value chain, either directly or indirectly, making it an important rural income and employment source in Namibia. Some charcoal producers in the radius of the proposed plant may be keen to provide wood chips to NamPower rather than convert it to charcoal, if the price is right. Given the large amount of biomass available, the proposed project is unlikely to threaten the charcoal industry or the firewood industry; harvesters/charcoal makers could move to other farms. If the number of biomass plants increased significantly over the next 20 years, the availability of biomass for charcoal may be reduced, but the impact from the proposed Power Station is likely to have little significance.

Taking the above mentioned into consideration, the severity is rated as Medium in the unmitigated scenario as there is a risk that existing producers may switch away from charcoal to woodchips, causing a drop in supply to existing markets. This may compromise Namibia's charcoal processors' ability to fulfil export markets which have taken time to build up. In the mitigated scenario, the severity reduced to Low.

Duration

The duration of this potential negative impact is rated as Medium in the unmitigated scenario as new charcoal producers are likely to emerge to fill the demand and the regeneration of bush is likely within 10 years so the impact is reversible.

Spatial scale

The spatial scale is high in the unmitigated scenario as the impact on the charcoal industry could affect other regions and even international markets. Woodchips are more likely to be sourced close to the plant to minimise transport costs, even though the project is considering sourcing biomass from more than 100 km from the Power Station.

Consequence

The determining consequence of these negative impacts is high in the unmitigated scenario, reducing to medium in the mitigated scenario, because the severity, duration and spatial scale will all be reduced.

Probability

The probability of the negative impacts occurring is rated as Medium.

Significance

The significance of a potential negative impact on the charcoal industry is High in the unmitigated scenario, reducing to medium in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.11.5.3 *Tabulated Summary of the Assessed Impact – Impact on Existing Wood Biomass Users*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**M**	**H**	**H**	**M**	**H**
Mitigated	**L**	**L**	**M**	**M**	**M**	**M**

7.11.5.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 14).

Objective

To ensure that charcoal and/or woodchip producers fill the market demand for both woodchips and charcoal.

Actions

- It is advised that NamPower pro-actively engages with producers and processors once construction begins to ensure that new or expanded charcoal and/or woodchip producers can meet the demand for both woodchips and charcoal.
- It is advised that NamPower facilitates the process of ensuring sufficient numbers of woodchip producers have access to capital and OPEX to ensure the required tones of woodchips are delivered to the power station.

Emergency situations

- None Identified.

7.11.6 Issue: Bush-Thinning on Land Productivity

7.11.6.1 *Introduction*

This issue relates to the increased forage resources for grazing animals, but also the habitat creation for grassland invertebrate and vertebrate species due to post-harvest release from woody competition.

The proposed biomass Power Station is located outside Tsumeb, where the surrounding land is predominantly owned freehold by commercial farmers. Some of these farms have been sub-divided and leased by the Government to poor households as resettlement farms. Further away from the plant are communal farming areas. Figure 7-1 shows that Tsumeb lies in Bush Encroachment Zone 7 which has an area of over 3.7 million hectares heavily bush encroached by *Dichrostachys spp* commonly exceed 10,000 trees/bushes per hectare (NNF, 2016 p. 49).

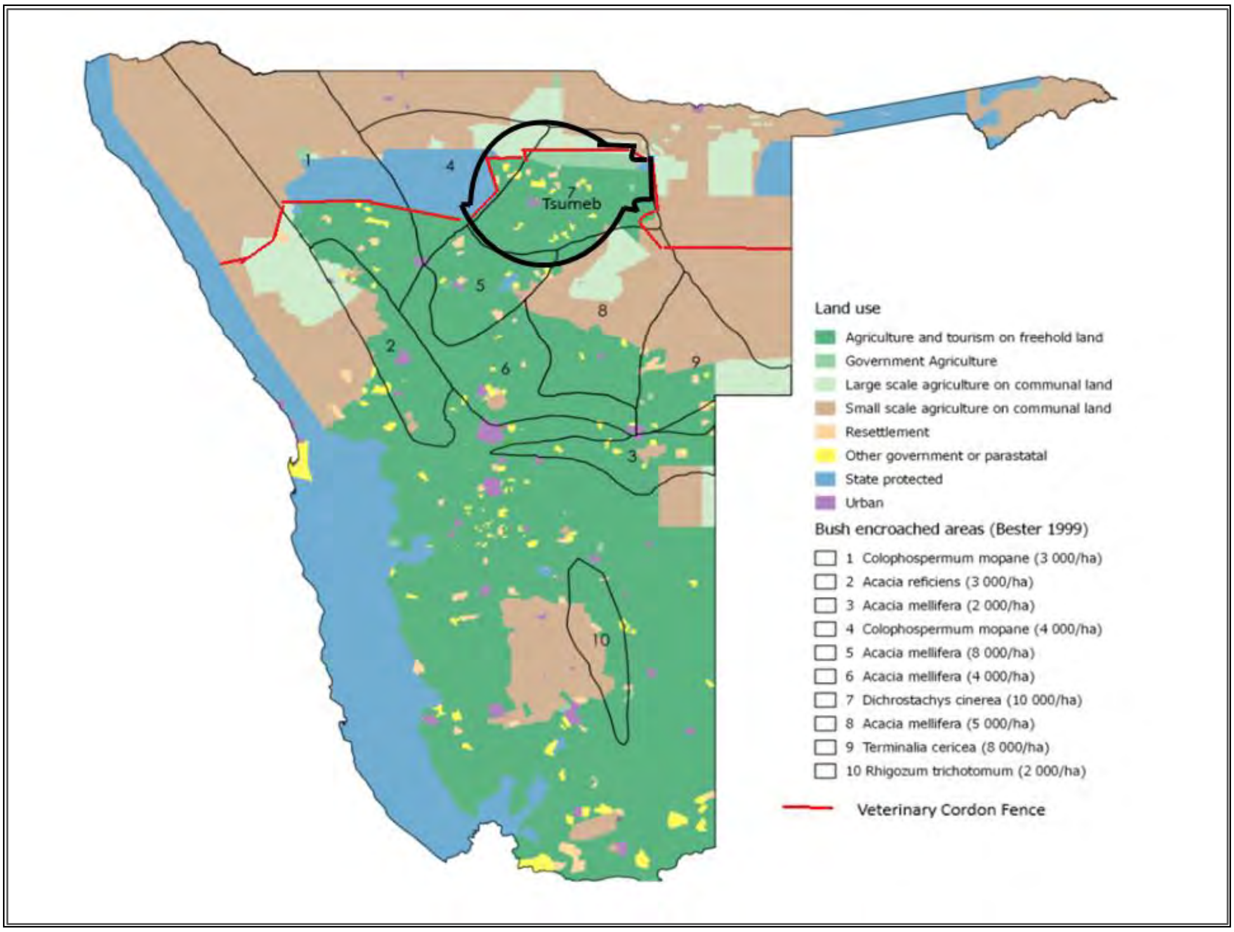

FIGURE 7-1 LAND USE AND BUSH ENCROACHMENT ZONES

Source: Adapted from (NNF, 2016)

The Department of Forestry supports bush thinning to return the land to savannah keeping some tree cover, rather than the complete removal of all encroacher bush. Harvesters should be encouraged to follow biomass harvesting guidelines (see the EMP in Appendix 15). It is important not to over-clear: tree equivalents/ha that should remain after thinning should follow the recommended rainfall-TE guidelines per dominant encroacher species (SAIEA, 2016).

The NNF recommended that bush densities should be reduced by not more than 67%, leaving a density of at least 33% of current levels (NNF, 2016). The NNF calculated that Zone 7 (Figure 7-1) has nearly 14 million tonnes of *Dichrostachys cinerea* dry weight of standing wood of an appropriate size for charcoal production (and therefore for woodchips), of which 9.4 million tonnes is on commercial land and 4.6 million tonnes is on communal land.

7.11.6.2 *Assessment of Impact*

Severity

The NNF used the 2014 Ministry of Agriculture, Water and Forestry livestock census to calculate there were over 134,400 cattle in Zone 7 (Figure 7-1) of which approximately one third are on communal land and two thirds are on commercial farms (NNF, 2016). Zone 7 has a bush encroached area of approximately 3,733,000 hectares on which the carrying capacity in live weight per hectare has been reduced to at least half.

It is estimated that after reducing the bush to 33% of the current density, it would take four years to double the livestock carrying capacity of an area of rangeland (NNF, 2016). However, NamPower believes this is optimistic and Cirrus Capital therefore used a 70% increase in carrying capacity of livestock, from one animal every 17 hectares, to an improvement of one animal every 10 hectares (Cirrus Capital, 2018). Using NamPower's estimate that a 40MWe plant will require 200,200 tonnes of biomass per annum (at a ±70 % capacity factor), attained from bush-thinning approximately 16,000 ha, approximately 650 new head of livestock will be able to be carried on that land after four years. If all the farmers managed to increase their stock rates by 70%, those 650 additional head of cattle would be worth over N$4 million, from one year's biomass supply to the Power Station. Meat production was estimated at 247kg per head of cattle and 2015 average producer price was N$27.3/kg so the NNF calculated that a farmer would gain about N$6,740 for every additional head of cattle kept on the restored rangeland.

It estimated that the livestock carrying capacity in Zone 7, under optimal rangeland conditions without bush encroachment, could reach between 30-60 kg live weight of cattle per hectare. Most of the land in Zone 7 is south of the veterinary cordon fence enabling farmers to get a higher price for their cattle.

If encroacher bush thinning for the Power Station focused more to the south, east and north-east of Tsumeb, it would have a greater potential to increase livestock carrying capacities, due to the higher carrying capacity than de-bushing to the west and north of the Power Station site.

Dichrostachys spp are extremely prone to regeneration, therefore the farmers will need to adopt an intensive aftercare programme to maintain the savannah with thinned bush to increase livestock production and ensure habitat creation for invertebrate and vertebrate species. If the aftercare programme is not thorough, the farmers will only benefit from an increase in grass production for a few years after bush thinning, after which there would be a gradual decrease in grass/meat production as the bush thickens.

Thinning the bush improves groundwater recharge from rainfall which would assist rangeland restoration. Good rangeland management will be required to prevent overstocking of livestock too early which could lead to overgrazing and another cycle of bush encroachment.

The economic impact of bush-thinning is likely to have potential benefits to biodiversity and therefore tourism as habitats become more diversified and sustain a greater range of game species which can bring increased revenue from hunting and wildlife viewing.

Taking the above mentioned into consideration, the benefits of bush-thinning to farmers, and the ecosystem in general, are ranked as Medium to High positive in the unmitigated scenario although the farmer will incur costs to prevent regrowth and to restock livestock. In the mitigated scenario the severity is rated as High positive.

Duration

The duration of the positive impact is rated as Medium as it lasts for the life of the plant and regrowth could be rapid, if there is no aftercare. In the mitigated scenario, the duration will be long term.

Spatial scale

The spatial scale is rated as Medium to High as farms more than 100km from the plant will be considered for bush-thinning, although transport costs will favour farms close to the plant.

Consequence

The consequence of the positive impacts is High.

Probability

The probability of the impacts occurring is Medium to High in the unmitigated scenario and High in the mitigated scenario, as the plant depends on biomass.

Significance

The significance of the positive impacts is Medium to High in the unmitigated scenario and high in the mitigated scenario. SLR's confidence level is low to moderate for this significance rating due to the unclear ownership of management of the harvesting activities; non-aligned or competing land management objectives of landowners; unclear financial incentives regarding the harvesting and aftercare activities, uncertainty of post-harvesting follow-up.

7.11.6.3 *Tabulated Summary of the Assessed Impact – Bush-Thinning on Land Productivity i.e. Improvement of Rangeland Productivity*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M-H+**	**M**	**M-H**	**M-H+**	**M-H**	**M-H+**
Mitigated	**H+**	**H**	**M-H**	**H+**	**H**	**H+**

7.11.6.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Harvesting and Associated Activities EMP (Appendix 14).

Objective

To maximise land productivity after bush-thinning. Not all farmers will have the resources to successfully implement an aftercare programme which is essential to improve land productivity. In these circumstances:

Actions

- Comparatively little is known about the degree to which rangeland primary productivity recovers after harvesting, how sustainable it is with or without maintenance and aftercare and what the key management actions are that could improve productivity. Additionally, little is known about the ultimate effect of harvesting on livestock production, whether the inputs into harvesting are offset by improved incomes from livestock, and what the key management actions are that could improve productivity. It is therefore proposed that this should be investigated in a dedicated study (See EMP in Appendix 15 for more details).

- Annual post-harvest control of coppicing and establishing woody plants.
- Sound rangeland management principles applied such as appropriate stocking rates for forage availability, resting for at least significant part of growing season.
- If desirable perennial grass species are lost or at very low density, reseeding with indigenous, desirable grass species.
- NamPower should encourage the biomass producers to source wood from potentially more productive land to the North-East and South of Tsumeb as these areas have greater livestock carrying capacity than to the West/North West
- NamPower should consider including resettlement farms and communal areas where the Department of Forestry has granted biomass harvesting permits for potential harvesting areas.

Emergency situations

None Identified.

7.11.7 Issue: Impact on Safety, Security and Health in the Farming Community During Bush Harvesting

7.11.7.1 *Introduction*

Harvesting from one farm may take several months, depending on the number of machines, level of mechanisation used and the season of the year. A farmer may have to accommodate numerous harvesters on the farm during this period and they will need food supplies and probably access to the farm shop.

Many farmers are experienced in accommodating up to 20 charcoal workers as casual labour on their farms and minimising potential risks to safety, security and health. During the Scoping Phase of the EIA process, farmers have identified the following potential negative impacts associated with strangers/casual workers/contract workers having access to and residing on their farms:

- Crime - particularly theft of livestock, general theft, assault, housebreaking, damage to property, rape and attempted rape, and littering have all been recorded on farms. Security is a major concern for all farmers. They believe their best strategies are to maintain good relations with their employees as their most important security measure, in addition to high or electric fences, dogs and night patrols. Good partnerships between the Namibian Police, neighbours and the community have led to successful incidents of catching poachers in many parts of Namibia.
- Social ills – are often alcohol related and occur more frequently around paydays. Alcohol abuse tends to lead to violence, often gender based violence, and casual sex which increases the spread of sexually transmitted diseases such as HIV and AIDS. Farmers fear that newcomers "with cash in their pockets" can destabilise their farm-workers' households. Farmers may try to keep the bush harvesters as far removed as possible from the housing area of their permanent workforce.

More labour intensive methods of bush harvesting may increase the number of casual workers, and for a longer period, thus increasing the potential risks detailed above.

The Namibian Labour Act stipulates specific requirements for agricultural workers in terms of food provisions, which can in some ways reduce the need to poach small game for food. The accommodation for all onsite harvesters should be in line with the minimum housing requirements agreed by the Forest Stewardship Council's (FSC) National Forest Stewardship Standard of Namibia which comply to the International Labour Organisation's requirements. These include weatherproof housing (tents, traditional housing or caravans), access to potable water via a borehole or water tanks, long drop toilets or portable toilets, washing/showering facilities and regular garbage collection.

7.11.7.2 *Assessment of Impact*

Severity

Employees of the harvester, who are not directly contracted by the farmer, who are living on the farm bring added security, safety and health risks to all the households living in that farming community. The impact is rated as Medium social and or economic deterioration in the unmitigated scenario, reducing to Low in the mitigated scenario.

Duration

The duration of the impact is long term and therefore ranked as High as the potential threats to community safety, security and health may have impacts which last beyond the lifespan of the harvesting.

Spatial scale

The spatial scale is rated as Medium as it may only impact on the farm being harvested and its immediate neighbours.

Consequence

The determining consequence is High in the unmitigated scenario and Low in the mitigated scenario.

Probability

The probability of the impacts occurring is High in the unmitigated scenario as crime and social ills could occur throughout society. In the mitigated scenario, the probability would be reduced to Low.

Significance

The significance is High in the unmitigated scenario, reducing to Low in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.11.7.3 *Tabulated Summary of the Assessed Impact – Safety, Security and Health in the Farming Community During Bush Harvesting*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**M**	**H**	**H**	**H**
Mitigated	**L**	**H**	**M**	**M**	**M**	**M**

7.11.7.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Harvesting and AssociatedAactivities EMP (Appendix 14).

Objective

The overall objective is that NamPower and its primary contractors and first tier suppliers duly anticipate, avoid or minimise, and effectively mitigate risks and adverse impacts to the health and safety of host communities within the project's determined area of influence (including all associated facilities) as well as end users, during both construction and operation phases.

To minimise the opportunities for crime and the occurrence of social ills.

Actions

- Namibian legislation and the requirements of its financing partners in terms of workers' rights and employment conditions, the rights of indigenous peoples and other vulnerable groups and community relations, which is also applicable to Ad Hoc Fuel Suppliers.
- Harvesting contractors to have a comprehensive HIV, AIDS and TB workplace policy and wellness programme which will detail HIV awareness and prevention measures in the workplace and enable easy access to AIDS treatment, care and support for employees. A simplified workplace health programme is applicable to Ad Hoc Fuel Suppliers.
- Critical stakeholders such as local farmers, to assist with the monitoring of social impacts and the effectiveness of the mitigation measures put in place.
- Contractors shall have a zero tolerance to alcohol in the workplace, which should also be applicable to Ad Hoc Fuel Suppliers.

Emergency situations

- Develop a transparent Public Consultation and Disclosure Plan which is regularly reviewed to ensure stakeholders' concerns and grievances are addressed promptly.

7.11.8 Issue: Community Resilience in Tsumeb to Population In-Migration Relating to all Project Components

7.11.8.1 *Introduction*

Community resilience refers to the ability of the communities nearest to the site to absorb an influx of people who move to the area as a result of the proposed project.

The construction of the proposed biomass project will require over 300 workers made up of both NamPower employees and contractors for a two year period. Some of these workers may be sourced from Tsumeb but some skills may be brought in from outside the area. Construction workers have long been a health threat to host communities as they usually are temporary residents and come without their partners and families. They work hard, have cash in their pockets, and expect to have good times with local community members, who are often young women as most construction workers are still men. The women and girls are at higher risk of sexual harassment and violence, of unwanted pregnancies, disruption of school career, and the long-term responsibility of bringing up the children.

The Power Station itself is expected to employ about 65 permanent employees which is unlikely to make an impact on the resident community. Bush harvesting methods vary enormously and could employ between 130 to 1,200 people, depending on the level of mechanisation used. Some may already live in the Tsumeb area while many harvesters are likely to originate from elsewhere and some may bring their families to the town. These harvesters are likely to come to Tsumeb for residence, shopping, entertainment and recreation. Labour intensive harvesting methods will employ greater numbers of people, increasing the potential impacts on the community.

In addition, there are likely to be unsuccessful job seekers who come to the town on the off-chance of work and then stay.

7.11.8.2 *Assessment of Impact*

Severity

An influx of job seekers and workers are likely to bring:

- an increased demand for basic local services – land, water, power;
- the full range of housing options – rental, informal shacks, low income, middle to high income and a concomitant increase in prices, affecting the local population;
- an increased demand for health care services;
- social ills of which sexually transmitted diseases such as HIV and AIDS are likely to be of high risk to construction workers, bush harvesters and the communities where they temporarily stay;
- an increase in crime; and
- an increased pressure for more school places and classrooms, if migrants bring their families with them.

The impact of an influx will be largely dependent on the numbers of people in-migrating. The IFC's detailed publication on in-migration (IFC, 2009) draws from the experience of impacts of infrastructure projects worldwide. It identifies two main factors described below that are likely to induce in-migration to the area, and these are known to be relevant in Namibia:

- A mobile population - people who live in areas with high unemployment, under-employment and rural subsistence livelihoods are likely to be attracted to such an economic opportunity.
- The area's capacity to meet project needs - this region of Namibia has a local population which could only partly meet the project's demand for labour, goods and services.

Experience across the world indicates that for every project worker employed, 3 to 10 additional jobs (formal and informal) are created in the area and 3 to 4 additional camp followers tag along. Given that Tsumeb has existing infrastructure in place, it is predicted that the area will experience low to medium in-migration.

In-migration should not be viewed as only negative. Migrants are often the movers and shakers in a community and they set up small businesses which add to the local economy.

Tsumeb is already experiencing significant numbers of people living in informal settlements and it is likely to be able to absorb more. As a large town by Namibian standards it is more likely to have an experienced construction labour force which will reduce the need to bring in workers from outside the area. Tsumeb already has a sizable population and has experienced rapid population growth over the last decade, therefore it is likely to be fairly resilient to a moderate influx of people.

Taking the above into consideration, the severity is rated as Medium in the unmitigated scenario, reducing to Low in the mitigated scenario.

Duration

The duration of impacts relating to in-migration are High, as some people will stay, even after closure, until a better economic opportunity arises elsewhere.

Spatial scale

The spatial scale is Medium as the impacts are local but beyond the site boundary.

Consequence

The determining consequence of in-migration is High in the unmitigated scenario and Medium in the mitigated scenario.

Probability

The probability of in-migration occurring is rated as Medium.

Significance

The significance of in-migration is High in the unmitigated scenario and medium in the mitigated scenario. SLR's confidence level is high for this significance rating.

7.11.8.3 *Tabulated Summary of the Assessed Impact – Community Resilience to Population In-Migration Relating to all Project Components*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**M**	**H**	**M**	**H**	**M**	**H**
Mitigated	**L**	**H**	**M**	**M**	**M**	**M**

7.11.8.4 *Conceptual Description of Proposed Enhancement Measures*

Conceptual discussion of the enhancement measures is provided below and detailed in the Power Station and Power line and the Harvesting and associated activities EMPs (Appendices 14 and 15).

Objective 1: To minimise in-migration and manage the impacts thereof.

Actions

- Build up local skills prior to and during construction to maximise the local labour force.
- Give employment preference to local and Oshikoto Region residents, particularly to women, members of the San communities and residents on group resettlement farms, to reduce the influx of workers and whole families into the project area.
- Initiate a recruiting centre in Tsumeb to reduce in-migration.
- Inform the public about the employment policies and procedures and when vacancies have been filled to reduce potential migrants.
- Establish regular meetings with the Tsumeb Municipality and Oshikoto Regional Council to plan, monitor and manage the potential impacts.

Objective 2: To manage the need for land and housing

Actions

- Construction workers to live locally in Tsumeb to boost the local economy.
- If any temporary buildings are erected on site for the construction period only, NamPower will ensure reusable construction materials are used as much as possible, so they can be passed on to the local community.
- NamPower will promote home ownership by employees by assisting its employees to buy local houses.

Objective 3: To manage the need and demand for improved health care and education services

Actions

- Ensure contractors have a comprehensive HIV, AIDS and TB workplace policy and wellness programme which will detail HIV prevention measures in the workplace such as condoms, and enable easy access to AIDS treatment, care and support for employees.
- Promote public health and safety by supporting the Ministry of Health and other stakeholders' initiatives to reduce the spread of communicable diseases such as sexually transmitted diseases (including HIV), TB and Malaria, by organising awareness programmes, ensuring that codes of conduct for workers are implemented and adhered to, and by promoting healthy lifestyles and in their health campaigns.
- Develop a relevant Corporate Social Responsibility Programme.

Objective 4: to promote safety and security in the local communities

Actions

- Establish and regularly update a stakeholder engagement plan, that includes critical stakeholders such as the Tsumeb Municipality and local farmers, to assist with the monitoring of social impacts and the effectiveness of the mitigation measures put in place.
- Zero tolerance to alcohol and drugs in the workplace.
- Support partnerships that encourage a sense of community and those combat social ills, e.g. multi-purpose community & skills development centres; sports tournaments, social clubs, youth clubs, activities that promote women's empowerment and gender equality and community policing.

Emergency situation

Stakeholders are best handled through a transparent Public Consultation and Disclosure Plan which is regularly reviewed to ensure stakeholders' concerns and grievances are addressed promptly.

7.11.9 Issue: Upholding Human Rights and Interests of Vulnerable People and Labour

7.11.9.1 *Introduction*

This section covers the rights and interests of vulnerable groups, identified in this proposed project's context as the San and women, of labour/workers. Furthermore, it covers Occupational Health and Safety related issues of workers.

Vulnerable Groups - San

Section 6.12.10.1 describes how the different San groups experience marginalisation and a level of poverty unmatched by that of any other group in Namibia. Their widespread marginalisation is attributable to a combination of factors, which are interrelated and partly conditional upon each other and include the following:

- lack of access to land / lack of secure land tenure;
- limited post-settlement support / lack of access to productive assets;
- discrimination relating to culture;
- very low levels of education; and
- limited political representation, participation and consultation.

Vulnerable groups – Women

Section 6.12.10.2 found that although women were disadvantaged in terms of employment and pay levels, the gender equality gap is only by a few percentage points on most parameters. Where women are most vulnerable is in the family where traditional patriarchal values discriminate against women's equal access to and ownership of land, to finance/credit, to their inheritance rights and to their vulnerability to gender based violence.

The Power Station and bush harvesting are unlikely to cause negative impacts on San groups or women unless thoughtless policies are put in place, such as avoid bush-thinning on resettlement farms or there is continued discrimination against selecting members of vulnerable groups in job selection. If these decisions are taken, the project will perpetuate the human rights abuses that marginalised groups and some women experience. The section below provides measures that can be taken to ensure it is EIB and internationally compliant in upholding the rights and interests of vulnerable groups and labour.

Labour practices, including their occupational health and safety

NamPower has its own workplace practices and standards which it will need to check that they meet the EIB Standards 8 and 9 for all project activities.

Bush harvesting practices vary from the small farmer using contract labour to harvest bush for firewood and /or charcoal to large scale operators. They all should be compliant with Namibian law regarding labour and human rights, but Namibian law is not specific in some aspects of bush harvesting working conditions and therefore some existing harvesters may not be meeting EIB Standard 8 and/or 9.

Some Namibian charcoal companies are selling their product as Forest Stewardship Council (FSC) certified which means they have to meet high FSC standards, and their operations have to be strictly audited for compliance. The FSC has recently approved the Forest Stewardship Standard of Namibia which details international best practices regarding, amongst others, workers' rights, labour practices, including occupational Health and Safety aspects, adapted to the Namibian conditions (FSC, 2019).

Principle 2 of the FSC standards sets standards on workers' rights and conditions of employment which are more stringent than some aspects of Namibian law and meet the principles and rights at work as defined in the ILO Declaration on Fundamental Principles and Rights at Work (1998) which are based on the eight ILO Core Labour Conventions as well as the UN Guiding Principles Business and Human Rights (UN, 2011). The FSC Standard also meets or exceeds EIB Standards 7, 8 and 9 and it is recommended that these are adopted for all suppliers of wood chips to the proposed Biomass Power Station.

7.11.9.2 *Assessment of Impact*

Severity

The project is unlikely to negatively affect human rights and interests of the San people, women or its workers. However, the project can influence employers to adopt positive measures which can enhance the rights and interest of vulnerable groups, through prioritising them for job selection, skills development and prioritising their farms for bush-thinning.

The project can adopt working conditions of labour which exceeds that stipulated by Namibian legislation. These actions will not only raise awareness and reduce occupational risk but improve their livelihoods.

The severity is therefore rated as High positive in the mitigated scenario.

Duration

The duration of the impact is high as improving peoples' human rights and their livelihoods should last beyond the timeframe of the project.

Spatial scale

The spatial scale is Medium as its sphere of influence will be to direct beneficiaries in the project harvesting area.

Consequence

The determining consequence is Medium.

Probability

The probability of the positive impacts occurring is High as NamPower is a reputable employer and upholding human rights and interests of vulnerable groups and labour are non-negotiable requirements of a potential investor.

Significance

The significance of the impacts is Medium (positive).

7.11.9.3 *Tabulated Summary of the Assessed Impact – Upholding Human Rights and Interests of Vulnerable People and Labour*

Mitigation	Severity	Duration	Spatial Scale	Consequence	Probability of Occurrence	Significance
Unmitigated	**H+**	**H**	**M**	**M+**	**H**	**M+**
Mitigated	**H+**	**H**	**M**	**M+**	**H**	**M+**

7.11.9.4 *Conceptual Description of Mitigation Measures and Proposed Enhancement Measures*

Objective 1: To ensure the human rights of vulnerable groups are upheld and opportunities to uplift them from poverty are promoted.

Actions:

- The organisation responsible for selecting bush harvesting sites should be encouraged to consult with San traditional authorities and San living on bush encroached resettlement farms. The the aim to prioritise their farms for bush-thinning and to prioritise San people for jobs opportunities, where possible.
- The proposed project and its harvesting contractors must ensure that wages are paid to the individual and not to a spouse.
- NamPower should review its policies and procedures to ensure it complies with international standards regarding human rights, with particular emphasis on ways it can protect and uphold the rights of San peoples and women.

Objective 2: To ensure that NamPower and its wood chip suppliers complies with international standards regarding workers' rights and occupational health and safety.

Actions:

Relevant to all project activities

- NamPower should review its policies and procedures to ensure it complies with international standards regarding human rights, with particular regard on ways it can protect and uphold the rights of San peoples and women.

Relevant to the harvesting and associated activities

- The bush harvesting operators supplying the biomass Power Station should ensure they align to the guidelines detailed in the Principle 2 of the Forest Stewardship Standard of Namibia.

  For example, by aligning with the FSC Standard for Namibia, Criteria 2.1 and 2.2, the bush harvesting organisations will be aligned with the ILO standards regarding the use of child labour, forced or compulsory labour, debt bondage, discrimination in employment and occupation, freedom of association, gender equality, wage gender equity, maternity and paternity leave and sexual harassment. (On some issues, the ILO standards give more detail than Namibia's Labour Act).

  FSC Criterion 2.3 details aspects of health and safety practices to protect workers from occupational safety and health hazards which meet or exceed the recommendations of the ILO Code of Practice on Safety and Health in Forestry Work and the relevant sections of EIB Standard 9. Annexures C and D of the FSC Standard details specific health and safety measures for bush harvesters and minimum housing requirements, respectively.

  FSC Criterion 2.4 – 2.6 details job-specific training, mechanisms of engagement to resolve grievances and disputes.

7.12 HEALTH RISK ASSESSMENT

This section is based on the Air Quality, Climate Change and Health Risk Assessment (Airshed, 2018) included in Appendix 5.

The pathways through which toxic pollutants can enter the body were identified as air, ingestion and dermal exposure. Since emissions from the proposed Biomass Power Project will be released into the atmosphere, was identified as the dominant pathway and of most interest to this study.

Environmental issues related to the operation of the biomass plant were identified as air emissions from the stack, odour from storage of biomass, wastewater from flue gas treatment systems, disposal of waste, noise emissions and operational hazards.

Perceived health impacts by communities living in close proximity to Biomass Power Stations, as informed by the literature, comprise of physical, mental and social health impacts. Physical impacts included dust irritating their respiratory system and the perception of increased risk of road accidents. Mental health impacts were feelings of frustration by having to clean the house more frequently, because of the dust from the Power Station, and annoyance by the noise emanating from the plant operations. Social impacts were related to the perception of problems posed by immigrant workers in their community and the risk for communicable disease.

The contaminant of greatest concern in the study area was identified as SO_2, due to the presence of the Tsumeb Smelter in the near vicinity of the proposed project. Based on the very low impacts simulated in the air quality impact assessment (refer to section 7.7), the Air Quality/Health Risk Specialist decided to focus the quantitative assessment of the incremental risk to the ambient population as a result of the proposed Project on SO_2.

7.12.1 Hazard Quantification

Exposure to SO_2 concentrations above certain threshold levels increases the prevalence of chronic respiratory disease and the risk of acute respiratory illness. Incremental and cumulative simulated SO_2 concentrations from background concentrations of SO_2 due to the operational activities at Tsumeb Smelter, at selected sensitive receptors, were tabulated.

A background literature search was performed to obtain information on respiratory health problems and air quality related complaints in the study area. A key study was found in the public domain in the form of a community health assessment undertaken as part of the Environmental and Social Impact Assessment process for the proposed Tsumeb Smelter expansion project (refer to Section 6.10).

The objective of the health assessment was to investigate the impact of the smelter operations on Tsumeb residents. It was found that, compared with the control sample in the Oshakati region, there was evidence of asthma-related symptoms being significantly more prevalent in Tsumeb. Half of all those surveyed in Tsumeb had some asthma-related symptomatology and half of these again experienced some degree of severity of these symptoms, constituting an appreciable burden of asthma-related morbidity spread across all the areas of Tsumeb and the farms to the north.

The predominant symptoms reported were cough and throat irritation, upper respiratory system responses. Less prevalent symptoms reported were the more severe lower respiratory symptoms such as shortness of breath and chest discomfort. The study concluded that, while not severe, these symptoms impose some burden of discomfort on the residents in all areas of Tsumeb i.e. a nuisance impact.

7.12.2 Exposure Assessment

Exposure assessment is the evaluation of the potential exposures to humans and the environment from a chemical substance. Exposure assessment determines the likelihood, magnitude, frequency, and duration of exposure assessment principles.

Chronic SO_2 exposure i.e. exposure factor (EF) was determined by calculating the average daily dose (ADD) in µg/kg-day for specific population groups – infant, child, adult, for these age groups have different mean body weights and inhalation rates at which pollution concentrations are taken in, only for the Power Station incremental scenario.

7.12.3 Risk Characterisation

Risk characterisation provides an integrated assessment of hazard identification, dose response relationship and exposure characterisation. The risk estimates can be for the general population, thus pertaining to average population statistics, or it can be done for specific population groups – in this study the risk estimates applied to sensitive receptors surrounding the project site (refer to Figure 6-45).

SO_2 has no chronic reference exposure level and the South African annual SO_2 limit value of 50 µg/m³ was used instead[28].

The chronic hazard quotient (HQ)[29] for SO_2 based on simulated incremental ground level concentrations, due to the proposed 40 MW Biomass Power Station – Scenario 2, are given in Table 7-26. From the low values in Table 7-26 (< 1) the health hazard posed by the proposed project is insignificant.

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[28] WHO only provides 24-hour limits, no chronic limit.

[29] HQ = Hazard quotient (1 is considered to be the benchmark where no adverse health effects are expected, but if it is above 1 it does not necessarily mean that adverse effects would occur)

TABLE 7-26: CHRONIC HAZARD QUOTIENT FOR SO_2

Receptor	Child Resident	School child	Adult resident	Adult worker
1. Farmstead A	2.08E-02	1.79E-03	5.95E-03	2.08E-03
2. Farmstead B	9.58E-03	8.21E-04	2.74E-03	9.58E-04
3. Farmstead C	5.16E-03	4.43E-04	1.48E-03	5.16E-04
4. Namfo (Pty) Ltd	1.74E-03	1.49E-04	4.97E-04	1.74E-04
5. Farmstead D	2.07E-03	1.77E-04	5.92E-04	2.07E-04
6. Farmstead E	2.00E-03	1.72E-04	5.72E-04	2.00E-04
7. Tsumeb Town	1.73E-03	1.49E-04	4.96E-04	1.73E-04
8. Farmstead F	2.09E-03	1.79E-04	5.98E-04	2.09E-04
9. Farmstead G	6.46E-02	5.54E-03	1.85E-02	6.46E-03
10. Farmstead H	1.13E-02	9.70E-04	3.23E-03	1.13E-03
Significance Threshold	**1**	**1**	**1**	**1**

7.12.3.1 *Conceptual Description of Mitigation Measures*

Conceptual discussion of the mitigation measures is provided below and detailed in the Power Station and Power line and Harvesting and Associated Activities EMPs (Appendices 14 and 15).

Objective

The objective of the mitigation measures is to avoid health risk to third parties.

Actions

Power Station

- Periodic emissions monitoring should be done to ensure that combustion emissions due to the Power Station are below the limits stipulated in Table 7-17 Scenario 1.
- A complaints register should be kept in order to become aware of any health complaints perceived by nearby residents, and followed up on.
- CCTV could be installed to address complaints that dark smoke is being emitted from the stack. CCTV coverage of the stack could show that under certain weather conditions there will be condensation due to flue gas from the stack coming into contact with ambient conditions.

Biomass Harvesting

- It is recommended that sensitive areas within harvest zones be identified via field inspection prior to commencement of felling operations and that setback distances be determined between harvest zones and sensitive populations, taking into account the topography and prevailing wind directions.
- Harvest intensity should be reduced close to sensitive land uses, harvesting blocks should be kept small (i.e. done in patches, with vegetation kept in between) and vegetation buffers should be retained

between harvesting activities and sensitive receptors to reduce the potential of windblown dust from open areas.
- Dust bucket monitoring may be done at identified sensitive receptors, three months prior to and during biomass harvesting to assess whether additional mitigation measures are required.

7.13 CLIMATE CHANGE EVALUATION

This section is based on the Air Quality, Climate Change and Health Risk Assessment (Airshed, 2018) included in Appendix 5.

The scope of work related to evaluating climate change comprised the following aspects:

- A study of the legal requirements pertaining to climate change, both national and international;
- quantification of the carbon footprint of the biomass process, which will be limited to the proposed plant and the encroacher bush area to be harvested – this includes the quantification of greenhouse gases from all direct sources of emission associated with the process.

The Carbon Footprint is an indication of the greenhouse gases estimated to be emitted directly and/or indirectly by an organisation, facility or product. This report considers Scope 1 emissions as well as Scope 2 emissions, in line with the guidelines provided by the International Finance Corporation (IFC, 2012). This is in line with the EIB methodologies where Scope 1, direct GHG emissions, is required for all projects. It should be noted that projects with an absolute or relative threshold of <20 000 tonnes CO2e per year are not required to be included into the EIB Carbon Footprint.

International agreements in the form of the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, and Paris Agreement are discussed in Appendix 5. Key milestones in Namibia's response to climate change are outlined, and Namibia's Intended Nationally Determined Contribution (INDC), Greenhouse Gas Reporting, and Draft Bush Encroachment Policy are detailed in Appendix 5. These will not be repeated in this report.

The carbon footprint of the biomass process was quantified by assessing the following:

- The GHG emissions during the operation of the project when compared to the global and Namibian emission inventory.
- The impact of climate change on the project, i.e. the robustness of the project over its lifetime with respect to climate change.
- The vulnerability of communities in the immediate vicinity of the project with respect to climate change.

7.13.1 Greenhouse gas (GHG) Emissions

There have been various GHG studies related to the use of encroacher bush as a biomass feedstock to generate electricity in Namibia. These studies were conducted at various stages within the conceptual phase of the Project, using different underlying assumptions and methods in their GHG calculations and reporting. The main studies are listed below:

- Preliminary Carbon Funding Analysis (WSP Environment and Energy, 2012);
- Micro and Macroeconomic Impact Assessment of a 20-Megawatt Encroacher Bush Biomass Power Plant near Tsumeb (Cirrus Capital , 2018);
- Air Quality, Climate Change and Health Risk Assessment (Airshed, 2019); and
- Greenhouse Gas Assessment of Bush Control and Biomass Utilisation in Namibia (UNIQUE Forestry and Land Use Gmb, 2019).

Based on the variances and principle differences in the assumptions used in the abovementioned reports, these studies all produced different GHG values. All of the reports concluded that despite the direct emissions from the power station and harvesting activities, that electricity generation using biomass results in a net carbon sink when taking into account; offset emissions from imported electricity, more sustainable harvesting practices, and sequestration from regrowth of the encroacher bush within the defined harvesting area.

As the project moves from development to implementation it is imperative that NamPower develops a specific GHG model based on the actual implementation of the power station and harvesting activities. NamPower have commenced with the process of developing a comprehensive GHG model and are finalising the model based on the requirements of various Development Financing Institutes.

7.13.2 Potential Impact of Climate Change on the Project

The threats and opportunities to the project that might be encountered due to changing climatic conditions were assessed by using the seasonal plan tool. The seasonal plan tool portrays climate scenario information according to changing seasonal circumstances. The seasonal analysis was based on climatic information available for Tsumeb, the historical data on droughts and floods in Namibia and a case study from the literature with respect to the impact of changing climatic conditions on a Finland Combined Heat and Power (CHP) biomass Power Station.

The following was found with regards to climate change and its potential impact on the project:

- Rainy season in Otjikoto (December to March) – A delayed rainy season, drought and possible flooding, which may occur as a result of climate change, will cause higher temperatures, which will generally increase biomass growth, the risk of naturally occurring biomass fires and the onset of the rainy season to become more variable. Heavy rain, lightning strikes, hail and flooding may result in increased biomass moisture which will change the transportation and storage conditions. Flooding could make roads impassable and interrupt harvesting activities, and possible damage to harvesting equipment/Power Station may occur during hailstorm and flooding events.
- Dry season in Otjikoto (May to September) – Higher temperatures during the dry season, increased evaporation and overall reduction in water availability may cause encroacher bush harvesting to become easier in dry conditions, and changes in transportation and storage circumstances to occur (less humidity, microbes, biomass heat value etc). Prolonged drought which causes severe water shortages may interrupt Power Station and harvesting activities, increase the possibility of heat-related illnesses among biomass harvesting personnel, increase the risk of overheating the equipment/machinery with effects on production, and increase the risk of naturally occurring biomass fires as a result of lightning.

7.13.3 Potential Effect of Climate Change on the Community

The vulnerability of farming households to climate change was assessed in terms of exposure, sensitivity, potential impact and adaptive capacity. The Oshikoto Region has an adaptive capacity of 32.1%, from the literature, based on indicators such as poverty incidence, illiteracy rate, HIV prevalence, malnutrition in children under 5 years old, and population without access to sanitation, safe water or health facilities. The vulnerability of Oshikoto Region (North-Central Region of Namibia) to climate change was found to be High to Very High.

7.13.4 Project Adaptation and Mitigation Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening emissions and/or enhancing sinks through human intervention.

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use; this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation around the Power Station and to ensure that that as much as possible revegetation occurs and possibly even the addition of vegetation surrounding the Power Station area.

8 KEY ASSUMPTIONS, UNCERTAINTIES AND LIMITATIONS

Assumptions, uncertainties and limitations relating to each of the environmental aspects are presented in the various specialist studies (Appendices 5 to 13) and summarised below.

8.1 TRAFFIC

- The assessment of the roads in the Power Station vicinity was limited to the Trunk Road 1/10 directly adjacent to the Power Station site. All the roads, to be used in future by trucks for the delivery of biomass, could not be visited. The only information available to determine the condition of these roads is the visual assessment data undertaken by the Roads Authority.
- Assumptions had to be made on the condition, alignment and width of DR 3007.

8.2 SURFACE AND GROUND WATER

- The assumptions made are that the water demand predicted will not exponentially exceed the calculated amounts.
- Site layout was provided later than assessment, therefore a storm water management plan is outstanding.
- No detailed topography was provided.
- Assessment made mostly based on literature and desk study (GROWAS), AsterDEM from the USGS.
- Budget constraints prohibited site visits to the harvest area and therefore existing information of the area was used.

8.3 SOIL

- The sheer size and inaccessibility of the harvesting area presented a limitation. Satellite imagery proved a great advantage in ensuring, with a large measure of confidence, that no major sensitive areal feature was overlooked.
- A reconnaissance scale assessment was conducted on the harvesting area with a semi-detailed scale assessment on the plant area.
- Validity of interpolation between data points as long as terrain features, parent material, vegetal signature and climate remains spatially unchanged.
- Scientific description, laboratory analysis and soil classification, through knowledge of covariation between soil properties, allowed statements about properties that were not actually measured, as long as certain covariant key properties had been determined. Examples include:
    - soil depth, covariant with a component of water holding capacity and a component of water erodibility;
    - soil colour, covariant with internal drainage and wetness;
    - soil clay and silt content, covariant with the matric potential component of water holding capacity;
    - exchangeable cations, covariant with base status and natural fertility;
    - soil pH, covariant with micronutrient availability; and
    - cation exchange capacity, covariant with soil clay mineralogy etc.
- In terms of the ash assessment, a limitation in the study was identified in that analytical results for the fly ash and bottom ash were not available for assessment.

8.4 VERTEBRATES AND VEGETATION

- The fieldwork during the assessment phase was limited to relatively short visits to the proposed Power Station site and proposed harvesting area. Because of the large size involved, only a small fraction of the total harvesting area could be visited. The observation period for ecological studies is always critical.

Short periods of observation and measurement lead to more uncertainty, because more of the conclusions must be based on generalisations about the ecosystem obtained from literature studies. An important outcome of this situation and a key point that we want to make in the report, is that, apart from specific knowledge gaps, there is still a clear need for intensive monitoring of savanna dynamics under various harvesting and post-care scenarios to determine long-term outcomes and to inform careful, adaptive, and pre-emptive management. Throughout we have also tried to be clear where uncertainties may affect the overall interpretation of results.

- The data sources available on the distribution range of species may not reflect actual ranges accurately. For example, new data gathered through the citizen science project of the Environmental Information System, has discovered snake species occurring outside the known distribution range. This is certainly also true for other taxa than reptiles.
- The assessment of potential impacts to biodiversity is essentially an evaluation of the risk that individuals, populations, habitats, or processes will be affected in such a way that their persistence in the region or, in the worst cases globally, is threatened. A key input into this risk assessment is knowledge of the species, their ecology, and their dynamics based on these aspects, the significance of the impact and the most appropriate mitigations are determined. The better these aspects are known, the easier it is to obtain a confident estimate of the risk that certain actions or developments can cause harm. Often, however, the biology and ecology of a species are poorly known, simply because the species has not been studied that well in the past or because it is particularly rare or sparsely distributed and therefore seldom encountered. Similarly, knowledge about ecological processes, e.g. dispersal routes, interactions of species with their predators, even ecosystem-level processes such as nutrient cycling, is lacking for many of Namibia's natural systems because these kinds of studies require specialist capacity that has not existed in the past. Some generalisations must therefore be made about expected responses in the proposed harvesting area from studies conducted in other savanna types, e.g. southern Kalahari savannas.

8.5 INVERTEBRATES

- The National Museum of Namibia is completely dysfunctional and unable to accept sample material and the Entomology section is currently without staff.

8.6 AVIFAUNA

- Bird atlas records (SABAP 1 & 2) were used as the basis for compiling the bird checklists; apart from reflecting parameters such as species diversity/abundance per Quarter Degree Square (QDS), however, these checklists are also a reflection of the atlassing effort, which varies among sampling areas. Despite this limitation, the atlas lists are regarded as a useful tool for determining (and comparing) bird species diversity/abundance on a standardised basis. It should be noted that bird species diversity in encroached areas at present may be lower than before these areas were encroached, and more recent atlassing results should therefore be regarded as a minimum reflection of the potential diversity in such areas.
- In terms of the bird atlassing data used as a basis for compiling the bird checklists, the older SABAP1 records are more comprehensive, although dating back to 1992; the more recent SABAP2 data for Namibia are not as comprehensive as the older data. A combination of the two sets of data was therefore used, supplemented by personal observations.
- The exact locality of the proposed biomass plant for each site was not available at the time of the site visits; therefore, the larger peripheral area around each substation was investigated/ assessed, in order to accommodate the various options for the site. The final plant site is also heavily encroached by bush and is therefore not readily accessible.
- Details of the localities of the areas to be harvested and the degree of encroachment were also not available at the scoping stage (apart from a broad delineated radius of 70-100 km from the proposed biomass plant sites), therefore a detailed assessment could not be made in these areas; a precautionary

approach was thus used in terms of the potential for a species to occur/nest in the biomass harvesting areas, including vultures.

- Records of bird and power line incidents in heavily encroached areas in Namibia are limited, due to the constraints of physical access to power line servitudes for monitoring in such areas. Bird and power line incident data from other more accessible areas were thus used as an indication of species' sensitivity to such impacts in the biomass Power Station area.
- Bird species diversity in bush encroached areas may be lower than that in the same areas before they were encroached.
- Biomass harvesting will take place in more densely infested areas; but not along ephemeral watercourses; not in rocky areas; not on steep gradients (>12.5°) or on mountains; and not in formally protected areas or within demarcated buffer zones.
- It is assumed that a bush thinning approach will be used for harvesting, rather than total bush clearing or bulldozing; large trees (diameter >18 cm/height >4 m) will not be cleared. The bush thinning approach needs to be double-checked with the rest of the biodiversity team and potential further requirements.
- Biomass harvesting activities are not likely to impact on purely aquatic bird species, although some priority aquatic species could well be involved in power line interactions associated with the biomass Power Station while making nomadic movements.

8.7 ARCHAEOLOGY

- With the exception of eight national monuments within c.100km, there is a general paucity of existing documentation for archaeological sites and cultural heritage in the area, which makes it difficult to establish a valid baseline against which to assess potential impacts. Field survey is an important technique to balance this gap in available information, but the density of vegetation in many parts of the study area and the large extent of it at c.100km zone around the Biomass plant, makes such survey physically impossible. Remote scanning through use of available satellite imagery via Google Earth, has enabled some degree of survey to assist with the assessment, and the assumption is that further sites would be identified in similar types of terrain, geology and hydrological conditions once the current vegetation is removed. The remote scanning has identified a selection of historical sites, but prehistoric archaeology is too ephemeral to be detected by these means. There is an assumption that the bush harvesting zone would not be devoid of prehistoric archaeology, and therefore archaeological input would be required as part of mitigation during harvesting activities, to ensure that both prehistoric and historic sites are identified and recorded.

8.8 NOISE

- The information reported has been based on the interpretation of noise data collected and has been accepted in good faith as being accurate and valid. The number and duration of baseline noise measurements have been chosen to give reasonably representative information on the environment, and the locations of measurements have been restricted to those that are easily accessible without undue risk to the surveyor. The number of sampling points and the methods of sampling and testing cannot preclude the existence of ‘hotspots’, where noise levels may be higher than those actually measured. Noise sources may be intermittent or fluctuate in intensity, and consequently may not be present or may not be present in full intensity for some or all of the survey duration.
- The techniques available to predict the likely noise effects from construction are necessarily based on quite detailed information on the type and number of plant being used, their location within the site and the length of time they are in operation. A detailed list of construction plant and methods is not yet available therefore, the assessment of construction noise has been based on information and data from experience on similar developments.
- The predicted construction noise levels have assumed the concurrent use and 100% on-time for all plant for each stage of construction. In all cases, it is likely that plant would operate for much shorter periods

and not all activities would occur at the same time, resulting in lower noise levels. The assessment therefore presents a worst case scenario for construction noise levels.

- The identified operational noise sources, and their corresponding sound power or sound pressure levels, have been referenced to available information for a similar Power Stations and other published sources. Where information has not been available, appropriate assumptions have been made with respect to the likely noise levels associated with the operation of the Power Station.
- For the purposes of the assessment, the façades and roof of the buildings within the site are assumed to comprise 70mm Kingspan panel, 100mm rock wool and 0.8mm steel liner with an overall sound performance of 42dB Rw. Doors would achieve a minimum acoustic performance and are anticipated to be kept closed for the majority of time. Ventilation would be provided by louvres within the façades of the buildings. Whilst the exact size and location of each of the louvres is to be confirmed, it is assumed that these would be acoustically attenuated.
- With respect to the harvesting of biomass fuel, this would be undertaken in areas around the proposed biomass Power Station site, within a radius of approximately 100km. It has not been possible to define the location of the closest NSRs for harvesting, as the exact location(s) for this activity is unknown.
- For the assessment of construction and operational traffic, reference has been made to the results of the Traffic Impact Assessment (TIA) for traffic which would be generated on the surrounding road network.

8.9 AIR QUALITY, THIRD PARTY HEALTH & CLIMATE CHANGE

- The scope of work did not include any site visit, ambient monitoring, meteorological monitoring, or source monitoring.
- Although health risk can occur due to exposures through inhalation, ingestion and dermal contact, the main focus was on the exposures via the inhalation pathway.
- Emissions of proposed Power Station operations were quantified based on latest design specifications provided. This includes site layout plans, operational schedules and production rates.
- The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.
- Ambient SO_2 and PM_{10} measurements from the Tsumeb smelter (6.5 km away) ambient monitoring Stations were made available to the assessment to estimate cumulative impacts.
- Impact potentials as estimated in this study are conservative and likely to be over rather than under-predicted in that maximum possible exposures were assumed, i.e. public exposures for 24-hours a day over a 70-year lifetime were assumed to occur beyond the fence lines of the proposed Power Station.
- Emission reduction measures were provided as generic amounts, specific control designs, and products were not provided.
- The climate change evaluation was limited to GHG emissions from the proposed biomass plant and encroacher bush harvesting. According to the EIB, only plants with absolute or relative emissions of greater than 20,000 tonnes CO_2e/year need to be quantified and included in the carbon footprint. The IPPC emission factors were used to determine the proposed Power Stations contribution.

8.10 VISUAL

- The extent of the study area is determined by the zone of potential influence for the Otjikoto site, which in this study relates to a radius about the project site of 5,0km. At 5,0 km and beyond the project components would recede into background views with the potential impact of the Power Station and overhead power line greatly reduced.
- Due to the extent of this area, during the site visit the entire region was not visited and the use of aerial photography, via Google Earth, was used to give the author an understanding of its landscape characteristics.
- The viewshed analysis for each of the Otjikoto site assumed an average position of the Power Station and associated overhead power line. An offset of 25m above ground level was used, a median height of

approximately two thirds of the height of tallest structures i.e. boiler 30m and the stack approximately 50m. The purpose of the viewshed analysis is to express the potential visibility of the Power Station within the study area and beyond, up to 15km was used. The viewshed was conducted using topography only and did not consider tree cover as bush and therefore represents the worst-case scenario.

8.11 SOCIO-ECONOMIC STRUCTURE/PROFILE

Details of the bush harvesting locations, methods and the remuneration model between the landowner and the harvester for the bush thinning activities and supply of biomass for the Power Station have not been defined.

The assumptions made in the project's techno-economic study (COWI - Techno-Economic Report, 2017) and those given by NamPower to Cirrus Capital (Cirrus Capital, 2018) for their study on the micro and macroeconomic benefits of a 20 MW biomass Power Station form the basis of this report. These are supplemented by information from an assessment of the economics of land degradation related to bush encroachment in Namibia study by the Namibia Nature Foundation (NNF, 2016); where relevant, comments from existing bush harvesting operators have been included.

Specific gaps which will influence the economic impacts include:

- Lack of knowledge of the remuneration model between landowner and harvester.
- Lack of knowledge on the responsibility and cost of the after-care programme.
- Lack of knowledge about the entities responsible for the harvesting of wood chips and supply of biomass to the Power Station.

9 ENVIRONMENTAL IMPACT STATEMENT AND CONCLUSIONS

The receiving environment was studied as part of the EIA process for the proposed Biomass Power Project, (section 6) and environmental aspects and potential impacts associated with the activities and facilities were identified as part of the Scoping Phase, for further consideration and assessment during the assessment phase of the EIA. The full suite of facilities and activities, associated with the construction, operation, and decommissioning phases of the proposed Biomass Power Station and overhead powerline; as well as the harvesting and associated activities are described in section 4 of this report.

Potential environmental impacts were identified by SLR in consultation with I&APs, regulatory authorities, specialist consultants (see team of Specialists in section 1.4.1) and NamPower. The impacts were assessed under the identified issue headings in section 7. Impacts were considered in a cumulative manner where possible such that the impacts of the proposed Biomass Power Project were assessed in the context of the baseline conditions described in Section 6.

Table 9-1 and Table 9-2 provide a summary of the environmental aspects associated with the proposed Biomass Power Station and overhead powerline; and the harvesting and associated activities respectively, how these could impact the biophysical and human environments; and the assessment ratings, in the unmitigated and mitigated scenarios.

The project with its positive impacts envisaged from the generation of renewable power and the harvesting of the fuel source has the potential to benefit the country, society, and surrounding communities both directly and indirectly. Other than the benefits associated with the electricity generation, the implementation of the proposed Encroacher Bush Biomass Power Project will have benefits such as contributing to a reduction in bush encroachment and the restoration of rangeland through bush thinning practices, increasing land productivity, increased rain water infiltration and improved business, employment and skills development opportunities.

A number of high significant negative impacts are however specifically associated with the harvesting and associated activities in the unmitigated scenario. It is possible to mitigate the potential negative impacts by committing to apply the findings of the assessment and related mitigation objectives and actions as presented in the two EMPs. The significance of the potential impacts associated with achieving the savanna ecological restoration goals in the harvesting area, or not, is assessed as high negative in the unmitigated scenario and high positive in the mitigated scenario.

Apart from specific knowledge gaps identified by the Biodiversity Team, there is still a clear need for intensive monitoring of savanna dynamics under various harvesting and postcare scenarios to determine longterm outcomes and to inform careful, adaptive, and pre-emptive management. An adaptive management approach is recommended to ensure the restoration outcomes are achieved.

TABLE 9-1: DESCRIPTION OF ENVIRONMENTAL ASPECTS AND POTENTIAL IMPACTS ASSOCIATED WITH PROPOSED BIOMASS POWER STATION AND OVERHEAD POWERLINE

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
Traffic	• Vehicle movement associated with earth moving activities. • Transportation of construction workers. • Deliveries, including abnormal vehicles.	• Deliveries, including chemicals for the Power Station. • Transportation of operational personnel to the Power Station and back, on a daily basis. • Collection activities, in particular waste and ash from the plant.	• Vehicle movement associated with demolition and rehabilitation activities. • Transportation of workers.	**Impact on road capacity and road condition/deterioration – TR 1/10**	**M**	**L**
				Impact at the TR 1/10 and DR 3007 Intersection	**M**	**L**
Soils	• Soil compaction through vehicle movement. • Removal of soil for infrastructure development. • Oil and fuel spills from equipment and vehicles used.	• Soil compaction through vehicle movement. • Removal of soil for infrastructure development. • Deposition of ash material during the operational phase in the plant area. • Oil and fuel spills from equipment and vehicles used.	• Soil compaction through vehicle movement. • Oil and fuel spills from equipment and vehicles used.	**Soil compaction potentially affecting plants and animals above the soil surface, as well as soil macro-fauna and microorganisms below the soil surface**	**M**	**L**
				Loss of the natural functioning of the soil as growth medium – Power Station area	**M**	**L**
				Soil contamination through deposition of ash material from the plant	**H**	**L**

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
		• Clearing activities – i.e. removal of protective shrubs and trees.		**Soil contamination through fuel and oil spills at the Power Station site**	**M**	**L**
Biodiversity	• Activities associated with clearing of existing natural bush before construction of the Power Station and power line. • Various construction activities causing general disturbance. • Erection of a new overhead power line. • Oil and fuel spills from equipment and vehicles used.	• Possible pollutants, i.e. chemicals used at the Power Station, ash from the plant, sewage, etc. causing impacts to biodiversity habitats and populations. • Potential (overhead) power line impacts on birds.	• General demolition and rehabilitation activities • General disturbance • Oil and fuel spills from equipment and vehicles used.	**Loss of habitat, destruction of animals and plants and general disturbance of biodiversity**	**M**	**L**
				Collisions and Electrocution of birds on power line structures	**L**	**L**
Surface Water	• Spillages of hydrocarbons, paints, etc. during	• Pollutants, i.e. chemicals used at the Power	• Spillages of hydrocarbons during	**Decrease in downstream surface water runoff due to the Power Station and associated infrastructure**	**L**	**L**

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
	construction activities.	Station, ash from the plant, sewage, etc. • Hydrocarbon spills from vehicle movement during operation. • New infrastructure development.	decommissioning activities.	**Contamination of surface water from pollutants at the Power Station and associated activities**	**H**	**L**
				Contamination of surface water from ash from the Power Station ending up in the runoff	**H**	**L**
Groundwater	• Spillages of hydrocarbons, paints, etc. during construction activities.	• Water abstraction for the Power Station. • Pollutants, i.e. chemicals used at the Power Station, ash from the plant, sewage, etc. • Water treatment activities i.e. release of brine.	• Spillages of hydrocarbons during decommissioning activities.	**Impacts of groundwater over-abstraction on the underlying aquifer**	**L**	**L**
				Contamination of Groundwater from pollutants at the Power Station and associated activities	**H**	**L**
				Seepage of effluent (i.e. discharged brine) from the water treatment plant impacting the water quality in the underlying aquifer	**M**	**L**
				Leaching of ash constituents from the onsite storage/disposal piles, impacting on the underlying aquifer	**H**	**L**

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
Air Quality	• Exhaust fumes (vehicles, generators) • Construction / building activities (including earthworks, general construction activities, vehicle movement, etc.) causing dustfall, PM_{10} and $PM_{2.5}$	• Vehicle Entrained Dust from Paved Roads • Materials handling and storage causing dust • Power Station stack emissions (i.e. combustion) • Exhaust fumes (vehicles, generators) • Ash disposal activities.	• Exhaust fumes (vehicles, generators) • Demolition • Decommissioning activities, i.e. blasting during the demolition of infrastructure, handling and disposal of building waste causing dustfall, PM_{10} and $PM_{2.}$	**Air pollution impact to third parties i.e. nuisance impacts and third party health impacts.** • Construction phase – TSP, PM_{10} & $PM_{2.5}$ • Operational – PM_{10}, $PM_{2.5}$, SO_2 and NO_2	**M**	**L**
Noise	• Site preparation & establishment. • General construction activities. • Earthworks for all surface infrastructure. • Construction of foundations. • Equipment maintenance. • Access road construction. • Vehicle movement.	• General site management activities. • Off-loading of biomass. • Materials handling. • Equipment maintenance. • Vehicle movement. • Power Station operations. • Waste management. • Water management (pumps). • Support services and amenities.	• Demolition. • General decommissioning and rehabilitation activities. • Earthworks. • Vehicle movement. • Support services and amenities.	**Noise pollution – impact to third parties i.e. nuisance**	**L**	**L**

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
	• Generators. • Other support services and amenities.					
Archaeology	• Site preparation & establishment. • Earthworks for all surface infrastructure. • Soil stripping and stockpiling. • General construction activities. • Access road construction. • Vehicle movement.	• General operational activities.	• N/A	**Damage to archaeological resources – Power Station and power line site and the immediate landscape**	**L-M**	**L**
Visual	• Site preparation & establishment. • Earthworks for all surface infrastructure. • Soil stripping and stockpiling. • General construction activities.	• General operational activities. • Transport systems. • Power generation plant, particularly stacks. • Waste management. • Support services and amenities.	• General demolition and rehabilitation activities. • Earthworks. • Scaffolding & cranes. • Waste management. • Vehicle movement.	**Visual Impact to third parties**	**L**	**L**

Environmental component	Project Phase Aspects			Potential Impacts	Assessment Significance Rating	
	Construction	Operational (Largely related to the Power Station)	Decommissioning and Closure		Unmitigated	Mitigated
	• Scaffolding & cranes • Access road construction. • Vehicle movement.					
Socio-economic	• Community resilience and population influx during construction. • New (hazardous) activities and infrastructure • Community's safety, health and security. • Employment during construction phase.	• Operations of the new Biomass Power Station and fuel supply. • Employment during operations. • Hazardous infrastructure impacting.	• Closure of the plant.	**Hazardous excavation and infrastructure that could impact safety of third parties**	**H**	**L**
				Economic impacts associated with the Biomass Power Station	**H+**	**H+**
				Job Creation and Skills development	**H+**	**H+**
				Community resilience to population in-migration	**H**	**M**

TABLE 9-2: DESCRIPTION OF ENVIRONMENTAL ASPECTS AND POTENTIAL IMPACTS ASSOCIATED WITH PROPOSED HARVESTING & ASSOCIATED ACTIVITIES AND TRANSPORTATION OF BIOMASS

Environmental component	Environmental and Socio-Economic Aspects		Potential Impacts	Assessment Significance Rating	
	Harvesting and associated activities	Transport of Biomass to the Power Station		Unmitigated	Mitigated
Traffic	• Moving equipment and workers to the specific harvesting area.	• Transport of the wood chips to the Power Station.	**Impact on road capacity and road condition/deterioration – TR 1/10**	**M**	**L**
			Impact on road capacity and road condition/deterioration – gravel roads:		
			• **DR 3007**	**M**	**L**
			• **Other gravel Roads**	**L**	**L**
			Impact at the TR 1/10 and DR 3007 Intersection	**M**	**L**
Soils	• Soil compaction through vehicle movement and machinery used for harvesting activities. • Oil and fuel spills from equipment and vehicles used. • Removal of protective shrubs and trees causing erosion. • Reduction in nutrient transfer from deep soil layers though seasonal leaf fall in the harvesting area. • Improved soil carbon cycle and soil structure. • Use of arboricide during aftercare.	• Soil compaction thought increased vehicular movements associated with the transport of the wood chips to the Power Station. • Oil and fuel spills from vehicles used.	**Soil compaction potentially affecting plants and animals above the soil surface, as well as soil macro-fauna and microorganisms below the soil surface**	**M**	**L**
			Wind and water erosion in the harvesting area	**M**	**L**
			Reduction in nutrient transfer from deep soil layers though seasonal leaf fall in the harvesting area	**M**	**M**
			Improved soil carbon cycle and soil structure	**M+**	**-**
			Soil contamination through fuel and oil spills in the harvesting area and arboricides after-effects	**M**	**L-M**

Environmental component	Environmental and Socio-Economic Aspects		Potential Impacts	Assessment Significance Rating	
	Harvesting and associated activities	Transport of Biomass to the Power Station		Unmitigated	Mitigated
Biodiversity	• Improvement of rangeland productivity. • Improvement of biodiversity and ecological integrity of savannas. • Harvesting operations (using heavy machinery and labourers) causing physical destruction of organisms and habitats and / or the general disturbance to biodiversity.	• Transportation of the biomass causing physical destruction of organisms and habitats and / or the general disturbance to biodiversity.	**Failure to achieve savanna ecological restoration goals in the harvesting area**	H	H+
			Large scale loss of protected woody species, including fruit-bearing species important for humans and other fauna, as well as rare, iconic and timber species due to indiscriminate and excessive take-off	H	M
			Loss of and disturbance of animals in harvesting area	M-H	L-M
Surface Water	• Increased salinization through de-bushing, impacting surface water quality. • Surface water contamination as a result of hydrocarbon spills from harvesting machinery and trucks. • Non environmental friendly arboricides impacting surface water quality. • Ash from the power station taken back to the harvested farms.	• Surface water contamination as a result of hydrocarbon spills from trucks during transportation of biomass.	**Bush harvesting activities causing increased salinization, causing surface water quality impacts**	H	L
			Non environmentally friendly arboricides used after bush harvesting i.e. aftercare, impacting on surface water quality	H	L
			Contamination of surface water from hydrocarbon spillages and undetected leakages from harvesting equipment and trucks transporting biomass	M	L
			Contamination of surface water from ash from the Power Station taken back to the harvested farms	M	L

Environmental component	Environmental and Socio-Economic Aspects		Potential Impacts	Assessment Significance Rating	
	Harvesting and associated activities	Transport of Biomass to the Power Station		Unmitigated	Mitigated
Groundwater	• Positive impacts of bush harvesting activities on the groundwater levels. • Groundwater contamination as a result of hydrocarbon spills from harvesting machinery and trucks transporting biomass. • Impact of De-Bushing on Groundwater (and soil) through Salinization. • Impact of seeping of arboricides into the underlying aquifer. • Ash from the power station taken back to the harvested farms	• Groundwater contamination as a result of hydrocarbon spills from trucks during transportation of biomass.	**Impact of de-bushing on the groundwater levels**	**M+**	**-**
			Impact of de-bushing on groundwater and soil through salinization	**M**	**L**
			Non environmentally friendly arboricides used after bush harvesting i.e. aftercare, impacting on groundwater quality	**M**	**L**
			Contamination of groundwater from hydrocarbon spillages and undetected leakages from harvesting equipment and trucks transporting biomass	**M**	**L**
				M	**L**
Air Quality	• Dust from bush harvesting activities causing impacts to third parties' health and causing nuisance. • Gaseous and particulate emissions from vehicle tailpipes	• Dust from transportation on gravel roads causing impacts to third parties' health and causing nuisance. • Gaseous and particulate emissions from vehicle tailpipes	**Air pollution**	**M**	**L-M**
Noise	• Vehicle movement and machinery used for bush thinning activities, including: • Felling, stacking, feeding, chipping and shuttling.	• Increased vehicular movements associated with the transport of the wood chips to the Power Station.	**Noise pollution**	**L**	**L**
Archaeology	• Vehicle movement and machinery used for bush thinning activities.	• Increased vehicular movements associated with	**Damage to archaeological resources**	**H**	**L**

Environmental component	Environmental and Socio-Economic Aspects		Potential Impacts	Assessment Significance Rating	
	Harvesting and associated activities	Transport of Biomass to the Power Station		Unmitigated	Mitigated
		the transport of the wood chips to the Power Station.			
Visual	• Moving equipment and workers to the specific harvesting area. • Bush thinning activities.	• Increased vehicular movements associated with the transport of the wood chips to the Power Station.	**Visual impact to third parties**	**L**	**L**
Socio-economic	• Harvesting contracts/business opportunities. • Harvesting contractors (i.e. workers) working on farms near residences. • Other biomass users in the area. • Land productivity improvements.	• Transport of biomass using contractors.	**Job creation and skills development**	**H+**	**-**
			Creating business opportunities	**H+**	**-**
			Impact on existing wood biomass users	**H**	**M**
			Bush-thinning on land productivity i.e. improvement of rangeland productivity	**M-H+**	**H+**
			Impact on Safety, Security and Health in the farming community	**H**	**M**
			Community resilience to population in-migration	**H**	**M**
			Upholding human rights and interests of vulnerable people and labour	**M+**	**M+**

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APPENDIX 1: CURRICULUM VITAE

APPENDIX 2: I&AP DATABASE

APPENDIX 3: NAMPOWER SHEQ POLICY

APPENDIX 4: MET (NOW MEFT) ACCEPTANCE OF THE FINAL SCOPING REPORT

APPENDIX 5: AIR QUALITY, CLIMATE CHANGE AND HEALTH RISK ASSESSMENT

APPENDIX 6: BIODIVERSITY ASSESSMENTS

6.1 Vertebrate and Vegetation Baseline Study, Integration of all Biodiversity Components and Biodiversity Impact Assessment.

6.2 Avifauna Impact Assessment

6.3 Invertebrates Baseline Study

APPENDIX 7: NOISE IMPACT ASSESSMENT

APPENDIX 8: VISUAL IMPACT ASSESSMENT

APPENDIX 9: ARCHAEOLOGY IMPACT ASSESSMENT

APPENDIX 10: SOCIO-ECONOMIC IMPACT

APPENDIX 11: GROUNDWATER AND SURFACE WATER IMPACT ASSESSMENT

APPENDIX 12: SOIL IMPACT ASSESSMENT

APPENDIX 13: TRAFFIC IMPACT ASSESSMENT

APPENDIX 14: EMP FOR THE ACTIVITIES ASSOCIATED WITH THE PROPOSED POWER STATION AND OVERHEAD POWERLINE

APPENDIX 15: EMP FOR THE HARVESTING AND ASSOCIATED ACTIVITIES

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