BIODIVERSITY & WETLAND ASSESSMENT FOR THE FGD PROJECT AT MEDUPI POWER STATION – LEPHALALE, LIMPOPO

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NSS Ref No: 2112
Date: January 2018

All pictures taken on site

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LIST OF ACRONYMS

ACRONYM	DESCRIPTION
ADF	Ash Disposal Facility
APPA	Atmospheric Pollution Prevention Act
CARA	Conservation of Agricultural Resources Act
CBA	Critical Biodiversity Area
CBG4	Central Bushveld Group 4
CI	Conservation Important
CR	Critically Endangered
CIS	Conservation important species
CITES	Convention on International Trade in Endangered Species
CoPs	Conference of the Parties
DAFF	Department of Agriculture, Forestry and Fisheries
DCA	TWINSPAN Detrended Correspondence Analysis
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
ECA	Environmental Conservation Act
EA	Environmental Authorisation
EI	Ecological Importance
ES	Ecological Sensitivity
ESA	Ecological Support Area
EIAs	Environmental Impact Assessments
EIS	Ecological Importance and Sensitivity
EMPRs	Environmental Management Programme Reports
EMPs	Environmental Management Plans
EN	Endangered
EO	Environmental Officer
EWT	Endangered Wildlife Trust
FEPA	Freshwater Ecosystem Priority Area
FGD	Flue Gas Desulphurisation
FRAI	Fish Response Assessment Index
GG	Government Gazette
GPS	Global Positioning System
HGM	Hydro-geomorphic
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectrophotometer
ICP-MS	Inductively Coupled Plasma – Mass Spectrophotometer
JPOI	Johannesburg Plan of Implementation
LC	Least Concern
LEDET	Limpopo Department of Economic Development, Environment and Tourism
LCPlan	Limpopo Conservation Plan
LSB	Limpopo Sweet Bushveld
LO	Likelihood of Occurrence
LT	Least Threatened

ACRONYM	DESCRIPTION
m.a.s.l	Meters above sea level
MBG	Mining & Biodiversity Guidelines
MoP 5	5th Meeting of the Parties
MPS	Medupi Power Station
NT	Near Threatened
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Environmental Management Act
NEPAD	New Partnership for Africa's Development
NWA	National Water Act
NSS	Natural Scientific Services
NSBA	National Spatial Biodiversity Assessment
PES	Present Ecological State
PS	Protected species
PT	Protected
Pr.Nat.Sci.	Professional Natural Scientist
QDS	Quarter Degree Square
SABAP	Southern African Bird Atlas Projects
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System Version 5
SQG	sediment quality guidelines
SEW	Semi-Ephemeral Washes
SMPs	Strategic Management Plans
ToR	Terms of Reference
ToPS	Threatened or Protected Species
UNFCCC	UN Framework Convention on Climate Change
VU	Vulnerable
WDBP	Waterberg District Bioregional Plan
WMA	Water Management Area
WMLA	Waste Management Licence Application
WRG	Water Research Group
WULA	Water Use Licence Application
WQ	Water quality

1. Introduction

In South Africa, the legislation affirms the national commitment to conservation. The National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) has the objective to provide for, amongst others the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998; the protection of species and ecosystems that warrant national protection; and the sustainable use of indigenous biological resources.

> Biodiversity is defined as "…***the variability among living organisms from all sources including…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 Convention of Biological Diversity, 1992). In other words, plants, animals and micro-organisms, their genes, and the ecosystems that living organisms inhabit, are all facets of biodiversity.

Further to this, South Africa has various pieces of legislation governing activities in and around wetlands under International, Regional and National legislation and Guidelines. The National Water Act, 1998, (Act 36 of 1998) (NWA) is the principle legal instrument relating to water resource management in South Africa, with all wetlands protected under the NWA. The National Water Act (Act No. 36 of 1998), (NWA) defines a wetland as: "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils* ."

This report represents an amalgamation of work done by NSS on terrestrial biodiversity and wetlands since 2014 at Medupi Power Station (MPS) as it relates to the Flue Gas Desulphurisation (FGD) Retrofit Project. Medupi is located about 15km west of the town of Lephalale in the Limpopo Province. The project essentially involves the reduction of sulphur dioxide (SO_2) emissions from power station and the consequent disposal of its by-product, gypsum, on the proposed ash disposal facility. Medupi will be the first coal-fired power station in the Eskom fleet to deploy this supercritical abatement technology which will reduce SO_2 emissions by over 90%.

Zitholele Consulting (Pty) Ltd (Zitholele) was appointed in 2014 to undertake the environmental processes including an Environmental Impact Assessment (EIA), Water Use Licence Application (WULA) and Waste Management Licence Application (WMLA) for the MPS Flue Gas Desulphurisation (FGD) Retrofit project. In 2017, the MPS FGD project scope was extended to include the environmental authorisation process for the other FGD associated infrastructures including the railway yard and siding, limestone and gypsum handling facilities, diesel storage facilities, new access roads, a Waste Water Treatment plant, and facilities for temporary storage of salts and sludge (hazardouswaste). Additionally the project is dealing with the Water Use Licence Application (WULA) for the wetlands which were detected by NSS during 2015 within the study area and a 500m buffer around it. Therefore NSS was requested by Zitholele to provide biodiversity and wetland input into this greater EIA process.

It must be noted that the construction of the MPS is almost complete and the ADF construction already commenced prior to 2012 (**Figure 1-1**). The majority of the site is now cleared and any depressions, washes and other wetlands that were within the footprint have now been removed. NSS therefore focused on areas within the railway yard, MPS and ADF that were not transformed as well as within the 500m buffer of the site.

Ongoing construction of the ADF

Ongoing construction of the MPS

Figure 1-1 Construction of MPS and the ADF facilities

2. Terms of Reference

Based on requests made by ESKOM at the FGD scope consolidation workshop held in December 2017, this report represents an amalgamation of NSS work conducted to date for Medupi Power Station (MPS) as it pertains to the FGD project area as a whole. The various projects for which NSS was previously appointed are summarized in **Table 2-1**.

Table 2-1 Work performed by NSS for the Medupi FGD project

WORK REQUESTED	STATUS
Eco assessment FGD railway yard -September 2014:	Submitted – March 2015
Eco & Wetland assessment (2,12 &13) - October 2014	Stopped, fieldwork completed – December 2015
Eco opinion sites 2,12 & 13	Submitted – January 2016
Screening additional ADF sites – April 2016	Cancelled
Wetland assessment Site 13 - October 2016	Submitted – December 2016 - revised 2017
Wetland offset and rehabilitation plan - May 2017	**Ongoing**
Wetland & eco assessment for FGD area – November 2017	**Ongoing**

More specifically the SoW for this report is as follows:

- Combine relevant sections of reports into one integrated biodiversity and wetland report for the FGD study area which includes the Medupi Power Station, the FGD / railway yard area and the area earmarked for the ADF (referred to as Site 13) and a 500m buffer around these areas.
- Over and above integration, address any new impacts which may be associated with the construction and operation of the FGD system within the Medupi Power Station Footprint as well as that of the railway yard, limestone and gypsum handling facilities between the Medupi Power Station and existing ADF.
- The Report includes:
    - An Introduction and Terms of Reference;
    - List of applicable legislation, guidelines, standards and criteria;
    - A broad description of the biophysical environment wherein Medupi is situated;
    - The terrestrial assessment methods and results including:
        - A description of regional vegetation and local floral (including their structure, dominant plant composition and condition);
        - Recorded alien invasive species;
        - The local diversity of mammals, birds, reptiles, frogs, butterflies, odonata (dragonflies and damselflies), scorpions and megalomorph spiders;
        - Recorded Conservation Important (CI) species of flora and fauna.
    - The wetland assessment methods and results including:
        - The delineation of wetlands (including pans) within 500m of the MPS and ADF footprint based on limited field work.
        - The sediment and water quality analysis of surface water bodies – especially the FEPA to the south-west of the ADF area;
        - An assessment of pan invertebrate diversity through laboratory hatching tests.
        - Wetland ecosystem goods and services;
        - The determination of wetland buffers.

- A qualitative assessment (and mapping) of the relative sensitivity or conservation importance of local floral, faunal and wetland biodiversity.
- A detailed Impact Assessment with recommended impact mitigation measures.
- Concluding remarks.
- References.
- Appendices.

3. Project Team

This assessment was conducted and managed by NSS (**Table 3-1**). The NSS team has extensive experience in project management and fieldwork for numerous ecological and biodiversity studies as well as aquatic and wetland assessments. The team has also been involved in the management of Environmental Impact Assessments (EIAs), Environmental Management Programme Reports (EMPRs), Strategic Management Plans (SMPs) and Environmental Management Plans (EMPs) for the Conservation, Mining, Waste, Commercial and Industrial sectors. The following professional registrations and accreditations apply to NSS:

- The senior team members are registered Professional Natural Scientists in the ecological, environmental, aquatic and zoological fields.
- The aquatics team are accredited with Department of Water and Sanitation (DWS) to perform the SASS5 (South African Scoring System version 5) for aquatic macro-invertebrate monitoring.
- The Wetland Specialists is acknowledged by the DWS as a Competent Wetland Delineator.

Table 3-1 Project team with associated areas of specialisation

ASPECT INVESTIGATED	SPECIALIST	QUALIFICATIONS
Ecology, Wetlands & Project Management	Susan Abell	M.Sc. Resource Conservation Biology (WITS). Pr.Nat.Sci. Registered – Ecology & Environmental Science. (400116/05)
Wetlands & Fauna	Tyron Clark	M.Sc. – Zoology in progress (WITS).
Fauna	Dr Caroline Lötter	Ph.D. – Zoology (UP). Pr.Nat.Sci. registered (400182/09) – Zoology.
Sediment Analysis	Dr Wynand Malherbe	Ph. D – Aquatic Science. Water Research Group (Ecology) NW University Pr.Nat.Sci. Registered – Zoology (400200/13)
Review	Kathy Taggart	M.Sc. Resource Conservation Biology (WITS). Pr.Nat.Sci. Registered – Ecology & Environmental Science. (400225/08)
GIS mapping	Tim Blignaut	M.Sc. – Geography (UJ) – in progress.

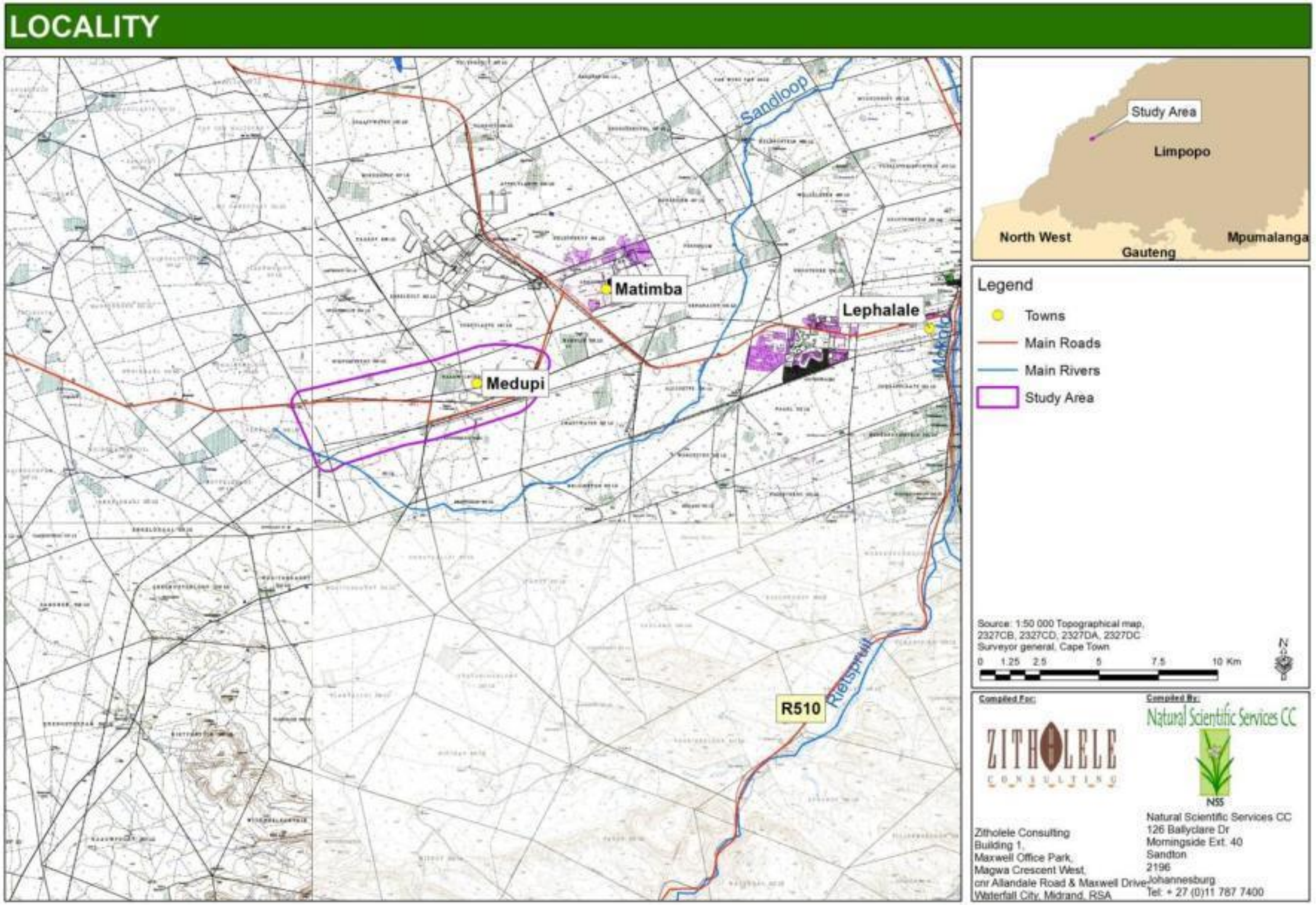
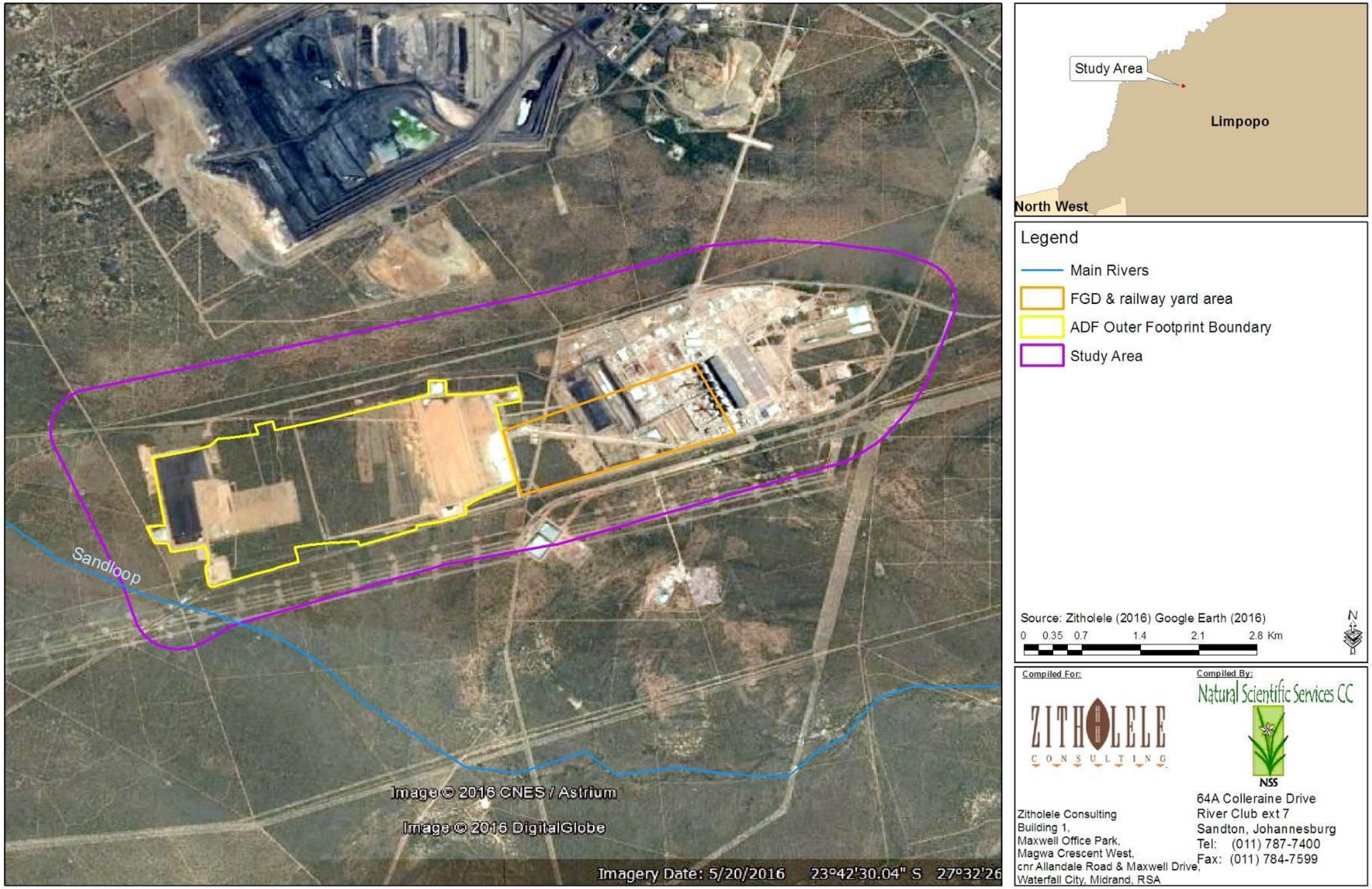


Figure 3-1 Locality map of the study area showing the position of the Sandloop FEPA

ADF FOOTPRINT



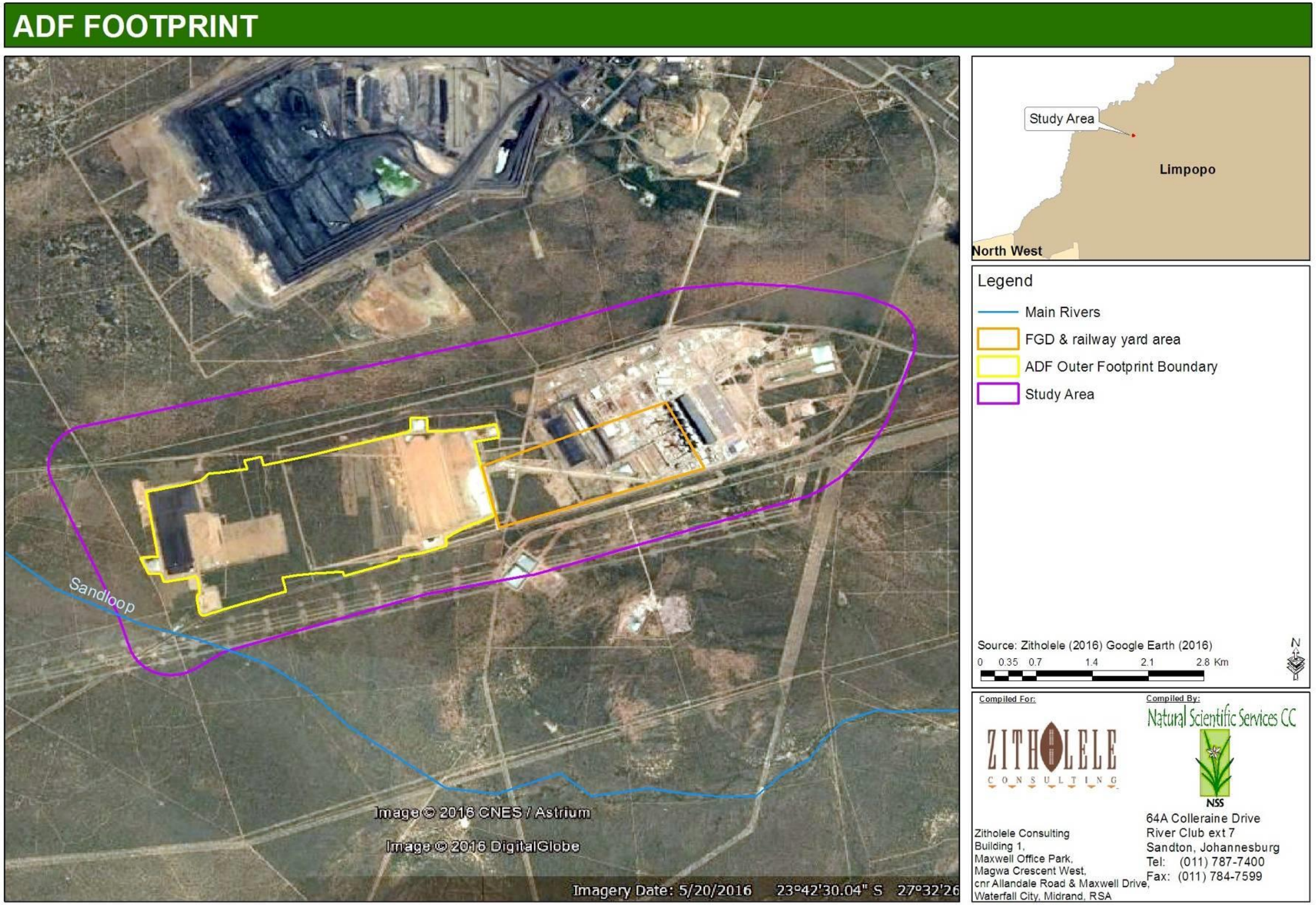


Figure 3-2 Locality map of the study area showing the position of the proposed FGD Footprint area

4. Applicable Legislation

There are several international treaties and considerable national and provincial legislation regarding the sustainable use and conservation of terrestrial and wetland biodiversity including species and ecosystems. As coal fired power stations such as MPS inevitably have the potential to have major negative impacts on biodiversity, all the below-mentioned international, regional, national and provincial legislation, policies and guidelines are applicable to the proposed project. While the list below is extensive, additional legislation, policies and guidelines that have not been mentioned may apply.

4.1. International Agreements

- *World Summit on Sustainable Development*, 2002;
- *Johannesburg Plan of Implementation* (JPoI), Chapter 4, 2002. The JPoI acknowledges that biodiversity is critical for the planet, sustainable development, poverty eradication, human well-being and the cultural integrity people. It also recognizes that biodiversity is currently being lost at unprecedented rates due to human activities, and that this trend can only be reversed if local people benefit directly from the conservation and sustainable use of biological diversity in their countries. South Africa uses the National Biodiversity Strategy and Action Plan (NBSAP) as a means to achieve the JPoI biodiversity targets;
- *UN Framework Convention on Climate Change* (UNFCCC), 1994. UNFCCC is an international agreement to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This agreement, although non-binding, does provide for updates called "protocols," which set mandatory emission limits.
    - *Kyoto Protocol*, 1997. The principal update is the Kyoto Protocol developed during the 3rd Conference of the Parties (CoP 3) in Kyoto, Japan in 1997, and was entered into force in 2005. Approximately 191 states have signed and ratified the Protocol including South Africa. Under the Protocol, 37 countries ("Annex I countries") committed themselves to reduce their greenhouse gas emissions by 5.2% on average for the period 2008-2012. This reduction was relative to their annual emissions in a base year, generally 1990.
    - *Copenhagen Accord*, 2009. This included the 15th Conference of the Parties (CoP 15) to the UNFCCC and the 5th Meeting of the Parties (MoP 5) to the Kyoto Protocol. A framework for climate change mitigation beyond 2012, the Copenhagen Accord, was drafted during the Summit by the United States, China, India, Brazil and South Africa. It was "taken note of," but not "adopted". The Accord recognizes that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2°C.

- *17th Conference of the Parties* (CoP 17). The 2011 UNFCCC in Durban was held to establish a new treaty to limit carbon emissions. This Convention agreed to a legally binding deal comprising all countries, which will be prepared by 2015 and to take effect in 2020. While the president of the conference, Maite Nkoana-Mashabane, declared it a success, scientists and environmental groups warned that the deal was not sufficient to avoid global warming beyond 2°C as more urgent action is needed.
- *Paris Agreement* to reduce climate change, and the Paris Pledge for Action. This latest agreement on climate change calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century. The agreement is due to enter into force in 2020, and Parties that have signed the Agreement, including South Africa, will need to adopt the Agreement within their own legal systems. By joining the Pledge, businesses, cities, civil society groups, investors, regions, trade unions and other signatories promise to ensure that the Agreement's ambition to limit the global temperature rise to less than 2ºC is met. A number of mining companies, including those operating in South Africa have joined this Pledge.

- *Convention on Biological Diversity* (Rio de Janeiro, 1992). The CBD has three main goals: conservation, and sustainable use of biodiversity, and equitable sharing of benefits arising from genetic resources. South Africa signed this treaty in 1998 showing further commitment to the conservation of biodiversity;
- *Agenda 21* and Rio Declaration, 1992;
- The *Bonn Convention* (on conservation of migratory species of wild animals), 1979. South Africa is a party to this Convention, which affords protection to all migratory animals in the project area including various bird, bat and butterfly species;
- *CITES* (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), 1973. CITES is an international agreement between governments, which aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. It accords varying degrees of protection to more than 33,000 species of animals and plants;
- The *World Heritage Convention*, 1972. This aims to preserve the world's natural and scenic areas and historic sites for present and future generations of humanity; The Convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two. Eight World Heritage Sites are currently recognized in South Africa, with the Mapungubwe Cultural Landscape being the closest to the study area.
- The *Ramsar Convention* (on wetlands of international importance especially as waterfowl habitat). This is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance but also to plan for the "wise use", or sustainable use, of all of the wetlands in their territories. In terms of the site, an

ephemeral system is existing the study area to the south west and there are a number of water bodies present just south of the site; and

- *United Nations Convention to Combat Desertification*.

4.2. Regional Agreements

- Action Plan of the Environmental Initiative of NEPAD. This New Partnership for Africa's Development (NEPAD) Action Plan was established during the 2003 African Convention on Conservation of Nature and Natural Resources held in Maputo. As a contracting state, South Africa has undertaken to adopt measures to ensure the conservation, utilization and development of soil, water, flora and faunal resources in accordance with scientific principles and with due regard to the best interests of the people.
- *African Convention on the Conservation of Nature and Natural Resources*, 1969.

4.3. National Legislation, Policies and Guidelines

- *Constitution of the Republic of South Africa* (Act 108 of 1996). According to South Africa's Constitution, South African citizens have the right to have the environment protected for the benefit of present and future generations.
- *Conservation of Agricultural Resources Act* (CARA; Act 43 of 1983). CARA includes the use and protection of land, soil, wetlands and vegetation and the control of weeds and invader plants. In 1984 regulations were passed under CARA, which declared about 50 plant species as "weeds" or "invader plants." On 30 March 2001 the Minister of Agriculture promulgated an amendment to these regulations, which now contain a comprehensive list of declared weed and invader plant species. Further additions to the law have occurred and are discussed under NEMBA below.
- *Water Services Act* (WSA; Act 108 of 1997). This Act provides for, among other things, the effective water resource management and conservation.
- *White Paper on Environmental Management Policy* for South Africa (1998). Through this Policy, Government undertakes to give effect to the many rights in the Constitution that relate to the environment.
- *National Veld and Forest Fire Act* (NVFFA; Act 101 of 1998). The purpose of this Act is to prevent and combat veld fires in the country. The NVFFA was amended by the National Forest and Fire Laws Amendment Act (NFFLAA; Act 12 of 2001).
- *National Water Act* (NWA; Act 36 of 1998). The NWA recognises that water is a scarce and unevenly distributed natural resource that should be equitably utilised in a sustainable manner. The Act ensures that water resources are protected, used, developed, conserved and controlled in ways that take into account a range of needs and obligations, including the need to "Protect aquatic and associated ecosystems and their biological diversity." The NWA specifies that water use must be authorised. It indicates the means for authorisation and includes minimum requirements for evaluation and decision-making by relevant authorities. To protect aquatic

ecosystems and biodiversity, the NWA has a number of requirements, which are controlled by the DWS, including:

- Section 19(2) which states that: responsible persons of pollution of any water resources must take all measures to prevent and remedy effects of pollution.
- Section 21 which states that a license for water use is required if activities such as taking water from a water resource; storing water; impeding or diverting the flow of water in a watercourse or engaging in a stream flow reduction activity amongst others. As per the NWA, a General Authorisation from Section 21 (c) and (i) water use is not an entitlement for the use of water in terms of section 21 *(c)* and *(i)* within a 500 metre radius from the boundary of any wetland and is based on the outcome of a Risk Assessment.
- Section 37(2) states that activities (described in Section 37(1)) require authorization before being undertaken and include: irrigation on any land with waste or water containing waste generated through any industrial activity of by a waterworks; intentional recharging of an aquifer with any waste or water containing waste; and an activity which has been declared by the minister as a "controlled activity."

- *National Forests Act* (NFA; Act 84 of 1998) and Protected Tree Species. An objective of the NFA is to provide special measures for the protection of certain forests and tree species, and to promote the sustainable use of forests for environmental, economic, educational, recreational, cultural, health and spiritual purposes. In terms of Section 15(1) of the NFA forest trees or Protected Tree Species may not be cut, disturbed, damaged, destroyed and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold – except under license granted by the Department of Agriculture, Forestry and Fisheries (DAFF) or a delegated authority. Government Notice 35648 of 2012 provides the latest List of Protected Tree Species within the borders of South Africa under the NFA.
- *National Environmental Management Act* (NEMA; Act 107 of 1998). NEMA is an umbrella Act covering broad principles of environmental management. NEMA can be regarded as the most important piece of general environmental legislation covering three main areas namely: Land, planning and development; Natural and cultural resources use and conservation; Pollution control and waste management. According to NEMA sustainable development requires the consideration of all relevant factors including:
    - That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;
    - That the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource; and
    - That the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised.

According to Section 2(r) in NEMA, sensitive, vulnerable, highly dynamic or stressed ecosystems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. Grasslands and wetlands in Mpumalanga are a strong case in point.

- *National Heritage Resources Act* (NHRA; Act 25 of 1999). According to the NHRA heritage sites, sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, dolomitic land and ridges, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.
- *National Mineral and Petroleum Resources Development Act* (NMPRD; Act 28 of 2002). The NMPRDA is concerned with equitable access to and sustainable development of the nation's mineral and petroleum resources.
- *National Environmental Management Protected Areas Act* (NEMPAA: Act. 57 of 2003). The NEM:PAA is focussed on the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes, and addresses, inter alia:
    - The protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes;
    - The establishment of a national register of all national, provincial and local protected areas;
    - The management of those areas in accordance with national standards;
    - Inter-governmental co-operation and public consultation in matters concerning protected areas.
- *National Environmental Management: Biodiversity Act* (NEMBA; Act 10 of 2004). A main objective of NEMBA is to provide for the management and conservation of South Africa's biodiversity within the framework of NEMA and to ensure the sustainable use of indigenous biological resources. In addition to regulations on Threatened, Protected, Alien and Invasive Species in South Africa, the NBSAP was formulated where under the NSBA was used to identify Terrestrial and Aquatic Priority Areas and Threatened Ecosystems for biodiversity conservation.
    - *Threatened, Protected, Alien and Invasive Species Regulations.* Chapter 4, Part 2 of NEMBA provides for listing of species that are threatened or in need of protection to ensure their survival in the wild while regulating the activities, including trade, which may involve such listed threatened or protected species and activities which may have a potential impact on their long-term survival. According to Section 56(1) of NEMBA, in February 2007 the Minister of Environmental Affairs and Tourism published a list of Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Protected Species (PS).
    - *Alien and Invasive Species Regulations, 2014* (GG 37885, 1 August 2014). These regulations listed all declared weeds and invasive plant species in South Africa.

- *National Biodiversity Strategy and Action Plan* (NBSAP). The development of the NBSAP is part of South Africa's obligations as a signatory to the CBD, and was compiled by the Department of Environmental Affairs and Tourism (DEAT 2005). Through the NBSAP it is recognized that biodiversity cannot be conserved through protected area networks only. All stakeholders, from private landowners and communities to business and industry must get involved in biodiversity management. The NBSAP highlights, in particular, that South Africa's rivers are poorly protected and that the present status of many of these freshwater ecosystems is disturbing. To ensure further protection and sustainability of South Africa's wetlands, the DWS (DWAF at the time) initiated the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) and River Health Programme (RHP).
- *National Spatial Biodiversity Assessment* (NSBA). The NSBA, which is part of the NBSAP, was led by the SANBI (Driver *et al.* 2004). Its main focus was on mainstreaming biodiversity priorities and making links between biodiversity and socio–economic development in South Africa. The NSBA represents South Africa's first national assessment of spatial priorities for conservation action, integrating terrestrial, river, estuarine and marine ecosystems, using available spatial data, biodiversity planning software and a series of expert and stakeholder workshops.
- *National Aquatic Ecosystem Health Monitoring Program* (NAEHMP) & *River Health Program* (RHP). The NAEHMP is a national programme managed by DWS's Resource Quality Services with support from the Water Research Commission (WRC), the Council for Scientific and Industrial Research (CSIR) and various regional and provincial authorities. The overall purpose of the NAEHMP is to provide ecological information for South African rivers and the broader aquatic ecosystems required to support the rational management of these systems. The best-known component of the NAEHMP is the RHP.
- *National Freshwater Ecosystem Priority Areas* (NFEPA). The NFEPA project is a multi-partner project between CSIR, South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The NFEPA project aims to:
  - Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems (through systematic biodiversity planning); and
  - Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

  FEPAs should be regarded as ecologically important and as generally sensitive to changes in water quality and quantity, owing to their role in protecting freshwater ecosystems and supporting sustainable use of water resources (Driver *et al*. 2011).

- *National Environmental Management: Air Quality Act* (NEMAQA; Act 39 of 2004). The Atmospheric Pollution Prevention Act (APPA; Act 45 of 1965), which largely governed point-source emission control and therefore did not take into consideration the cumulative impacts of air pollution, has been repealed by the NEMAQA. Amongst other objectives, this Act provides for the "prevention of air pollution and ecological degradation."
- *National Environmental Management: Waste Act* (Act 59 of 2008). This act serves inter alia to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development.
- *Mining & Biodiversity Guideline* (MBG). The mining industry plays a vital role in South Africa's growth and development and indirectly is connected to MPS. The MBG (DEA *et al*. 2013) interprets the best available biodiversity knowledge and science in terms of the implications and risks for mining in a practical and user-friendly guideline for integrating relevant biodiversity information into decision making. The development of this guideline was initiated by the Chamber of Mines and the South African Mining and Biodiversity Forum (SAMBF), in partnership with the DEA, the Department of Mineral Resources (DMR), and with technical input and co-ordination by the SANBI Grasslands Programme.
- *National Water Resource Strategy* (NWRS) 2. The NWRS2 (DWA 2013) builds on the first NWRS published in 2004. The purpose of the NWRS2 is to ensure that national water resources are protected, used, developed, conserved, managed and controlled in an efficient and sustainable manner towards achieving South Africa's development priorities in an equitable manner over the next five to 10 years.
- *Draft National Biodiversity Offset Policy.* The recently published draft National Biodiversity Offset Policy (GG 40733, GN 276, 31 March 2017) aims to ensure that significant residual impacts of developments are remedied as required by NEMA, and in line with the Constitutional right to an environment that is not harmful.

4.4. Limpopo Legislation, Policies and Guidelines

In addition to national legislation, some of South Africa's nine provinces have their own provincial biodiversity legislation, as nature conservation is a concurrent function of national and provincial government in terms of the Constitution (Act 108 of 1996).

- *Limpopo Environmental Management Act, 2003* (Act No. 7 of 2003). This Act repealed the former Lebowa, Gazankulu, Venda and Northern Province Acts and the Nature Conservation Ordinance (Ordinance 12 of 1983). It provides the lists for Protected and Specially Protected species under Schedule 2, 3 and 12 as well as the stipulation for permit applications to remove these species. In addition it gives protection measures for the terrestrial and aquatic biota and systems. Schedule 9 lists aquatic plant species that are prohibited in the province.
- *Limpopo Conservation Plan version 2,* 2013. This conservation plan is consistent with NEMA principles and the NEMBA. It is designed to support integrated

development planning and sustainable development by identifying an efficient set of CBAs that are required to meet national and provincial biodiversity objectives, in a configuration that is least conflicting with other land uses and activities. Where alternatives are available, the CBAs are designed to avoid conflict with existing IDPs, EMFs and SDFs in the region by favouring the selection of sites that are least conflicting with other land-uses.

- *Municipal Biodiversity Summaries Project,* 2010. This was the most relevant biodiversity conservation plan for Lephalale Municipality, prior to the C-Plan 2 publication.
- *Limpopo State of Environment Report (SoER), 2004*. This report provides a high-level overview of the State of the Environment in Limpopo.
- *Waterberg Environmental Management Plan* (EMP), 2006. The Waterberg EMP provides for the protection of the environment and describes how activities that have, or could have, an adverse impact on the environment, should be mitigated, controlled, and monitored. The Waterberg EMP is a coarse-scale planning tool that outlines strategic objectives. New development in the Waterberg District Municipality should be aligned with these objectives.
- *Waterberg Biosphere Reserve*. The Waterberg Biosphere Reserve, proclaimed in 2001 and recognized by UNESCO, covers a 654, 033ha area in the Waterberg wherein more than 80, 000 people live (DEA 2016). It is managed by the Waterberg Biosphere Reserve Committee and the Limpopo Department of Economic Development, Environment and Tourism (LEDET), which coordinates the provincial Man and the Biosphere Reserves programme. Like most other biosphere reserves, the Waterberg Biosphere Reserve comprises:
    - A (104, 179ha) Core Area for conserving biological diversity, monitoring minimally disturbed ecosystems, and undertaking non-destructive research and other low-impact uses.
    - A (185, 517ha) Buffer Area for cooperative activities compatible with sound ecological practices, including environmental education, recreation, ecotourism and applied basic research.
    - A (364, 336ha) Transitional Area, which contains a variety of agricultural activities, settlements and other uses in which local communities, management agencies, scientists, non-governmental organizations, cultural groups, economic interest and other stakeholders work together to manage and sustainably develop the area's resources.
- *Waterberg Spatial Development Framework, 2009*. The Waterberg Spatial Development Framework delineated areas of ecological sensitivity within the district, based on the occurrence of threatened species; centres of endemism; existing protected areas; occurrence of rivers and streams; vegetation types of conservation importance; and areas with high aesthetic value (Environomics, 2010).

- *Lephalale Spatial Development Framework, 2008*. The Lephalale Municipality compiled a Spatial Development Framework (SDF) with the purpose of guiding the form and location of future physical development within a Municipal area in order to address the imbalances of the past. This SDF identifies environmentally sensitive areas (e.g. mountain ridges, riverine environments) and makes recommendations regarding proposed developments in these areas.
- *Lephalale Integrated Development Plan (2014-2016)*. The role of an IDP is to facilitate local governments' planning and municipal management. Lephalale Municipality has an environmental function to execute and ensure that the fundamental environmental rights of the community as enshrined in the constitution are realized. The Municipality has sensitive and conservation worthy areas within its jurisdiction, such as the wetlands, river systems, cultural sites, rare and endangered species and part of the Waterberg biosphere. There are also many areas that require remedial attention i.e. the eradication of alien vegetation, soil erosion control and aspects that require special management, such as pollution control and land use management. The Municipality has the capacity to perform duties that enhance sound environmental management practices which include EIA related. Within the 2014/2015 Revenue and Expenditure Framework, no revenue/expenditure has been listed for Environmental and Biodiversity Sectors. However, a forecast of funds for environmental campaigns including educating the communities has been set up going forward (2016-2019).
- *Waterberg Bio-regional Plan* - The Waterberg bioregional plan considers the *Limpopo Conservation Plan version 2,* 2013 and *Waterberg EMF* together to develop an Integrated Development Framework.
- *Waterberg EMF, 2010* - The purpose of the Waterberg EMF is to develop a framework that will integrate policies and frameworks, and align different government mandates in a way that will streamline decision-making to improve cooperative governance and guide future development in an environmentally responsible manner.

5. Study Site Description

5.1. Locality and Land Use

The FGD study area includes the site for the ADF, the MPS precinct and a 500m buffer on this area (**Figure 3-1**). This area is 2745 ha in extent (1629 ha excluding buffer). The site is approximately 1.5km from Grootegeluk Mine, 12km from Lephalale and 4.5km from Marapong ('as the crow flies'). The site falls within the 1:50 000 topographical map Quarter Degree Square (QDS) 2327DA.

Within this greater study area NSS was commissioned to focus on two specific areas:

- The site for the ADF.
- The site for the FGD and associated infrastructure including the railway siding, limestone offtake and storage facilities.

Details on the operation design and conceptual layout of the ADF and FGD infrastructure will be detailed in the EIA and WULA application conducted by Zitholele and in the interim the reader is referred to the technical documents and design philosophies produced by Jones and Wagener and Knight & Piesold Consulting. The basic FGD process is outlined in **Figure 5-1**.

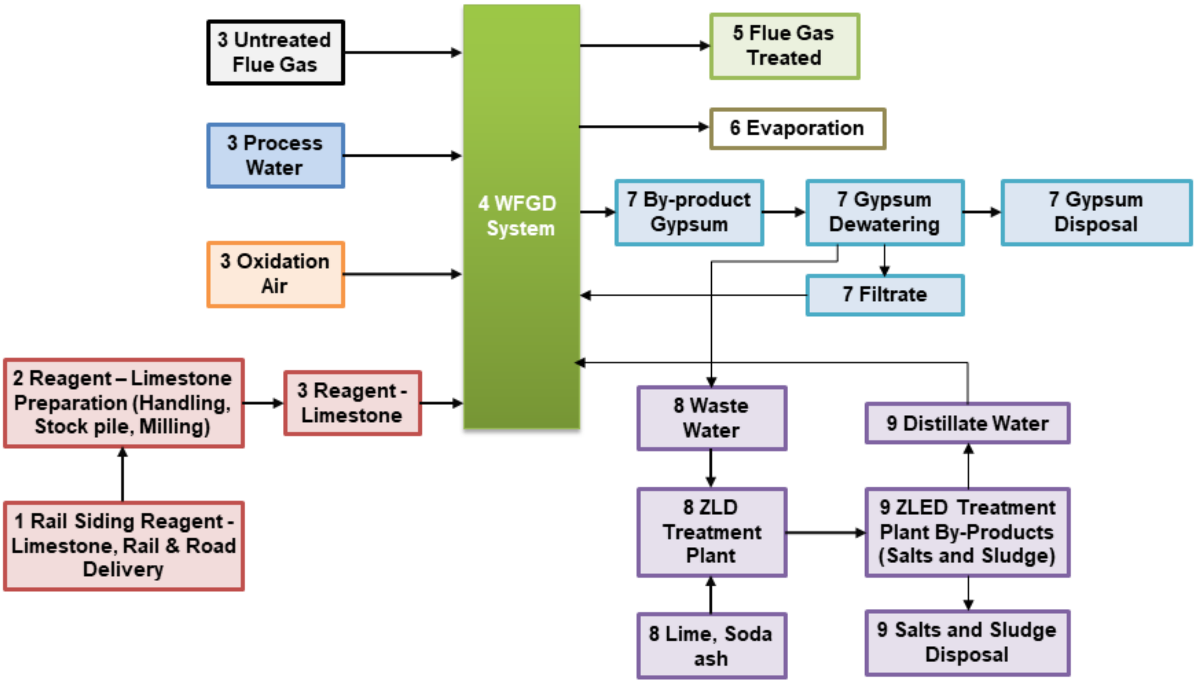


Figure 5-1 Basic process Flow Diagram for the FGD process at Medupi Power Station

Current forms of land use on and surrounding the site are presented in **Figure 5-2**. To the south and west of the study area are game and cattle farms consisting mostly of natural woodland vegetation. To the north of the FGD study area is the Manketti Reserve (the wildlife area of Grootegeluk Mine). To the east of the study area is the Matimba Power Station, game and cattle farms and the towns of Marapong and Lephalale.

5.2. Climate

The study region falls within a summer rainfall region and little to no precipitation is recorded in the months May, August and September whilst the maximum rainfall occurs in November and December. The average annual rainfall is recorded as 410.4mm per year (data from 1993-2009, Station [0674341 8]). The maximum summer temperature is experienced from November to February with an average high of 25°C and maximum temperatures reaching 37°C. The lowest temperatures are experienced between May and August. Monthly rainfall and temperature data measure at Lephalale since September 2014 are shown in **Figure 5-3**.

Game farms

Cattle farms

Mining and industrial related activities

Figure 5-2 Current Land Use for the site and surrounds

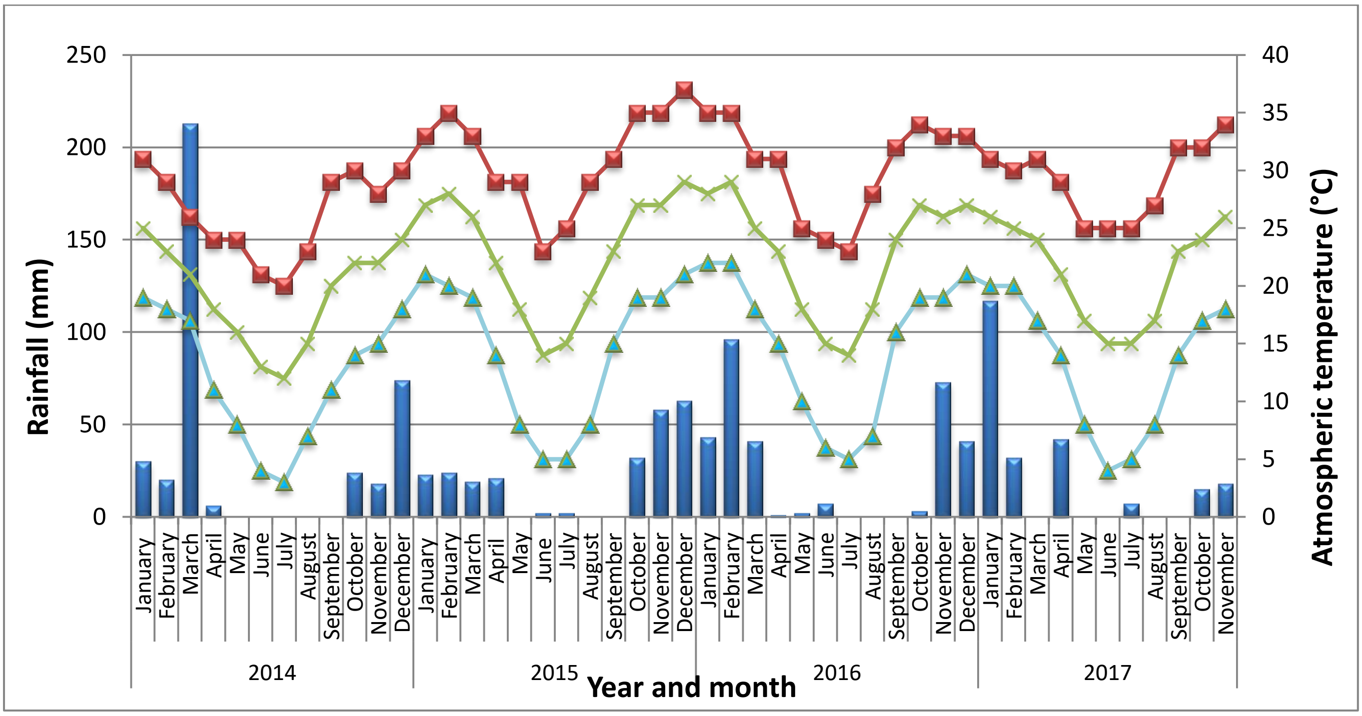


Figure 5-3 Monthly rainfall and temperature data measured at Lephalale

The rainfall data indicate that the study region had received a slightly below-average amount of (329mm) rainfall during the 12-month period preceding the site visit in November 2016. However, the 2016/2017 summer season was not as hot, and more promising in terms of rainfall, than the preceding 2015/2016 and 2014/2015 summer seasons. NSS conducted a number of site visits throughout the seasons and was able to obtain a reasonable understanding of the ephemeral systems within the study area and beyond. This was particularly the case for the December 2015 site visit, where the area received significant rainfall in the weeks preceding the visit. Not as much rain fell prior to the November 2016 visit, which allowed a broader understanding of the dynamics and fluctuation in these systems.

5.3. Geology and Soils

The study area is underlain with a sequence of yellow to purple coloured sandstones and conglomerate rock of the Waterberg Group. The majority of the Waterberg occurs within the Limpopo Province with exposures extending into Botswana. It lies unconformably over the Transvaal Group and is comprised of three subgroups. With regard to economic geology, the Waterberg was mined for lead in the early 20th century and currently is mined for tin in the Rooiberg region. Geohydrological studies indicate that the area is located over aquifers that contain limited amounts of groundwater. Groundwater flowing to the south and east is reported to be contaminated, although to a limited extent, by the ash deposited at the existing Matimba Power Station (Envirolution Consulting, 2009).

Land types represent areas that are uniform with respect to climate, terrain form, geology and soil. According to the Agricultural Geo-referenced Information System (AGIS, 2014), the site is situated in land type Ah86, Bd46 and Ae252 (**Figure 5-5**). This and the surrounding land types are associated with shale, sandstone, mudstone and coal from the Karoo sequence as well as sandstone and conglomerate rock from the Kransberg Subgroup. The study area is situated in a region where erosion rates are considered as moderate to high relative to other parts of the country and soils are generally sandy and rarely more than 3m thick. Clay soils are uncommon in the area.

Across a landscape, usually five terrain units can be identified. Wetlands occur most frequently in valley bottoms (unit 5), but can also occur on crests, mid slopes and foot slopes (units 1, 3 and 4). The catenas within land types Ah86 and Bd46 incorporate all of the four terrain units 1, 3, 4 and 5, whilst land type Ae252 mainly features terrain units 4 and 5 as shown in **Figure 5-4**. Presented in **Table 5-1** is an overview of the soil forms and their extent of coverage, which can be expected within different terrain units in land type Ae252, Ah86 and Bd46.

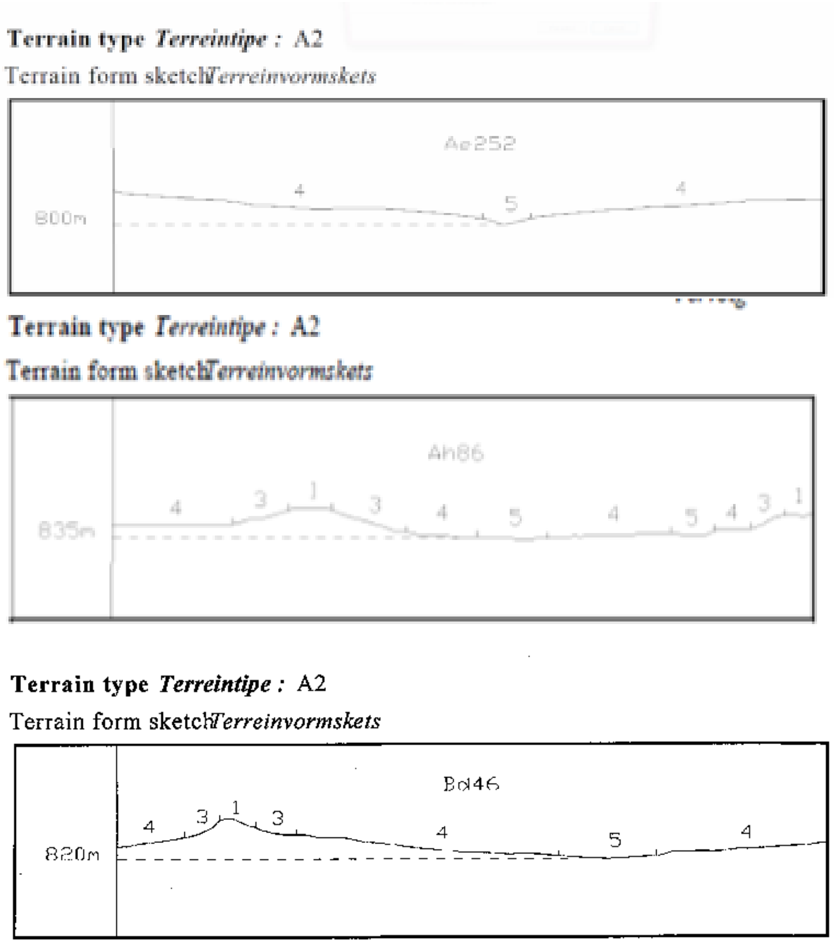


Figure 5-4 Terrain units occurring within land type Ae252, Ah86 and Bd46 (AGIS, 2014)

According to ESS (2015), the most dominant soil units for the study area (**Figure 7-15**) include:

- Shallow (<400mm) sandy to silty loams (salm/silm);
- Moderate to Shallow (400-600mm) sandy loam (salm); and
- Wet based soils with a variety of depths and clay composition.

Specifically important for the wetland assessment are the wet-based soils of varying depths and clay content. According to ESS (2015), the semi-arid climate and negative water balance combined with the horizontal attitude of the sedimentary host lithologies that characterise the Karoo sediments in the area have aided in the development of evaporates within the vadose zone. These include calcrete and in some areas ferricrete or laterite formations. The presence of the ferricrete or hard pan calcretes and plinthic horizons is considered of importance in the soil moisture regime and in many cases the reason for wet features within the soil profile. These soils classify as highly sensitive where they occur in the top 500mm of the profile.

Table 5-1 Soil forms, their wetland potential, coverage, and erodibility classes within the terrain units of land type Ae253, Ah86 and Bd46

SOIL FORM	% COVER PER TERRAIN UNIT			
	1	3	4	5
Ae253				
SLOPE (%)			**0-1%**	**1-2%**
Shigalo Hu46			79	
Mispah Ms10, Muden Ms20			11	10
Portsmouth Hu35			8	
Levubu Oa34, Jozini Oa36,				
Limpopo Oa46				70
Shorrocks Hu36			2	20
Ah86				
SLOPE (%)	**1-2%**	**0-2%**	**0-1%**	**1-3%**
Bontberg Hu25, Portsmouth Hu35	60	55	43	
Gutu Cv25, Denhere Cv35	40	45	38	
Shorrocks Hu36			4	25
Tweefontein Cv20, Ofazi Cv23, Annandale Cv33, Maputa Fw10			5	
Chester Hu22, Moriah Hu32			5	
Vaalsand Lo31			2	20
Windmeul Av35, Newcastle Av25, Soetmelk Av36, Uitkot Gc35			2	5
Lindley Va41, Limpopo Oa46, Mutale Oa47, Killarney Ka20				30
Blinkklip Cv36			1	5
Pans				15
Bd46				
SLOPE (%)	**1-3%**	**2-8%**	**0-1%**	**1-3%**
Denhere Cv35, Sandveld Fw12, Constantia Ct12	20	15	27	
Windmeule Av35, Soetmelk Av36, Leslie Gc36			28	
Paddock We31, Davel We32			14	4
Venda Oa35, Jozini Oa36, Limpopo Oa46, Valsrivier Va40			10	60
Portsmouth Hu35, Shorrocks Hu36	30	25	10	
Valssand Lo31			11	6
Mispah Ms10	50	60		
Slangkop Kd15				15
Stream beds/Stroombeddings				15

5.4. Hydrology

The Study Area falls within the Limpopo Water Management Area (WMA) 1 and is situated in the Mokolo River Catchment area (8387 km^2), where the Mokolo River (also known as the Mogol or Mogolo River) system varies from good to fair health (RHP, 2006). The Mokolo River rises in the western part of the Waterberg (between 1200 and 1600 metres above mean sea level). It originates in a flattish, open area with numerous koppies and flows through a steep gorge emerging above the town of Vaalwater. Here the river flows through a relatively flat area until it enters the Mokolo Dam. From there, it flows through another gorge before entering the Limpopo Plain, near the junction with the Rietspruit. From this point, the Mokolo River flows through flat sandy areas until it reaches the Limpopo River. The main tributaries joining the Mokolo River downstream of the Mokolo Dam are the Rietspruit, Poer se Loop, and Tamboti River (DWA, 2012a; 2012b, RHP, 2006). The Mokolo River is a major tributary of the Limpopo River and commands a total catchment area of over 8 387 km^2 (Savannah Environmental, 2013) with a total natural mean annual runoff (MAR) of almost 300 Mm^3/a. The towns of Lephalale and Vaalwater are situated in the Mokolo Catchment. Agriculture (irrigation) is the major water user in the catchment (RHP, 2006).

According to the RHP (2006), the river channel of the Mokolo River is dominated by sandy runs and pools, but is heavily infested with reed beds (*Phragmites mauritianus*). The lower part of the Mokolo river is afforded some protection by game farms and other private farms while the wide floodplain and reed beds also limit access. The river flow highly regulated from the Mokolo Dam with sporadic flows being released for the farming community. There are five major road bridges in this area. A number of farm dams are located in the Mokolo River close to the Limpopo confluence and sand mining is widespread. The lower Mokolo River is dominated by hardy, pool dwelling species of fish. It is possible that some species may have been lost due to fragmentation of the river from the Limpopo River. No fish species requiring permanent flow were recorded, but several species that require flowing water for breeding purposes still remain, such as the Large Scale Yellowfish (*Labeobarbus marequensis*) and other *Labeo* species. However, no alien fish species were recorded. The poor habitat diversity caused the invertebrate assemblage to be dominated by hardy families associated with marginal vegetation and sand. The moderately scoring SASS assessments are likely to be as a result of the irregular flow regime. The main vegetation impact is considered to be reed encroachment and there are clear indications that the regulated flow regime is contributing to this problem. Alien vegetation was very sparse and only a few Syringa (*Melia azedarach)* was recorded. Downstream from Lephalale, disturbance to the riparian zone was limited to bridges, sand mining, and agricultural practices (mostly water abstraction pumps and the cutting of vegetation to the river's edge) (RHP, 2006).

The Sandloop is a tributary of the Mokolo River. A summary of the Present Ecological State (PES), Ecological Importance (EI), Ecological Sensitivity (ES) and current impacts on the Sandloop is presented in **Table 5-2** (DWS, 2014). The Desktop PES of the Sandloop is moderately modified (C category) where the loss and change of natural habitats and biota have occurred but the basic ecosystem functions are still predominately unchanged. According to the DWS (2014), this river is seriously influenced by cattle grazing and land-use. The instream and riparian habitats are moderately influenced by agricultural fields, low water crossings, erosion, overgrazing and trampling. The WQ is also moderately impacted on by run-off from mining. These habitats are also affected by bed and channel disturbances, small farm dams, inundation, road crossings, urbanisation and vegetation removal but only to a lesser degree. The moderate EI of the Sandloop is due to the one wetland and two riparian habitat types, 12 different types of vegetation cover and three endemic species in this sub-quaternary catchment with a taxon richness of at least 25 species (wetland, riparian and aquatic vegetation). The size of stream, morphology and geomorphic habitat units determine the ES. The Sandloop has a low sensitivity to modified flow conditions and water level changes because this is an ephemeral system and has a natural lack of surface water (DWS, 2014). The Sandloop is a Lower Foothill and a Least Threatened (LT) system but poorly protected (Nel & Driver, 2012; Driver *et al*. 2011).

Table 5-2 Summary of the Sandloop and Mokolo River's Ecostatus and impacts (DWS, 2014)

Quaternary Catchment	Water Resource	Present Ecological State (PES)	Ecological Importance (EI)	Ecological Sensitivity (ES)	Current Impacts
A42J	Sandloop	**C Moderately Modified**	**Moderate**	**Low**	LARGELY: Cattle grazing (land-use) MODERATE: Agricultural fields, low water crossings, erosion, overgrazing and trampling, run-off from mining SMALL: Bed and channel disturbance, small (farm) dams, inundation, roads, urbanisation and vegetation removal.
A42	Mokolo River (after confluence with Sandloop)	**D Largely Modified**	**High**	**High**	SERIOUS: Water abstraction LARGE: Algal growth, inundation and irrigation MODERATE: Agricultural fields, bed and channel disturbance, small (farm) dams, Runoff and effluent from irrigation, grazing (land-use) and vegetation removal, SMALL: Alien vegetation, overgrazing/trampling and sedimentation.

5.5. Regional Vegetation

Mucina and Rutherford (2006) provide an extensive account of the vegetation of South Africa (in addition to Lesotho and Swaziland) via the employment of appropriate tools for vegetation mapping and description. The Study Area falls within the ***Limpopo Sweet Bushveld (code SVcb 19)*** vegetation type (**Figure 5-5**) as described by Mucina and Rutherford (2006). This area was formerly classified as Arid Sweet Bushveld by Acocks (1953), which was the original vegetation map of South Africa, and forms part of the Savanna Biome in South Africa. The Savanna biome covers the northern and eastern parts of South Africa where a continuously shifting balance occurs between the woody and herbaceous vegetation. The typical vegetation consists of short open woodland. In disturbed areas thickets of *Acacia erubescens*, *Acacia mellifera* and *Dichrostachys cinerea* are almost impenetrable. Important plant species for the Limpopo Sweet Bushveld are presented in **Table 5-3**.

The conservation status of the Limpopo Sweet Bushveld is classified as Least Threatened. In 2006, about 5% of the vegetation type had been transformed, mainly by cultivation and the area is suitable for game and cattle farming due to the high grazing capacity of sweet veld. Subsequent to 2006, the area has been facing increasing pressure from numerous coal mining projects within the vicinity with a much greater percentage of land transformed.

Table 5-3 Important plant species in the Limpopo Sweet Bushveld

SPECIES GROUP	IMPORTANT TAXA
Tall trees	***Acacia robusta*** (d), *Acacia burkei*
Small trees	***Acacia erubescens*** (d), *A. fleckii* (d), ***A. nilotica*** (d), *A. senegal* var *rostrata* (d), *Albizia anthelmintica (d),* ***Boscia albitrunca*** (d), ***Combretum apiculatum*** (d), ***Terminalia sericea***
Tall shrubs	*Catophractes alexandri* (d), ***Dichrostachys cinerea*** (d), *Phaeoptilum spinosum* (d), *Rhigozum obovatum* (d), *Cadaba aphylla, Combretum hereroense, Commiphora pyracanthoides,* ***Ehretia rigida* subsp. *rigida***, ***Euclea undulata***, ***Grewia flava***, *Gymnosporia senegalensis*
Low shrubs	*Acacia tenuispina* (d), *Commiphora africana, Felicia muricata, Gossypium herbaceum* subsp. *africanum, Leucospaera bainesii.*
Graminoids	***Digitaria eriantha* subsp. *eriantha*** (d), *Enneapogon cenchroides* (d), *Eragrostis lehmanniana* (d), *Panicum coloratum* (d), ***Schmidtia pappophoroides*** (d), ***Aristida congesta,*** *Cymbopogon nardus, Eragrostis pallens, E. rigidior, E. trichophora, Ischaemum afrum,* ***Panicum maximum***, *Setaria verticillata, Stipagrostis uniplumis,* ***Urochloa mosambicensis***.
Herbs	*Acanthosicyos naudinianus,* ***Commelina benghalensis***, *Harpagophytum procumbens* subsp. *transvaalense, Hemizygia elliotii, Hermbstaedtia odorata, Indigofera daleoides.*
Succulent herbs	*Kleinia fulgens, Plectranthus neochilus*

Source: Mucina & Rutherford (2006)

Key: (d) = dominant species; Species in **Bold** indicate those identified in the study area

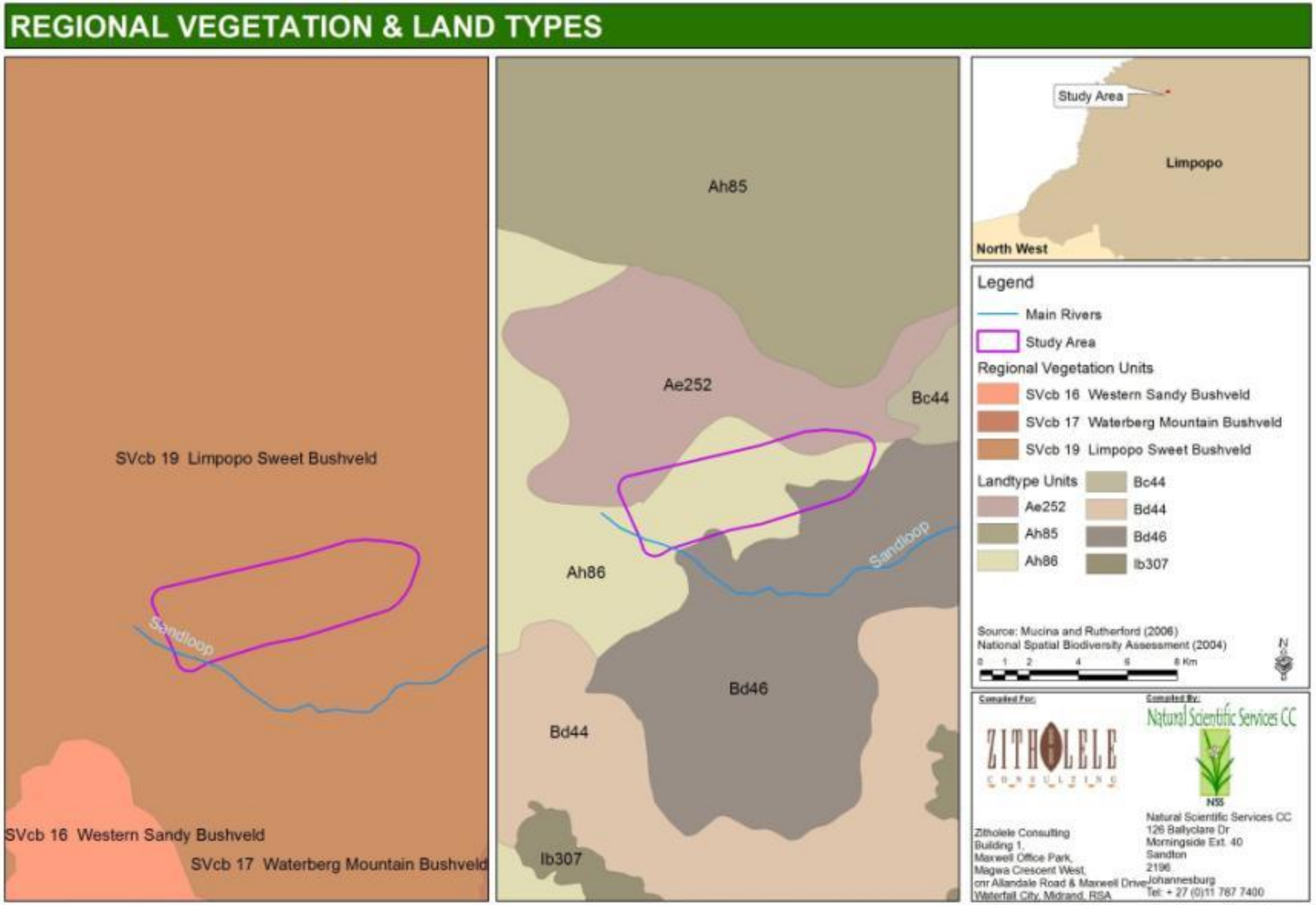


Figure 5-5 **Regional Vegetation and Land Types**

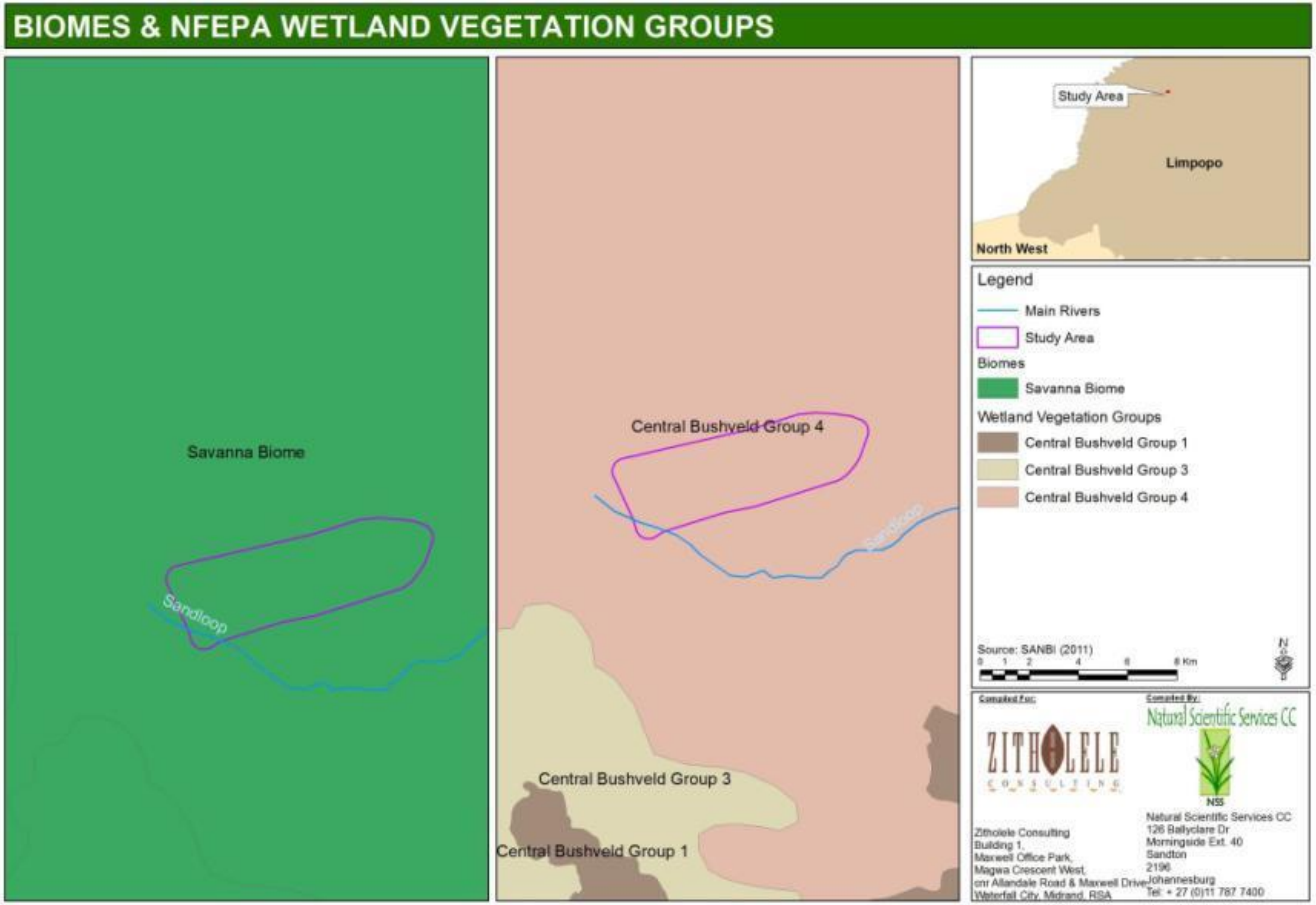


Figure 5-6 Biomes and Wetland Vegetation in the Study Area

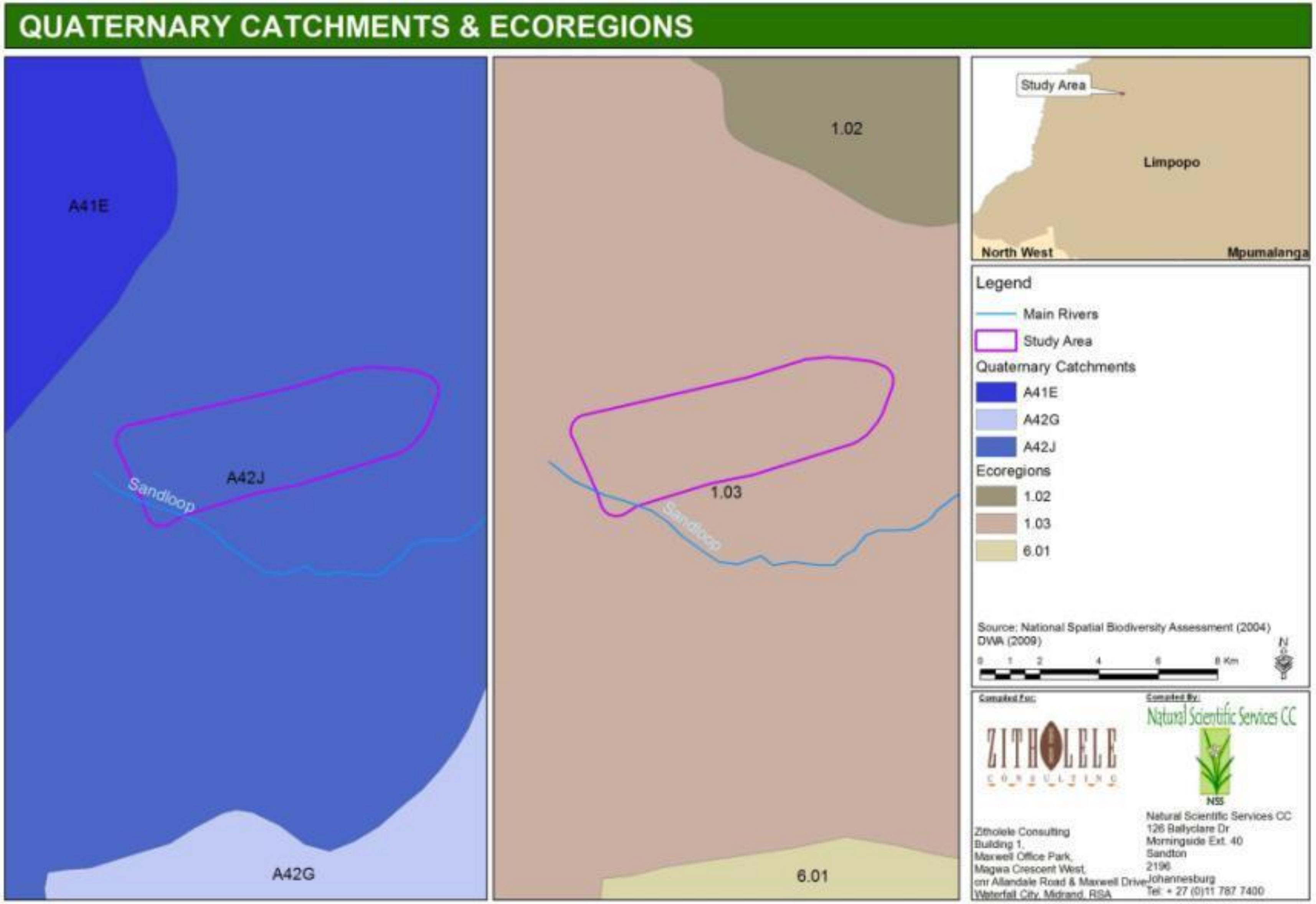


Figure 5-7 **Quaternary Catchments and Ecoregion in the Study Area**

6. Methodology

6.1. Vegetation & Floral Communities

6.1.1 *Desktop Research*

A desktop investigation of regional vegetation, including Conservation Important (CI) and alien, invasive floral species, was performed by consulting the following information sources:

- Google Earth (recent and historical imagery) and Bing satellite imagery. Historical imagery was incorporated into the assessment due to the continuous earth moving activities and developments occurring within the Medupi ADF, coal stockpile area and FGD portion of the Power Station.
- Mucina & Rutherford's (2006) vegetation map of southern Africa.
- The South African National Biodiversity Institute's (SANBI's) online PRECIS (PREtoria Computerised Information System), which provides taxonomic information for plant species occurring in southern Africa (in the format of Germishuizen & Meyer, 2003). For this study, plant species data were obtained for the quarter degree square (QDS) 2327DA.
- CI plant species records in the study region, supplied by Limpopo Conservation.
- The current Limpopo C-Plan (Version 2, 2013).
- The list of declared weeds and invader species as promulgated under the amended regulations (Regulation 15) of the Conservation of Agricultural Resources Act (CARA; Act 43 of 1983), and the Alien and Invasive Species Regulations (August, 2014) under Section 70 of the National Environmental Management: Biodiversity Act (NEMBA; Act 10 of 2004).

6.1.2 *Fieldwork*

Fieldwork was performed during January 2015, November 2015, December 2015 and December 2016 and involved:

- Sampling vegetation plots to determine the spatial extent, structure, condition and dominant species composition of different local floral communities (**Figure 6-1**) Sampling plot size was standardised at 100m^2. Whilst a plot was sampled, a list of plant taxa was compiled and each taxon was assigned a cover-abundance estimate using the Braun-Blanquet approach (Mueller-Dombois & Ellenberg 1974). The cover-abundance categories that were used for this purpose are listed in **Table 6-1**. It must be noted that the habitat in which the site fell was mostly homeogenous in nature, fragmented and disturbed, therefore the use of the Braun-Blanquet approach was limited.
- Walking random transects to detect localised and CI plant species (i.e. Red Data, endemic, protected and cultural species).
- Recording any observed alien and invasive plant species on site.

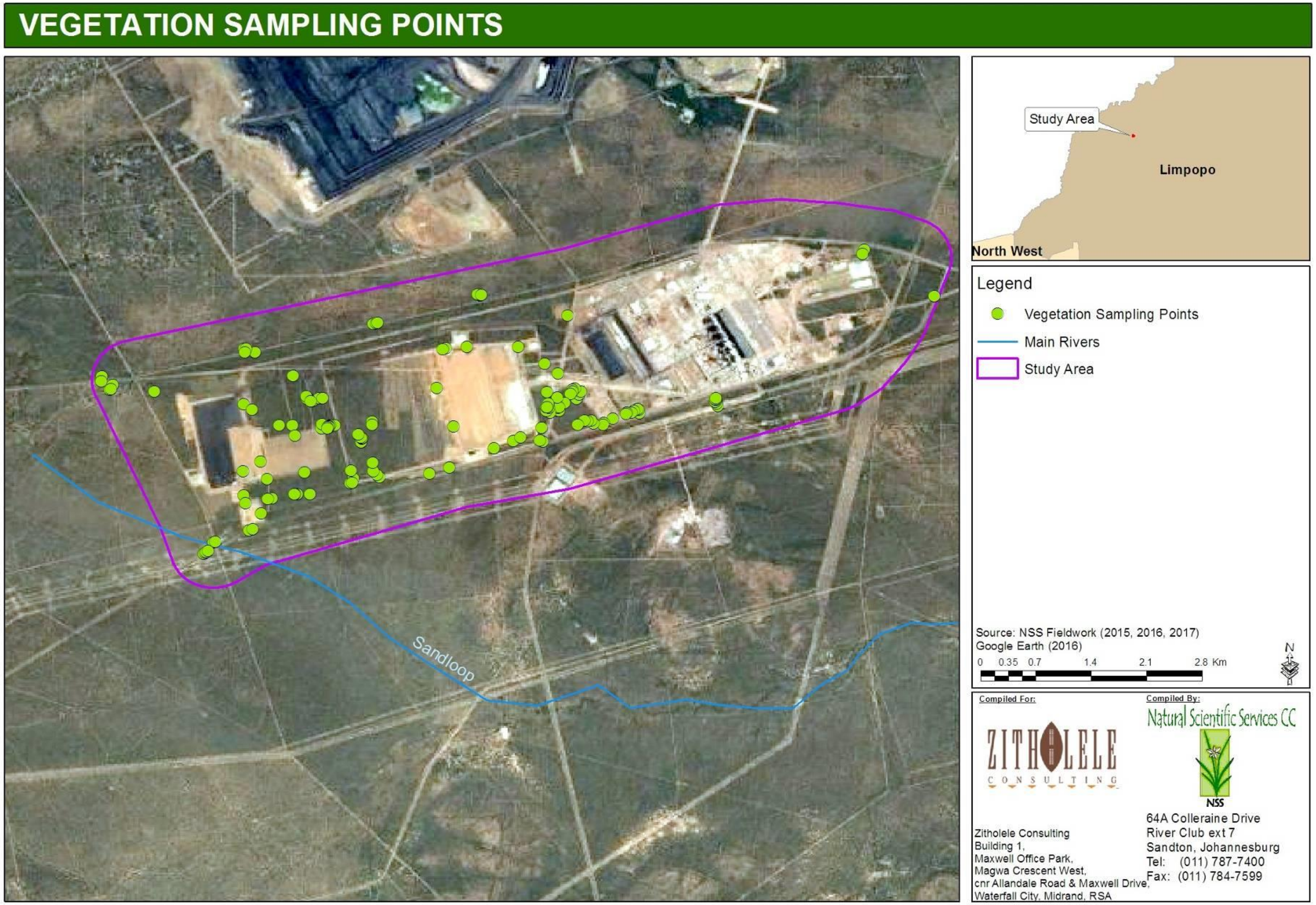


Figure 6-1 Main vegetation sampling points

6.1.3 *Data Analysis*

- The Juice (version 7.0.99) software program for management, analysis and classification of ecological data was used to conduct a TWINSPAN Detrended Correspondence Analysis (DCA) (Tichy & Holt, 2006) on the limited sampling points. The R-program was included as an add-on programme to Juice to conduct the DCA ordination.
- A TWINSPAN analysis (Hill 1979) of the Braun-Blanquet data, which represented the cover-abundance of species in each sample plot, was used to classify vegetation assemblages. TWINSPAN is used to investigate associations between samples with the purpose of objectively distinguishing groups or assemblages. Samples that cluster together are believed to have similar compositions. The data were left untransformed to allow for only common or dominant species to participate in the analysis.
- For CI floral species, Likelihood of Occurrence (LO) rating is assigned to each species based on the availability of suitable habitat using the following scale:
    - Present
    - Highly likely
    - Possible
    - Unlikely
    - No Habitat

Table 6-1 Braun-Blanquet cover classes (Mueller-Dombois & Ellenberg 1974)

CLASS	RANGE OF COVER (%)	MEAN
5	75-100	87.5
4	50-75	62.5
3	25-50	37.5
2	5-25	15.0
1	1-5	2.5
+	<1	0.1
r	<<1	0.01

6.1.4 *Limitations*

It is important to note that the absence of species on site does not conclude that the species is not present at the site. Reasons for not finding certain species during the different visits (all conducted in mid-summer) may be due to:

- The fragmented nature of the remaining natural vegetation within the boundary of the Medupi Power Station FGD Project area.
- The duration of fieldwork and the period at which rainfall events took place. I.e. while the December 2015 fieldwork took place during a heavy rainfall period – this was beneficial for faunal species. Floral species require some growth time after such events.
- Some plant species, which are small, have short flowering times, rare or otherwise difficult to detect may not have been detected even though they were potentially present on site.

- As an alternative to other vegetation cover methods (such as the Domin method), the Braun-Blanquet cover-abundance scale was used to analyse vegetation. It is reported that the Braun-Blanquet method requires only one third to one fifth the field time required to other similar methods (Wikum & Shanholtzer, 1978). Furthermore, cover-abundance ratings are better suited than density values to elucidate graphically species-environment relationships. For extensive surveys this method provides sufficiently accurate baseline data to allow environmental impact assessment as required by regulatory agencies. However, there are a couple of problems that have been detected with such sampling methods (Hurford & Schneider, 2007). These are as follows:
    - It can be seen as subjective and dependent upon the experience and knowledge of the vegetation type by the surveyor. The cover estimate may vary from observer to observer.
    - There also may be a problem when the cover estimate is very close to two different classes (on the border so to speak) and then it is for the observer to decide which class it should be allocated to. In Hurford & Schneider's (2007) experience, in marginal situations, where the cover of a species is close to a boundary between two classes, the chance of two observers allocating the species to the same cover class is no better than 50:50. However, when comparing to other sampling methods such as Domin, Braun-Blanquet scale is better adapted for monitoring (less cover classes and fewer boundaries).

6.2. Faunal Communities

6.2.1 *Desktop Research*

Lists of potentially occurring faunal species (**Appendices 2-7**) were based on distribution data sourced for:

- Mammals, using the published species distribution maps in Friedmann & Daly (2004), as well as the online species distribution data provided by the ADU's MammalMap (2018) for the regional QDSs 2327CB, 2327DA, 2327CD and 2327DC.
- Birds, using the online species distribution data from the first and second Southern African Bird Atlas Projects (SABAP 1 & 2, 2018) for QDSs 2327CB, 2327DA and respective pentads 2340_2725 and 2340_2730.
- Reptiles, using the published species distribution maps in Bates *et al.* (2014) and the online species distribution data from ReptileMap (2018) for all four regional QDSs.
- Frogs, using the published species distribution maps in Minter *et al.* (2004) and the online species distribution data from FrogMap (2018) for all four QDSs.
- Butterflies, using the online species distribution data from Mecenero *et al.* (2015) and LepiMap (2018) for all four QDSs.
- Dragonflies and damselflies (odonata), using distribution maps and habitat information provided in Samways (2008).

- Scorpions, using distribution maps and habitat information provided in Leeming (2003).
- Baboon Spiders, using distribution maps provided in Dippenaar-Schoeman (2002).

A Likelihood of Occurrence (LO) rating was then assigned to each species based on distribution and the availability of suitable habitat using the following scale:

1 Present
2 High
3 Moderate
4 Unlikely
5 The species would only occur in the area as a managed population.

Species lists were then supplemented with records obtained by BEC (2006) as part of the Medupi EMPR, as well as combined records from NSS studies in the Vicinity at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station.

6.2.2 *Fieldwork*

NSS visited the greater FGD study area three times i.e. during 12-13 January 2015, 9-11 November 2015 and 7-11 December 2015. During the first two visits a brief scan was performed, which involved active searching, deployment of motion cameras, and night time bat and frog acoustic surveys. The final five day survey followed a similar approach but with the addition of live-trapping.

Visual observations, grab-sampling and netting

Faunal observations were made during active point searches both by day and night on foot and incidentally while driving in and around the study area. Herpetofauna were searched for by turning rocks, logs and mats deployed during the November visit. Holes were investigated using a burrow scope. Tadpoles were sampled by dipnetting, and identified based on morphology and labial tooth row formula. Sweepnetting was used to sample butterflies. Scorpions were searched for under bark and rocks. Mammals were detected from observations of dead or live animals and their spoor, droppings, burrows and any other evidence of their presence. Birds were identified based on direct observation or from their calls and flight behaviour. Spotlighting during slow night drives was used to detect additional nocturnal fauna.

Live-trapping

In total, four live-trapping sites were installed in and around the FGD study area. Each trap site consisted of one array trap and a set of rodent traps. The trap sites operated over five days and four nights, and were checked daily. The location of each trap site is mapped in **Figure 6-5**.

Trap sites and techniques are shown in **Figure 6-2** and **Figure 6-4**, respectively. Additionally three sets of five large Astroturf mats were deployed during the November visit targeting reptiles, frogs and fossorial fauna. The mats were recollected during the December visit.

Trap Site 1 Trap Site 2 Trap Site 3 Trap Site 4

Figure 6-2 Live trapping sites

A schematic layout of an array trap site is presented in **Figure 6-3**. The array traps (Campbell & Christman, 1982) were used to sample herpetofauna (reptiles and frogs) and terrestrial macro-invertebrates. Each array consisted of three arms of plastic drift fencing (30cm high and 8m long). Pitfall traps (5 litre buckets sunken to ground level) were placed at the centre of the array and at the end of each drift fence. Each pitfall trap was provisioned with a stone, wet cotton wool and a raised, wooden cover board to provide shelter, moisture and shade for trapped animals. A plastic, mesh funnel trap was placed on either side of each drift fence and covered with a wooden board for shade.

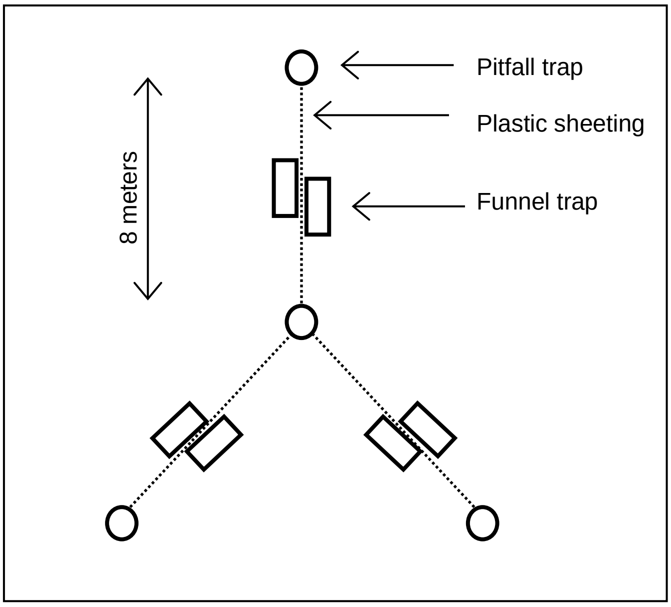


Figure 6-3 Schematic layout of an array trap including drift fences, pitfall and funnel traps

A live rodent trapping transect typically included a series of metal rodent traps spaced at 5-10m intervals. Each series included one pair of multi-entry traps, and 16 Sherman traps. Each trap was baited with a mixture of peanut butter, rolled oats, raisins, sunflower oil and seeds, and supplied with cotton wool and a wooden cover board to provide warmth and shade for trapped animals. The traps were checked daily and re-baited when necessary.

Funnel and pitfall traps along drift fence

Sherman rodent trap

Motion camera

Mat Trap

Figure 6-4 Examples of sampling techniques employed

Acoustic survey for bats and frogs

Bat calls were recorded during a short driven transect in the study area (**Figure 6-5**) using an ultra-sonic Echo Meter 3 (EM3) detector (Wildlife Acoustics, Inc., USA). Wildlife Acoustics Compressed (.wac) files of bat calls recorded by the EM3 detector were converted to zero crossing (.zc) and wave (.wav) files using the WAC2WAV and Kaleidoscope programmes (Wildlife Acoustics Inc., USA). The converted data were subsequently processed using the BatSound Pro (Pettersson Elektronik, Sweden) programme to identify bat taxa from detailed examination of the peak frequency, duration and band width of calls.

Camera-trapping

Motion-sensitive cameras, set to record both infrared and flash images, were installed in and around the FGD study area where vertebrate activity was deemed likely, such as near water holes, game feeding stations or along paths (**Figure 6-5** and **Figure 6-4**). Some cameras were baited to attract secretive, nocturnal, carnivorous mammals.

Designation of Conservation Status

In the appended faunal species lists the global, national and provincial conservation status of applicable species is provided. Global and National Red Lists are based on the IUCN Red List criteria and categories, shown in **Figure 6-6,** which were developed to provide a simple and effective system for rating the conservation status of species, mainly at global and regional levels. The global status of species was sourced from the IUCN (2017.3) Red List. The latest national Red List status of species was sourced for mammals, birds, reptiles, frogs and butterflies from the atlases and Red Data books by SANBI & EWT (unpubl.), Taylor *et al.* (2015), Bates *et al.* (2014), Minter *et al.* (2004) and Mecenero *et al.* (2013), respectively. A legally-binding national list of Threatened or Protected Species (ToPS, 2015) is provided under the 2004 National Environmental Management: Biodiversity Act (NEMBA). As there is often spatio-temporal variation in human disturbances, the conservation status of some species differs between the IUCN global/regional, national and provincial Red Listings.

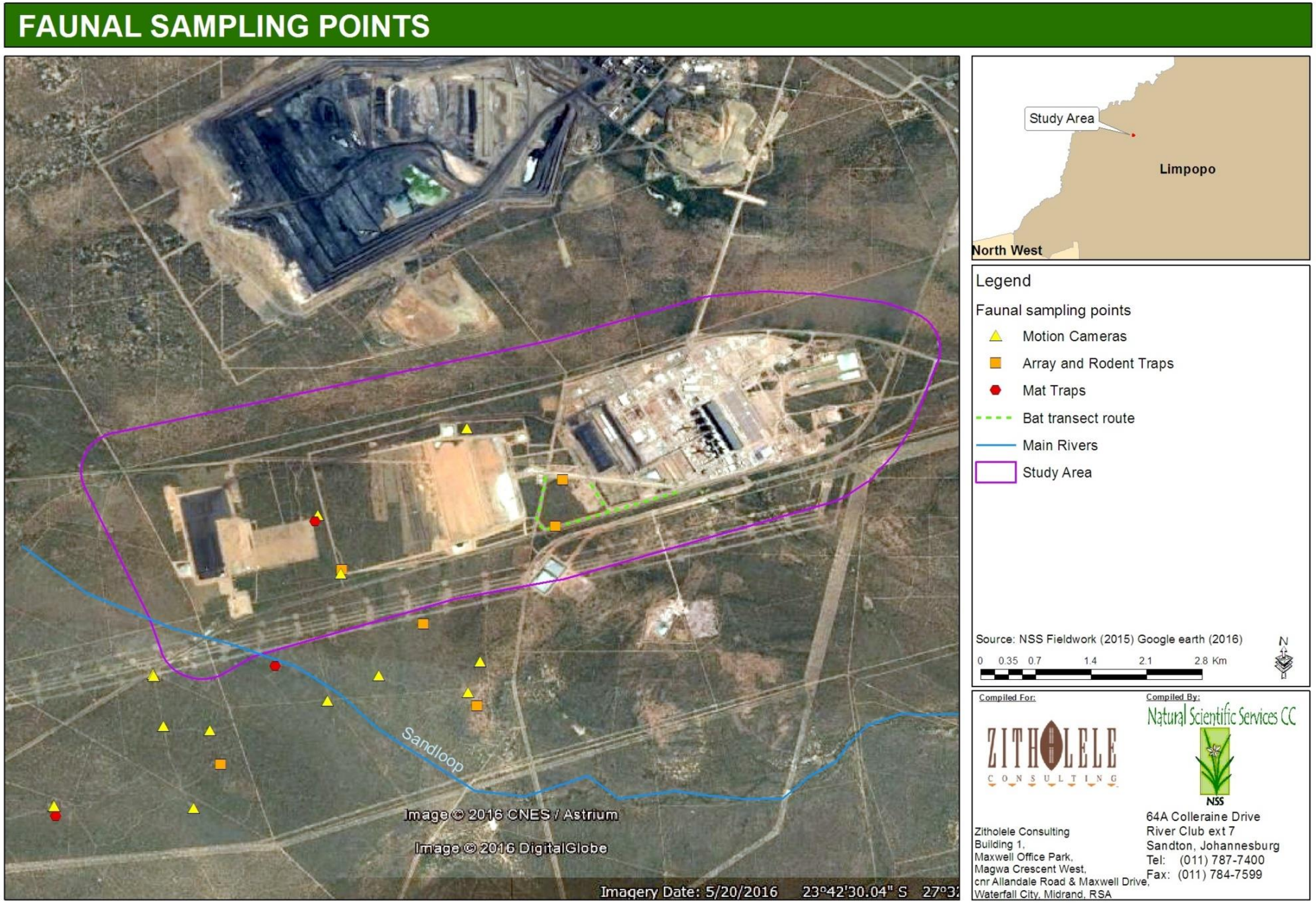


Figure 6-5 **Layout of faunal sampling points showing the bat acoustic transect and position of the motion cameras.**

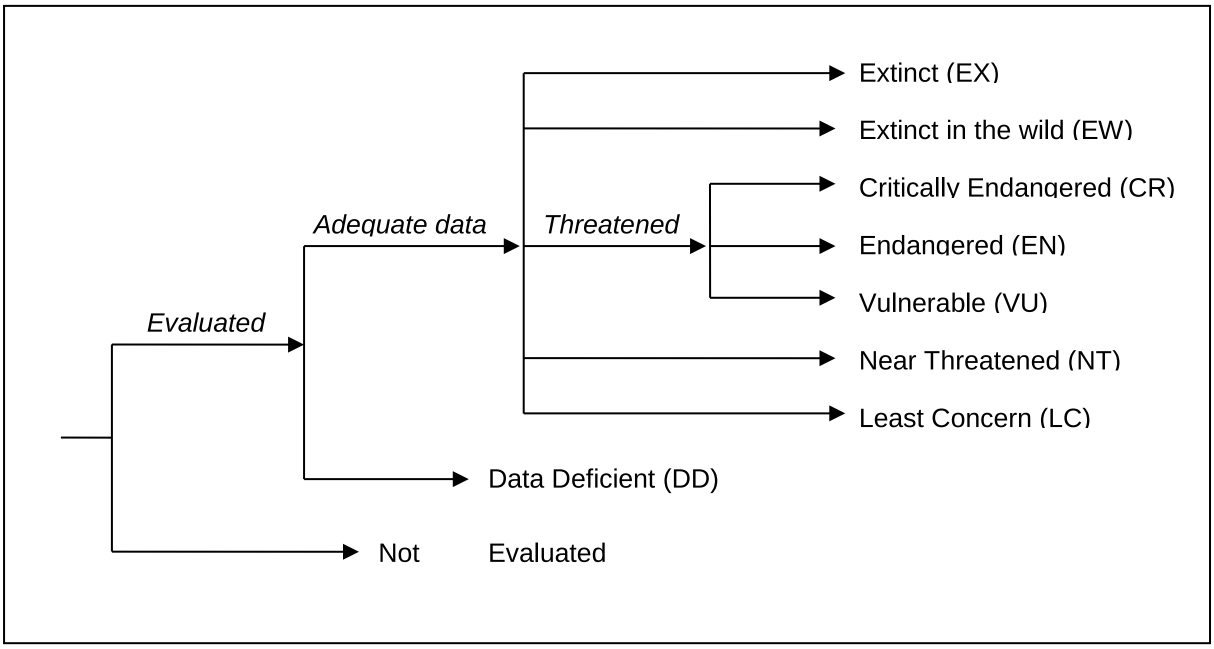


Figure 6-6 IUCN Red List categories

6.2.3 *Limitations*

Several inherent and unavoidable limitations need to be considered when interpreting survey results. Reasons for the lack of detection of some species include:

- Inductions and security protocol which significantly decreased the amount of time spent in the study area.
- The small, fragmented nature of the study area, and disturbances from Medupi Power Station.
- The short duration of each field survey, and the lack of significant rainfall preceding the January survey.
- The cryptic nature of certain species or simply lack of species presence. Some animal species, which are uncommon, small, migratory, secretive or otherwise difficult to find may not have been detected even though they were potentially present in the study area.

6.3. Watercourses, Wetlands and Ephemeral Systems

As part of this study it is important to define what systems are being investigated. As mentioned in **Section 5,** the study area lies within a drier region of the country where evapotranspiration exceeds rainfall. Rainfall in this region is approximately 400mm per annum. Systems, therefore within this region are largely ephemeral and are seen as drainage systems that potentially flow intermittently. These fall under the definition of a Watercourse.

A watercourse defined by the National Water Act (Act 36 of 1998) means –

(a) a river or spring;

(b) a natural channel or depression in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse as defined in the National Water Act, 1998 (Act No. 36 of 1998) and reference to a watercourse includes, where relevant, its bed and banks;

When discussing a wetland, the definition used within this study is that defined by the Ramsar Convention[1] and those used within publications such as the "Classification System for Wetlands and other Aquatic Ecosystems in South Africa" (Ollis *et al*. 2013) which incorporates both the definition of Aquatic Ecosystems[2] and Wetlands[3] as defined by the National Water Act (Act 36 of 1998).

The National Water Act defines a wetland as *"land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil".*

Due to the extent of the areas to be investigated, the ToR for NSS was to identify and delineate watercourses and wetland systems at a desktop level within a 500m buffer of the MPS and ADF and to then undertake limited ground truthing (mainly within December 2015 and November 2016) within the areas identified. Prior to any field investigations being undertaken, the area was therefore surveyed at a desktop level using 1:50 000 topographical maps, Google Earth™ Imagery, and available contour data (a relatively flat region, so contour data limiting in this assessment) to determine the layout of potential watercourses and wetlands within the study site and immediate surrounds.

6.3.1 *Classification of the Watercourses and Wetlands*

Where wetlands were found, they were defined using the classification system discussed above by Ollis *et al*. (2013), hereafter referred to as "the Classification System". The Classification System recognizes three broad inland systems: rivers, wetlands and open water bodies. Like Kotze *et al's.* (2008) classification of wetlands based on hydro-geomorphic (HGM) units, the Ollis *et al*. (2013) Classification System asserts that the

[1] "*Wetlands – areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters*" Ramsar Convention Secretariat, 2011.

[2] Aquatic Ecosystem: *an ecosystem that is permanently or periodically inundated by flowing or standing water, or which has soils that are permanently or periodically saturated within 0.5m of the soil surface.*

[3] *[3]* NWA defines a wetland as *"land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

functioning of an inland aquatic ecosystem is determined fundamentally by hydrology and geomorphology.

The Classification System has a six-tiered structure where under the determination of a system's HGM unit (Level 4) is the most fundamental:

Level 1 – Type of Systems (Marine, estuarine or Inland)

Level 2 – Regional Setting (Level 1 Ecoregions; NFEPA WetVeg units etc)

Level 3 – Landscape Unit (Valley Floor, Slope, Plain, Bench)

Level 4 – Hydrogeomorphic (HGM) Unit

Level 5 – Hydrological Regime

Level 6 – Descriptors (e.g. Natural vs Artificial; Salinity; pH etc)

6.3.1.1 Ephemeral Systems (Watercourses)

Within the study area there are a number of drainage features referred to hereafter as Semi-Ephemeral Washes (SEWs). These are situated in the upper reaches of their catchment and characterised by a very gradual slope (<1%) and cross sectional profile. Although a very slight change in vegetation structure (not composition) is sometimes apparent, no clearly defined channel is obvious and it is often difficult to locate these systems on the ground without the aid of aerial imagery.

6.3.2 *Wetlands and Riparian Extent*

Where required, the wetland delineation methods used in the field were the same as those outlined in the DWS field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2005). The following three indicators described by DWAF (2005) were used:

- *Terrain Unit Indicator*: The topography of the area was used to determine where in the landscape wetlands were likely to occur. During the December 2015 field visit the site experienced 38mm of rainfall in one week. This assisted NSS in determining the flow paths of a number of the ephemeral systems on site. In addition, aerial imagery and contour data were used to identify potential flow paths in the landscape.
- *Soil Wetness Indicator*: The soil wetness and duration of wetness are indicated by the colour of the soil. A grey soil matrix such as a G-horizon is an indication of wetness for prolonged periods of time and mottles indicate a fluctuating water table. In terms of the DWS guidelines (DWAF, 2005), signs of soil wetness must be found within the top 50 cm of the soil surface to classify as a wetland. Temporary wetlands in arid environments however do not usually exhibit mottling, because often the soils have naturally low levels of iron, and the soils are by definition not exposed to the specific conditions under which such indicators are formed so the absence of mottles does not necessarily indicate the absence of a wetland in these systems (Day *et al*, 2010). Where possible, soils data supplied by ESS (2016) for the study area were used to identify wet-based and alluvial soils; and
- *Vegetation Indicator*: Vegetation is a key component of the wetland definition in the National Water Act, 1998 (Act No 36 of 1998), and vegetation can be used as an indicator of wetland conditions. The presence / absence of hydrophytes usually

provide a useful additional criterion in determining the boundaries of wetlands. Within arid environments and the temporary wetlands identified on site it was more the change in vegetation structure and facultative wetland plants (helophytes) that were used as wetland indicators, as opposed to only hydrophytes. (Day *et al*. 2010). The delineation of riparian vegetation was conducted using the three simple steps outlined by Mackenzie & Rountree (2007), for sites that support predominantly indigenous and naturally occurring vegetation, as such:

- Starting at the sides of the channel, identify the edge of the zone of obligate riparian plants using the regional riparian vegetation indicator list.
- Check if there are hydric indicators in the soil, such as G-horizons or soil mottling, or evidence of unconsolidated recent alluvial sediment. Find the outer edges of these indicators.
- Examine the geomorphology (shape) of the channel and river banks. The locations selected based on riparian indicator species or soil features described above, should be at or close to the edge of the “macro-channel bank” (in the case of erosive rivers) or at the edge of an active floodplain / flood zone (in the case of alluvial depositional rivers). At this point, or nearby, should be an inflection point (change of slope) between the riparian area and the upland (terrestrial) slopes. This site can be considered as the edge of the riparian zone.

The study site was traversed, on foot, with select areas chosen from the desktop mapping for limited ground truthing. Soil samples, within the top 50cm and deeper where necessary, of the soil profile, were taken using a hand auger along transects across the property and within areas where wetland vegetation indicators were present. The areas were assessed for the above wetland indicators. Each auger point sampled was marked with a handheld Global Positioning System (GPS) device (Geographic projection, WGS 84 Datum).

6.3.3 *Present Ecological State*

6.3.3.1 Semi-Ephemeral Washes

Although this is not an HGM unit defined specifically in Ollis *et al* (2013), an attempt was made to obtain a PES score using the Level 1 WET-HEALTH tool of Macfarlane *et al.* (2008). In spite of this limitation it is our opinion that the scores attained for the wetlands are representative and therefore afforded a high confidence. The WET-HEALTH tool is designed to assess the health or integrity of a wetland. To assess wetland health, the tool uses indicators based on the main wetland drivers: geomorphology, hydrology and vegetation.

Macfarlane *et al.* (2008) explain that the application and methodology of WET-HEALTH uses:

- An impact-based approach, for those activities that do not produce clearly visible responses in wetland structure and function. The impact of irrigation or afforestation in the catchment, for example, produces invisible impacts on water inputs. This is the main approach used in the hydrological assessment.

- An indicator-based approach, for activities that produce clearly visible responses in wetland structure and function, e.g. erosion or alien plants. This approach is mainly used in the assessment of geomorphology and vegetation health.

With WET-HEALTH a wetland is first classified into HGM units (Level 4 – Ollis *et al.* 2013), and each HGM unit is separately assessed in terms of the extent, intensity and magnitude of impacts on the hydrology, geomorphology and vegetation of the unit, which is translated into a health score as follows:

- The *extent* of impact is measured as the proportion (percentage) of a wetland and/or its catchment that is affected by an activity.
- The *intensity* of impact is estimated by evaluating the degree of alteration that results from a given activity.
- The *magnitude* of impact for individual activities is the product of extent and intensity.
- The magnitudes of all activities in each HGM unit are then combined in a structured and transparent way to calculate the overall impact of all activities that affect a unit's hydrology, geomorphology and vegetation, and wetland PES is expressed on a scale of A-F (**Table 6-2**).

Table 6-2 Impact scores and Present Ecological State categories

ECOLOGICAL CATEGORY	DESCRIPTION	COMBINED IMPACT SCORE
A	**Unmodified, natural**	0-0.9
B	**Largely natural with few modifications**. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9
C	**Moderately modified**. A moderate change in ecosystem processes and loss of natural habitat has taken place but the natural habitat remains predominantly intact.	2-3.9
D	**Largely modified**. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9
E	**Seriously modified**. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9
F	**Critically modified**. Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10

Source: Modified from Macfarlane *et al.* (2008)

In addition, the threat and/or vulnerability of a wetland must be assessed to determine its likely "trajectory of change" (**Table 6-3**). Overall wetland health is then jointly represented by the wetland's PES and trajectory of change. This approach not only provides an indication of hydrological, geomorphological and vegetation health, but also highlights the key causes of wetland degradation.

Table 6-3 Trajectory of change classes, scores and symbols

TRAJECTORY CLASS	DESCRIPTION	CHANGE SCORE	CLASS RANGE	SYMBOL
Improve markedly	Condition is likely to improve substantially over the next five years	2	1.1 to 2	↑↑
Improve	Condition is likely to improve over the next five years	1	.3 to 1	↑
Remains stable	Condition is likely to remain stable over the next five years	0	-0.2 to +0.2	→
Deterioration slight	Condition is likely to deteriorate slightly over the next five years	-1	-0.3 to -1	↓
Deterioration substantial	Condition is likely to deteriorate substantially over the next five years	-2	-1.1 to 2	↓↓
Source:	Modified from Macfarlane *et al.* (2008)			

6.3.3.2 <u>Pan Systems</u>

Historically there has been little research done in South Africa on pans, especially when compared to palustrine[4] wetlands (Ferreira, 2012). In terms of assessing the functioning and ecosystem services supplied by ephemeral pans, the standard methods used in South Africa are not applicable as these focus on palustrine systems.

Ferreira (2012) undertook his PhD on developing a methodology for determining the ecological integrity of *perennial* endorheic pans within South Africa. Unfortunately this methodology is not applicable to the ephemeral pan system identified within the study area, and no method is available in South Africa to assess the habitat integrity of such systems. In spite of this limitation it is our opinion that the scores attained for the wetlands are representative and therefore afforded a high confidence. The main impacts for the various pan systems have therefore been discussed, based on expert opinion, under **Section 7.6**.

6.3.4 *Predicted Ecological State*

In order to assess the anticipated gains/losses to wetland health, specifically the semi-ephemeral washes associated with upper tributaries of the Sandloop as a result of the proposed development, a hectare equivalent approach was adopted using scoring guidelines and equations as presented in the WRC document WET – RehabEvaluate (Cowden & Kotze, 2008). First an overall ecological health score for the wetland with and without mitigation for all three alternatives was calculated by taking a weighted average of the three wetland drivers namely hydrology, geomorphology and vegetation using a 3:2:2 weighting ratio

[4] Palustrine: All non-tidal wetlands dominated by persistent emergent plants, emergent mosses or lichens, or shrubs or trees (Kotze *et al*, 2008)

respectively. Secondly this score was then used in to calculate hectare equivalents which represent the extent of functional wetland in relation to the total wetland extent. This was done using the following formula:

((Overall Health Score – 10) / 10) x Wetland Area = Hectare Equivalent

6.3.5 *Ecosystem Services*

The WET – EcoServices tool is a technique for rapidly assessing ecosystem services supplied by wetlands (Kotze *et. al.,* 2008). This tool has been designed for inland palustrine wetlands, i.e. marshes, floodplains, vleis and seeps and has been developed to help assess the goods and services that individual wetlands provide to support planning and decision-making. No palustrine wetlands were identified on site, but rather semi-ephemeral drainage features (Washes). This proposed methodology was only utilised in this assessment as a guide to the services offered by the different systems. In spite of this limitation it is our opinion that the scores attained for the wetlands are representative and therefore afforded a high confidence.

6.3.6 *Ecological Importance and Sensitivity*

The assessment of wetland Ecological Importance and Sensitivity (EIS) was based on the EIS Tool developed by Rountree and Kotze (2012). The purpose of assessing the EIS of water resources is to identify those systems that provide higher than average ecosystem services and/or biodiversity support functions, and/or are especially sensitive to impacts.

The Tool collectively considers:

- Ecological Importance and Sensitivity, incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWS and thus enabling consistent assessment approaches across water resource types;
- Hydro-functional importance, which considers water quality, flood attenuation and sediment trapping ecosystem services that the wetland may provide; and
- Importance in terms of basic human benefits - this suite of criteria consider the subsistence uses and cultural benefits of the wetland system.

It is recommended that the highest scoring of these three criteria be used to determine the overall Importance and Sensitivity category (**Table 6-4**) of the wetland system.

Table 6-4 Ecological importance and sensitivity categories – Interpretation of median scores for biotic and habitat determinants

Range of Median	Ecological Importance & Sensitivity (EIS)	Recommended EMC
>3 and <=4	**Very high** Wetlands that are considered ecologically important and sensitive on a national / international level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	**A**
>2 and <=3	**High** Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	**B**
>1 and <=2	**Moderate** Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	**C**
>0 and <=1	**Low/Marginal** Wetlands which are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	**D**

6.3.7 *Sediment*

Sediment samples were collected to determine the metal concentrations of the samples. These sediment samples were collected at six of the sampling sites during the high flow season (December 2015) and two additional samples within the November 2016 visit. The sediment samples were collected in PET jars, frozen to prevent any organic decomposition and sent to the Water Research Group (WRG) at the Potchefstroom Campus of North-West University for the metal analysis.

The analysis for metals involved a total digestion of sediments and was based on the methodology of Hassan *et al.* (2007). Each sediment sample was oven-dried for 2–4 days at 70°C. A known amount of each sample (approximately 0.5 g) was digested with Suprapur nitric acid (HNO_3) in a MARS 5 Microwave Digester for 20 minutes. The samples were then diluted and filtered with 0.45 µm cellulose nitrate under vacuum pressure. The filtered extract was analysed by Inductively Coupled Plasma – Optical Emission Spectrophotometer (ICP-OES) and an Inductively Coupled Plasma – Mass Spectrophotometer (ICP-MS). The results are expressed as mg/kg. Currently no sediment quality guidelines (SQGs) exist for freshwaters in South Africa. Therefore, the concentrations for each of the metals are compared to international standards and other local studies.

6.3.7.1 Invertebrate Hatching

The aim of the invertebrate hatching was to determine if any invertebrate resting eggs were present in the sediment from selected pans in the study area. Certain invertebrates, especially Branchiopoda, form resting eggs of ephippia to overcome the harsh conditions experienced in ephemeral wetlands. These resting eggs within the sediment are thus called the egg bank. The resting eggs remain in the sediment until the correct environmental triggers and conditions are present. The hatchlings are the first inhabitants of these ephemeral pans before other insect taxa colonise the system. When these ephemeral systems are dry it is impossible to determine what the biological community will comprise of when it is inundated. However, determining what the initial community will be comprised of can go a long way to provide an indication of the potential community.

Sediment samples from site MD7 and site MD8 were dried, at room temperature, upon receiving the samples from the field investigations, for a minimum of 48 hours. The hatching experiments were completed at a room temperature of approximately 22 °C. Each sample was hatched in triplicate. A known amount of sediment, 25g, was placed into 2L plastic containers for the hatching experiment. The experiment was initiated when 1L of distilled water was added to each hatching container. Due to time constraints the hatching experiment was allowed to run for 10 days but it would have been ideal to continue for up to 28 days. The hatching containers were examined every three to four days for any sign of invertebrate hatchlings. A small amount of oxygen was also added to each container when they were examined for invertebrate hatchlings. Both sites, MD7 and MD8, indicated that hatching of invertebrates occurred more or less after three days.

6.3.7.2 Comparative analysis with Water Quality Results

NSS collected water quality samples for Golder & Associates Surface Water Quality Assessment at the same time and position as the Sediment Samples. Water quality (WQ) is used to describe the aesthetic, biological, chemical and physical properties of water that determine its condition for a variety of uses and for the protection of the health and integrity of aquatic ecosystems. These dissolved or suspended constituents, in the water, could influence or control the WQ properties. For example, in some cases anthropogenic activities can cause the physio-chemical constituents that occur naturally in the water to become toxic under certain conditions. Each aquatic ecosystem possesses natural limits or thresholds to the extent and frequency of change it can tolerate without being permanently modified (DWAF, 1996). If an aquatic ecosystem crosses these thresholds, it will be difficult to recover or regain its functional capacity without mitigation. It must also be taken into consideration that determining the effects of changes in WQ on aquatic ecosystems is considered complex, as these systems can fluctuate spatially and temporally. For this project the results from the WQ analysis were used to compare those found within the sediment analysis.

6.3.8 *Limitations*

Even though all attempts were made to take samples under optimal conditions certain limitations were encountered. The limitations to this study included:

- Wetland assessment techniques are inherently subjective.
- The PES and EcoServices were also not designed for systems such as Ephemeral Washes
- The boundary determined by infield wetland delineation can often occur within a certain tolerance because of the potential for the change in gradient of the wetness zones within wetlands.
- The modification of the soil profile related to agricultural activities and the clearing of the site and the modification of the hydrological conditions within disturbed sites limits the accuracy of the resulting boundary as the sampling methodology relies heavily on interpretation of undisturbed soil morphology and characteristic.
- The use of vegetation indicators (seasonal and temporary zones) was limited to non-existent due to the ephemeral nature of the systems. Riparian vegetation was even not evident. Only vegetation structure in comparison to surrounding areas was conducted.
- Water was limited to sandy pools within the drainage features in the study area.
- None of the biomonitoring indices (**Box 1**) could be used due to the ephemeral nature of these systems (Not within this Scope). Instead Invertebrate hatching at two pans in the ADF site was conducted. Due to time constraints the hatching experiment was allowed to run for 10 days but it would have been ideal to continue for up to 28 days.

Box 1

* The assessment of macro-invertebrate communities in a river system is a recognised means of determining river “health”. Macro-invertebrates are good indicators because they are visible, easy to identify and have rapid life cycles (Dickens & Graham, 2002). According to Dickens & Graham (2002), the SASS5 (South African Scoring System, version 5) method is designed for low/moderate flow hydrology and is not applicable in wetlands, impoundments, estuaries and other lentic habitats. In addition, it has not been tested in ephemeral rivers and so should be used with caution.

* No fish sampling was performed during the current study as the sampling sites were shallow pools with limited water levels. The Fish Response Assessment Index (FRAI) developed by Kleynhans (2008) cannot not be used in these ephemeral systems.

7. Results

7.1. Vegetation Communities

SANBI frequently collect/collate floral data within Southern Africa and update their PRECIS database system (National Herbarium Pretoria (PRE) Computerised Information System) which is captured according to QDS. For this study, the site falls with 2327DA. Species within the POSA database for this QDS do not exceed 311 species (Date extracted February 2015) and represent 68 Families. The dominant families being FABACEAE, POACEAE and MALVACEAE (**Table 7-1**), with the herbs representing 30.87%, dwarf shrubs 14.47%, shrubs to small trees 15.76% and graminoids representing 11.25% of the total species listed for the area. This is a typical representation of vegetation structure for savanna communities.

Table 7-1 Top Ten Dominant Families and Most Dominant Growth Forms obtained from the POSA website for the QDS 2327DA

IMPORTANT FAMILIES	No. OF SPP	GROWTH FORMS	% TOTAL SPP
FABACEAE	38	Herb	30.87
POACEAE	35	Dwarf shrub	14.47
MALVACEAE	35	Graminoid	11.25
ACANTHACEAE	17	Shrub	9.65
ASTERACEAE	16	Shrub to small tree	6.11
CONVOLVULACEAE	11	Climbers	5.14
APOCYNACEAE	11	Geophyte	4.5
EUPHORBIACEAE	10	Succulent	3.86
HYACINTHACEAE	9	Tree	3.54
RUBIACEAE	8	Bryophyte	2.57

7.1.1 *Vegetation Communities*

For a more detailed sampling of the project area, sample points were investigated in various natural and semi natural habitats of the study area and analysed using TWINSPAN. The study area was very homogenous in nature, fragmented and largely disturbed through clearing etc. This made it difficult to use a sampling method that would yield different communities. The main plant communities were identified based on understory coverage and disturbances (**Table 7-2** and **Figure 7-2**). These communities were mainly *Acacia* dominated Woodlands with associated Wetlands and included: *Acacia nigrescens* - *Grewia* Open Veld; *Acacia nigrescens –Combretum apiculatum* dominated woodland, *Acacia erubescens - Grewia* Thornveld, Disturbed *A nigrescens-Dicrostachys-Grewia* fragmented Thornveld and Disturbed *Acacia* mixed woodland. Associated wetland and hydromorphic areas included the *Acacia* dominated Wetland Flats, Depressions and Artificial Waterbodies.


Acacia nigrescens –Combretum apiculatum dominated woodland

Acacia nigrescens - Grewia Open Veld


A nigrescens-Dicrostachys-Grewia fragmented Thornveld


Depressions within the *Acacia* Woodlands

Depressions within the *Acacia* Woodlands

Acacia erubescens - Grewia Thornveld

Acacia erubescens - Grewia Thornveld

Waterbodies

Waterbodies

Acacia mixed woodland

Acacia dominated Wetland Flat

Figure 7-1 Photographic representation of the different vegetation found within the study area

Table 7-2 Vegetation Communities

UNIT	HABITAT & VEGETATION COMMUNITIES	% COVERAGE
A	**Main Vegetation Communities – Acacia Woodlands**	
	Acacia nigrescens - Grewia Open Veld	9.19
	Acacia nigrescens –Combretum apiculatum dominated woodland	22.87
	Acacia erubescens - Grewia Thornveld	2.26

UNIT	HABITAT & VEGETATION COMMUNITIES	% COVERAGE
B	**Disturbed Woodlands**	
	A nigrescens-Dicrostachys-Grewia fragmented Thornveld	8.27
	Acacia mixed woodland	6.59
C	**Transformed**	
	Disturbed (previously scraped)	11.47
	Cleared areas and stockpiles	14.61
	Roads and Storm Water	4.32
	Infrastructure	16.21
D	**Wetland Areas / Hydromorphic Grasslands**	
	Acacia dominated Wetland Flat	3.56
	Depressions	0.37
	Artificial water points / Waterbodies	0.15

A description and photographic evidence for each main natural vegetation unit is provided in the Tables below (**Table 7-3** to **Table 7-7**). This excludes depressions (lack of vegetation, with only occasional hydromorphic species present), waterbodies and transformed areas such as the alien bushclumps and any agricultural areas. The *Acacia* dominated Wetland Flats were situated within the *Acacia* Woodland Communities and showed limited variation from the surrounding vegetation other than a denser leaf coverage and height change. Wetlands constituted over 4% of the study area.

Table 7-3 ***Acacia nigrescens - Grewia*** **Open Veld Vegetation Description**

Acacia nigrescens - Grewia Open Veld		
Photographic representation	 	
National Zones:	C-Plan Ecological Support Area; Waterberg CBA-Optimal, LC Vegetation Type ; Sweet Limpopo Bushveld	
Sub-Community	*A nigrescens-Dicrostachys-Grewia fragmented Thornveld*	
% Site Coverage	9.19 % - mainly in the northern region; Fragmented Habitat – 8.27%	
Condition:	▪ Limited to no alien encroachment ▪ Quicker establishing grass species – dominated by Increaser 2 and sub-climax species	
CI Species:	▪ *Sclerocarya birrea (A.Rich.)* (PT) ▪ *Spirostachys africana Sond.* (PT)	
Common	▪ *Abutilon cf austro-africanum*	▪ *Digitaria eriantha Steud.*

Acacia nigrescens - Grewia Open Veld		
species:	*Hochr.* ▪ *Acacia karroo Hayne* ▪ *Acacia nigrescens Oliv.* ▪ *Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.) Brenan* ▪ *Agathisanthemum bojeri Klotzsch subsp. bojeri* ▪ *Alistilus bechuanicus N.E.Br.* ▪ *Aristida congesta Roem. & Schult. subsp. barbicollis (Trin. & Rupr.) De Winter* ▪ *Aristida stipitata Hack.* ▪ *Asparagus cf cooperi Baker* ▪ *Boscia albitrunca (Burch.) Gilg & Gilg-Ben.* ▪ *Chlorophytum recurvifolium (Baker) C.Archer & Kativu* ▪ *Clerodendrum ternatum Schinz* ▪ *Combretum apiculatum Sond. subsp. apiculatum* ▪ *Commelina africana L. var. africana* ▪ *Commelina benghalensis L.* ▪ *Cyperus margaritaceus Vahl var. margaritaceus*	▪ *Dipcadi viride (L.) Moench* ▪ *Eragrostis superba Peyr.* ▪ *Evolvulus alsinoides (L.) L.* ▪ *Gomphocarpus tomentosus Burch. subsp. tomentosus* ▪ *Grewia flavescens Juss.* ▪ *Grewia monticola Sond.* ▪ *Heliotropium ciliatum Kaplan* ▪ *Hermannia spp* ▪ *Ipomoea bolusiana* ▪ *Kyllinga alba Nees* ▪ *Oxygonum dregeanum Meisn. subsp. canescens (Sond.) Germish. var. canescens* ▪ *Panicum maximum Jacq.* ▪ *Pavonia burchellii* ▪ *Polygala amatymbica Eckl. & Zeyh.* ▪ *Polygala sphenoptera var. sphenoptera* ▪ *Schmidtia pappophoroides Steud.* ▪ *Solanum panduriforme Droge er Dunal* ▪ *Stipagrostis uniplumis (Licht.) De Winter var. uniplumis* ▪ *Terminalia sericea Burch. er DC.*
Species Examples:	 *Agathisanthemum bojeri*	 *Pavonia burchellii*
Current Conservation Status		**Medium**
Current Conservation Status - *A nigrescens-Dicrostachys-Grewia fragmented Thornveld*		**Medium-Low**

* Alien Species; *[1] Category 1 Alien Invasive; PT: Protected –DAFF;

Table 7-4 *Acacia nigrescens –Combretum apiculatum* Woodland Vegetation Description

***Acacia nigrescens –Combretum apiculatum* dominated woodland**	
Photographic representation	 
National Zones:	C-Plan Critical Biodiverse Area;Ecological Support Area; Waterberg CBA, LC Vegetation Type; Sweet Limpopo Bushveld
% Site Coverage	22.87 % - central region
Condition:	▪ Limited to no alien encroachment ▪ Similar species contribution to *Acacia nigrescens* - *Grewia* Open Veld ▪ Pioneer to sub-climax species; Increaser 2 species the most common
CI Species:	▪ *Sclerocarya birrea (A.Rich.)* (PT)
Common species:	▪ *Abutilon cf austro-africanum Hochr.* ▪ *Acacia erubescens Welw. er Oliv.* ▪ *Acacia nigrescens Oliv.* ▪ *Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.) Brenan* ▪ *Agathisanthemum bojeri Klotzsch subsp. bojeri* ▪ *Aristida congesta Roem. & Schult. subsp. barbicollis (Trin. & Rupr.) De Winter* ▪ *Aristida congesta Roem. & Schult. subsp. congesta* ▪ *Aristida stipitata Hack.* ▪ *Asparagus cf cooperi Baker* ▪ *Boscia albitrunca (Burch.) Gilg & Gilg-Ben.* ▪ *Cenchrus ciliaris L.* ▪ *Combretum apiculatum Sond. subsp. apiculatum* ▪ *Cyperus margaritaceus Vahl var. margaritaceus* ▪ *Eragrostis superba Peyr.* ▪ *Evolvulus alsinoides (L.) L.* ▪ *Gomphocarpus tomentosus Burch. subsp. tomentosus* ▪ *Grewia flavescens Juss.* ▪ *Grewia monticola Sond.* ▪ *Kyllinga alba Nees* ▪ *Oxygonum dregeanum Meisn. subsp. canescens (Sond.) Germish. var. canescens* ▪ *Panicum maximum Jacq.* ▪ *Polygala sphenoptera var. sphenoptera* ▪ *Schmidtia pappophoroides Steud.* ▪ *Sida ovata Forssk.* ▪ *Solanum panduriforme Droge er Dunal* ▪ *Stipagrostis uniplumis (Licht.) De Winter var. uniplumis*

Acacia nigrescens –Combretum apiculatum dominated woodland		
	▪ *Commelina africana var. africana*	
Species Examples:		
	Polygala sphenoptera var. sphenoptera	*Gomphocarpus tomentosus*
Current Conservation Status		**Medium**

Table 7-5 ***Acacia erubescens - Grewia Thornveld*** **Vegetation Description**

Acacia erubescens - Grewia Thornveld		
Photographic representation		
National Zones:	Sandloop FEPA, C-Plan Critical Biodiverse Area; Waterberg CBA; LC Vegetation Type ; Sweet Limpopo Bushveld	
% Site Coverage	2.26 % - western section	
Condition:	▪ Limited to no alien encroachment ▪ Limited herbacous and grass cover present (even during the mid-summer sampling months)	
CI Species:	▪ *Ammocharis coranica (P)*	
Common species:	▪ *Acacia erubescens* ▪ *Acacia karroo Hayne* ▪ *Acacia nigrescens Oliv.* ▪ *Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.) Brenan* ▪ *Aristida congesta Roem. & Schult. subsp. barbicollis (Trin. & Rupr.) De Winter* ▪ *Aristida stipitata Hack.* ▪ *Asparagus spp*	▪ *Evolvulus alsinoides (L.)* ▪ *Eragrostis spp* ▪ *Grewia flava.* ▪ *Heliotropium ciliatum Kaplan* ▪ *Hermannia spp* ▪ *Ipomoea bolusiana* ▪ *Kyllinga alba Nees* ▪ *Oxygonum dregeanum Meisn.* ▪ *Panicum maximum Jacq.* ▪ *Pavonia burchellii* ▪ *Polygala amatymbica Eckl. &*

***Acacia erubescens - Grewia* Thornveld**		
	▪ *Chlorophytum recurvifolium (Baker) C.Archer & Kativu* ▪ *Clerodendrum ternatum Schinz* ▪ *Commelina africana L. var. africana* ▪ *Digitaria eriantha Steud.* ▪ *Eragrostis superba Peyr.*	*Zeyh.* ▪ *Schmidtia pappophoroides Steud.* ▪ *Solanum panduriforme Drҿge er Dunal* ▪ *Stipagrostis uniplumis (Licht.) De Winter var. uniplumis* ▪ *Terminalia sericea Burch. er DC.*
Species Examples:	 *Ammocharis cοránica* flowers	 *Ammocharis cοránica* leaves
Current Conservation Status		**Medium**

* Alien Species; *[1] Category 1 Alien Invasive; P: Protected under the ordinance;

Table 7-6 *Acacia* Mixed Woodland Vegetation Description

Acacia* mixed *woodland		
Photographic representation		
National Zones:	C-Plan Ecological Support Area; LC Vegetation Type; Sweet Limpopo Bushveld	
% Site Coverage	6.59% - eastern and southern region	
Condition:	▪ Alien encroachment evident, specifically weedy species such as *Gomphrena* present ▪ Very fragmented habitat ▪ Quicker establishing grass species – dominated by Increaser 2 and sub-climax species	
CI Species:	▪ *Sclerocarya birrea (A.Rich.)* (PT)	
Common species:	▪ *Acacia erubescens Welw. er Oliv.* ▪ *Acacia karroo Hayne*	▪ *Evolvulus alsinoides (L.) L.* ▪ *Gomphocarpus tomentosus Burch.*

Acacia* mixed *woodland		
	▪ *Acacia mellifera (Vahl) Benth. subsp. detinens (Burch.) Brenan* ▪ *Acacia nigrescens Oliv.* ▪ *Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.) Brenan* ▪ *Aristida congesta Roem. & Schult. subsp. congesta* ▪ *Aristida stipitata Hack.* ▪ *Cenchrus ciliaris L.* ▪ *Chenopodium album L.** ▪ *Combretum apiculatum Sond. subsp. apiculatum* ▪ *Commelina africana L. var. africana* ▪ *Commelina benghalensis L.* ▪ *Conyza bonariensis (L.)Cronquist** ▪ *Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummitt var. africana* ▪ *Eragrostis superba Peyr.*	*subsp. tomentosus* ▪ *Gomphrena celosioides Mart.** ▪ *Grewia flavescens Juss.* ▪ *Grewia monticola Sond.* ▪ *Ipomoea bolusiana* ▪ *Kyllinga alba Nees* ▪ *Melinis repens (Willd.) Zizka subsp. grandiflora (Hochst.) Zizka* ▪ *Monsonia glauca R.Knuth* ▪ *Panicum maximum Jacq.* ▪ *Pavonia burchellii* ▪ *Peltophorum africanum Sond.* ▪ *Schmidtia pappophoroides Steud.* ▪ *Sclerocarya birrea (A.Rich.) Hochst. subsp. caffra (Sond.) Kokwaro* ▪ *Sida ovata Forssk.* ▪ *Solanum panduriforme Droge er Dunal* ▪ *Stipagrostis uniplumis (Licht.) De Winter var. uniplumis* ▪ *Terminalia sericea Burch. er DC.*
Species Examples:	 *Terminalia sericea*	 *Justica flava*
Current Conservation Status		**Medium-Low**

Table 7-7 Transformed Areas

Transformed Areas	
Photographic representation	 
National Zones:	C-Plan Ecological Support Area; LC Vegetation Type; Sweet Limpopo Bushveld
% Site Coverage	46.61% but constantly increasing due to the construction of the ADF and coal stockyard
Condition:	▪ Alien species scattered throughout these areas ▪ Very fragmented habitat ▪ Dominated by Pioneer, Increaser 2 and sub-climax species
CI Species:	▪ *Sclerocarya birrea (A.Rich.)* (PT)
Common species:	▪ *Acacia karroo Hayne* ▪ *Achyranthes aspera* ▪ *Aristida congesta Roem. & Schult. subsp. congesta* ▪ *Cenchrus ciliaris L.* ▪ *Chenopodium album L.* ▪ *Commelina benghalensis L.* ▪ *Conyza bonariensis (L.) Cronquist* ▪ *Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummitt var. africana* ▪ *Gomphocarpus tomentosus Burch. subsp. tomentosus* ▪ *Gomphrena celosioides Mart.* ▪ *Melinis repens (Willd.) Zizka subsp. grandiflora (Hochst.) Zizka* ▪ *Monsonia glauca R.Knuth* ▪ *Nicotiana glauca* ▪ *Nidorella resedifolia DC. subsp. resedifolia* ▪ *Sida ovata Forssk.* ▪ *Solanum panduriforme Drοge er Dunal* ▪ *Urochloa brachyura (Hack.) Stapf* ▪ *Verbesina encelioides* ▪ *Xanthium strumarium L.*
Species Examples:	 
	Dactyloctenium aegyptium / *Monsonia cf angustifolia*
Current Conservation Status	**Low**

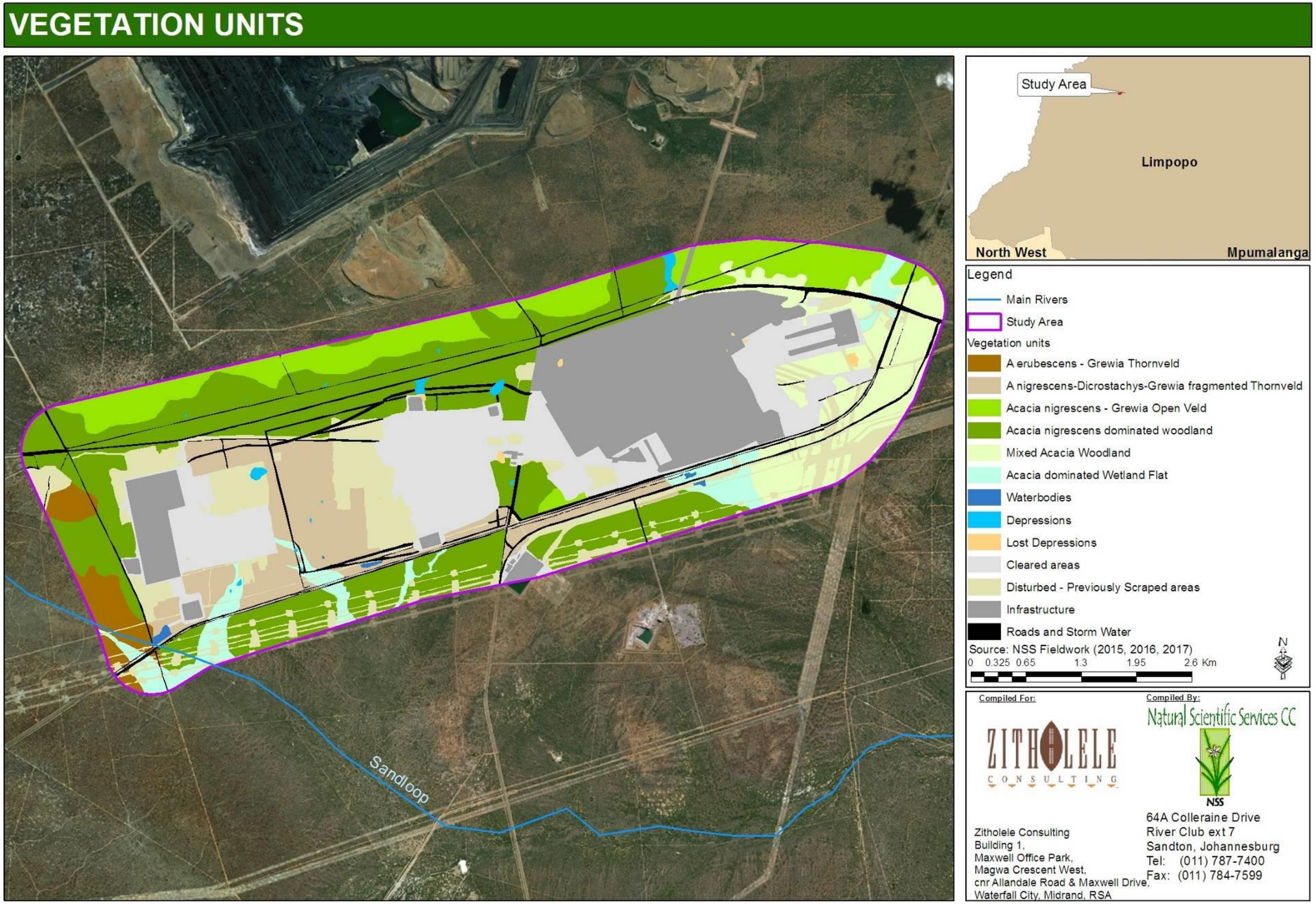


Figure 7-2 Vegetation Units for the study area

7.1.2 *Conservation Important (CI) species*

It is well documented that heterogeneous landscapes, diverse geology and a range of environmental conditions, provide a diverse number of habitats for plant species (Pickett, *et.al*. 1997; O'Farrell, 2006; KNNCS, 1999). These areas are normally associated with high levels of species endemism and richness. For example, at least 74% of the 23 threatened Highveld plant taxa occur on the crests and slopes of ridges and hills (Pfab & Victor 2002). However, homogenous landscapes, either natural or that have been transformed through historical farming practices and infrastructural development contain minimal diversity and endemism. The FDG Study Area is situated in an area that is both natural and modified through soil stockpiling, fragmentation and clearing for construction of the ADF and MPS associated infrastructure. The remaining fragmented natural areas largely consist of *Acacia* woodland habitat that is homogenous in nature.

The Threatened Plant Species Programme (TSP) is an ongoing assessment that revises all threatened plant species assessments made by Craig Hilton-Taylor (1996), using IUCN Red Listing Criteria modified from Davis *et al.* (1986). According to the TSP Red Data list of South African plant taxa (POSA, March 2015), there are 212 Red Data listed species (**Table 7-8**) within Limpopo Province (including Data Deficient species) of which 14 species are Critically Endangered (CR), 17 Endangered (EN) and 40 are Vulnerable (VU).

Table 7-8 Numbers of conservation important plant species per Red Data category within South Africa and Limpopo

Threat Status	South Africa	Limpopo	2327DA
EX (Extinct)	28	0	0
EW (Extinct in the wild)	7	2	0
CR PE (Critically Endangered, Possibly Extinct)	57	2	0
CR (Critically Endangered)	332	14	0
EN (Endangered)	716	17	0
VU (Vulnerable)	1 217	40	0
NT (Near Threatened)	402	21	1
Critically Rare (known to occur only at a single site)	153	5	0
Rare (Limited population but not exposed to any direct or potential threat)	1 212	45	1
Declining (not threatened but processes are causing a continuing decline in the population)	47	19	0
LC (Least Concern)	13 856	3598	287
DDD (Data Deficient - Insufficient Information)	348	13	0
DDT (Data Deficient - Taxonomically Problematic)	904	34	1
Total spp. (including those not evaluated)	**23 399**	**4799**	**311**

**POSA last updated in 2012 – data may be out of date

From the POSA website (QDS 2327DA) and the data supplied by Limpopo for the surrounding farms, 3 CI species have been recorded in the region. The most threatened species recorded within the QDS is the *Eulalia aurea,* which is listed as **Near Threatened**. However, habitat availability for this species is unlikely. *Corchorus psammophilus* could occur on site based on its habitat requirements. The conservation status of these species and others, their habitat preferences and the possibility of occurring on site has been provided in **Table 8.2** below. Although no Red Listed species were recorded, *Ammocharis coranica* and *Crinum buphanoides* were considered a Protected species under the Nature Conservation Ordinance, 12 of 1983, before Limpopo Province released more recent legislation [which repeals the Ordinance] - Limpopo Environmental Management Act NO. 7 OF 2003, the Protected Status of these species were revised and are no longer on the list.

Government Notice 39433 of 2015 provides the latest List of Protected Tree Species within the borders of South Africa under the NFA. A number of CI Protected Tree species were located during this study. Those found are represented in **Figure 7-3 and Table 7-9.**

- *Boscia albitrunca* (Burch.) Gilg & Gilg-Ben.
- *Sclerocarya birrea* (A.Rich.) Hochst. subsp. caffra (Sond.) Kokwaro
- *Spirostachys africana* Sond.

Boscia albitrunca (Burch.) Gilg & Gilg-Ben and *Sclerocarya birrea* are both Keystone species. Further information on these species and their importance is provided in **Section 9.1.5** below. In terms of Section 15(1) of the *National Forests Act* (NFA; Act 84 of 1998) forest trees or Protected Tree Species may not be cut, disturbed, damaged, destroyed and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold – except under license granted by the Department of Agriculture, Forestry and Fisheries (DAFF) or a delegated authority.

Table 7-9 Species recorded in the surrounding farms QDG (PRECIS Data)

Family	Species	Threat status	Habitat	LoO
EUPHORBIACEAE	*Acalypha caperonioides Baill. var. caperonioides*	DDT	In grassland, *Brachystegia* woodland and at margins of vleis, typically after grass fires.	Unlikely
POACEAE	*Eulalia aurea (Bory) Kunth*	NT	In water, along rivers and in occasionally inundated soils.	Unlikely
EUPHORBIACEAE	*Euphorbia waterbergensis R.A.Dyer*	Rare	Quartzite ridges and outcrops, mixed bushveld, 900-1100 m.	Unlikely
MALVACEAE	*Corchorus psammophilus Codd*	Threatened	Sandy flats in open *Terminalia sericea* veld.	Possible

NT = Near Threatened; DDT= Data Deficient Taxonomically; P = Protected Limpopo

Spirostachys africana bark

Spirostachys africana leaves

Boscia creating habitat and shade for numerous faunal species

Sclerocarya birrea- Fruit

Figure 7-3 Examples of the CI species located within the study area

7.1.3 *Local Disturbances*

Alien species, especially invasive species, are a major threat to the ecological functioning of natural systems and to the productive use of land. These plants can have the following negative impacts on our natural systems:

- A loss of biodiversity and ecosystem resilience as alien species out-compete indigenous flora and in doing so reduce complex ecosystems to mono-cultures therefore destroying habitats for both plant and animals;
- Through increased evaporative transpiration rates 'alien thickets', reduce the amount of groundwater thus reducing the volume of water entering our river systems;
- Alien invasive species dry out wetlands and riparian areas thereby increasing the potential for erosion in these areas;
- The loss of potentially productive land, and the loss of grazing potential and livestock production;
- Poisoning of humans and livestock;
- An increase in the cost of fire protection and damage in wildfires due to alien invasive stands being denser than natural vegetation and the wood more resinous, creating hotter fires;
- An increased level of erosion, following fires in heavily invaded areas, as well as the siltation of dams.

Two main pieces of legislation are applicable to this section:

- Conservation of Agriculture Resources Act, 1983 (Act No. 43 of 1983) (CARA)
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) (NEM:BA)
    - NEM:BA Regulations August 2014 -Government Gazette Vol 526, No. 32090

In terms of the amendments to the regulations under CARA, landowners are legally responsible for the control of alien species on their properties. Declared weeds and invasive species had been divided into three categories in accordance with the Act.

These categories are as follows:

Category 1: Declared weeds that are prohibited on any land or water surface in South Africa. These species must be controlled, or eradicated where possible.

Category 2: Declared invader species that are only allowed in demarcated areas under controlled conditions and prohibited within 30m of the 1:50 year flood line of any watercourse or wetland.

Category 3: Declared invader species that may remain, but must be prevented from spreading. No further planting of these species are allowed.

The protection of our natural systems from invasive species is further strengthened within Sections 70-77 of NEMBA. Chapter 5 of this Act specifically deals with Species and

Organisms Posing Potential Threats to Biodiversity. To summarise, the purpose of Chapter 5 is to:

- Prevent the unauthorised introduction and spread of alien species and invasive species to ecosystems and habitats where they do not naturally occur.
- To manage and control alien species and invasive species to prevent or minimise harm to the environment and to biodiversity in particular.
- To eradicate alien species and invasive species from ecosystems and habitats where they may harm such ecosystems or habitats.

Furthermore Section 73 (2) states that a person who is the owner of land on which a listed invasive species occurs must:

- Notify any relevant competent authority, in writing, of the listed invasive species occurring on that land;
- Take steps to control and eradicate the listed invasive species and to prevent it from spreading; and
- Take all the required steps to prevent or minimise negative impacts to biodiversity.

The regulations for this Act were issued for public comment on 3 April 2009 (Government Gazette Vol. 526, No. 32090) and promulgated in August 2014 (Government Gazette Vol. 590, No. 37885). The regulations list the categories for alien and listed invasive species. These are:

- Exempted species.
- **Category 1a** Listed Invasive Species -Species requiring compulsory control.
- **Category 1b** Listed Invasive Species - Invasive species controlled by an invasive species management programme.
- **Category 2** Listed Invasive Species- Invasive species controlled by area (2).
- **Category 3** Listed Invasive Species - Invasive species controlled by activity (3).

An updated set of Invasive Species Lists (as per the NEMBA Regulations) were published on 29 July 2016. This legislation became law on 1 October 2016 and replaced any earlier lists. Note: A species may be listed in different categories for different parts of the country.

According to POSA, over 55 species of Aliens have been recorded within the QDS. Of these 8 species are considered Category 1b species under NEMBA and must be controlled from any property on which they are found (i.e. an invasive species management programme needs to be in place). Patches of natural areas remain within the study area, specifically within the western section and therefore alien species did not completely dominate the landscape. Category 1 species that were identified on site occurred within the soil stockpile areas and included species such as *Nicotiana glauca* and *Xanthium strumarium*. (**Figure 7-4** and **Table 7-10**). These species will need to be controlled by the EO and team as part of MPS's management plan. A list of the main species recorded is supplied in **Table 7-10**.

Table 7-10 Main Alien Invasive Species found within the Study Area

FAMILY	SPECIES	GROWTH FORMS	CARA	NEMBA
AMARANTHACEAE	*Gomphrena celosioides Mart.*	Herb	Weed	Weed
ASTERACEAE	*Conyza cf. bonariensis (L.) Cronquist*	Herb	Weed	Weed
AMARANTHACEAE	*Achyranthes aspera*	Herb	1	
ASTERACEAE	*Xanthium strumarium L.*	Herb	1	1b
ASTERACEAE	*Verbesina encelioides*	Herb/shrub	Weed	Weed
CHENOPODIACEAE	*Chenopodium album L.*	Herb	Weed	Weed
SOLANACEAE	*Nicotiana glauca*	Shrub, tree	1	1b
VERBENACEAE	*Verbena cf bonariensis*	Herb		1b

* Highlights in green represent Category 1 species through either CARA or NEMBA

One species that was prolific in the soil stockpile areas close to the MPS was Golden crownbeard, (*Verbesina encelioides*). This species is part of the Asteraceae family from North America to the tropics and is an annual flowering shrub. As an invasive weed, it grows aggressively in stands within sandy soils, shading out indigenous vegetation, competing for nutrients and water as well as producing chemicals that are toxic to indigenous plants. Flowers produce up to 350 wind dispersed seeds by both cross- and self-pollination and stands self-seed annually. The seeds exhibit highest rate of germination in open, disturbed areas with sandy soils.

Conyza bonariensis

Achyranthes aspera

Nicotiana glauca

Nicotiana glauca in transformed area

Gomphrena celosioides

Verbesina encelioides

Figure 7-4 Evidence of Alien species found within the study area

7.2. Faunal Communities

NSS surveys in and around the FGD study area yielded 43 mammal, 158 birds, 20 reptile, 16 frog, nine butterfly, two dragonfly and one scorpion species, greatly contributing to the overall Medupi inventory. Context for these figures is provided in **Table 7-11** which gives a comparison of the observed species richness, with that expected at both local and regional scales**.** From **Table 7-11** it is evident that remaining natural and semi-natural areas in and around Medupi support a considerable proportion of the region's faunal diversity. Lists of potentially occurring faunal species are provided in **Appendices 2-9,** and the bat call data are presented in **Appendix 9**. Examples of some of the observed species are shown in **Figure 7-6** to **Figure 7-11**.

Table 7-11 Summary of faunal species richness in the study area as compared to a regional scale

FAUNAL GROUP	SPECIES RICHNESS						
	POTENTIAL			OBSERVED			
	REGION[1]	QDS[2]	MEDUPI[3]	BEC (2006)	FGD	MEDUPI	VICINITY[4]
Mammals	124	41	89	18	43	47	54
Birds	345	314	304	67	158	183	211
Reptiles	96	83	47	7	20	20	46
Frogs	27	22	20	8	16	19	14
Butterflies	176	149	88	3	9	26	15
Dragonflies & Damselflies	66	66	48	0	2	3	1
Scorpions	11	11	11	0	1	1	2
Megalomorph Spiders	4	4	2	0	0	0	1

KEY

[1]Species recorded during atlas projects within the four regional QDSs 2327CB, 2327DA, 2327CD & 2327DC

[2]Species that have been recorded during atlas projects within the QDS 2327DA wherein Medupi is situated

[3]Species that are likely to occur (LoO of 2 or 3) in Medupi

[4]Species recorded during NSS studies in the vicinity: Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

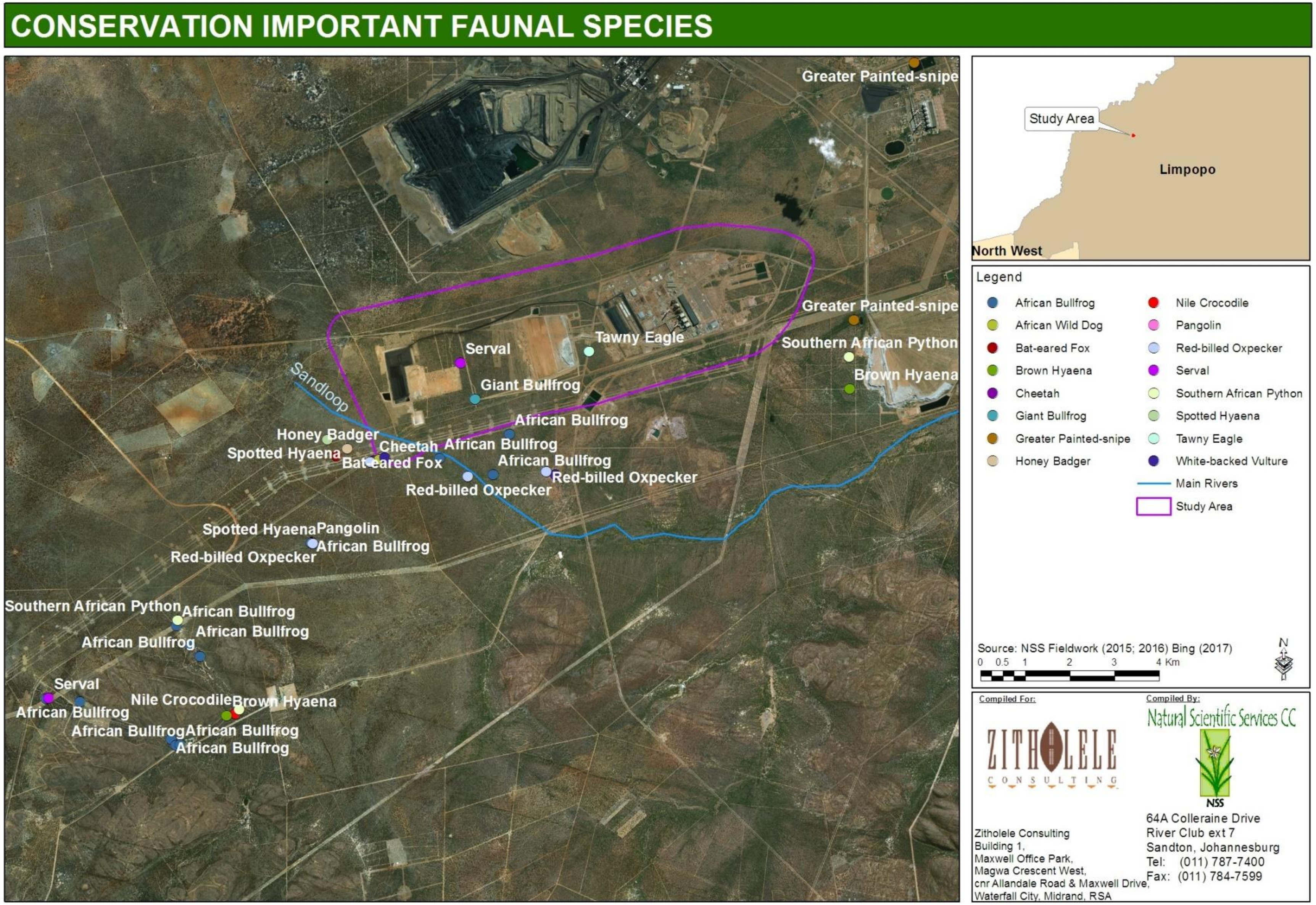


Figure 7-5 Localities of Conservation Important Fauna

Notable faunal observations in and around the FGD study area included Serval (**NT**), Brown Hyaena (**NT**), White-backed Vulture (**EN**), Tawny Eagle (**VU**) and Red-billed Oxpecker (**NT**), African Bullfrog (**PS**) and Giant Bullfrog (**NT**), and also an out of range observation of Sanderling (nearest SABAP 2 record 190km east near Polokwane), and a 300km westwards range extension on Green House Bat (*Scotophilus viridis*) based on recorded bat call data.

Local farmers reported the presence Leopard (**VU**), Cheetah (**VU**), African Wild Dog (**EN**), Spotted Hyaena (**NT**) and Pangolin (**VU**) as well as Southern African Python (**PS**) and Nile Crocodile (**EN**, now absent). African Bullfrogs were found to be particularly abundant in the more natural areas in and near the southern section of Medupi, where there are a number of breeding sites for this species. As both bullfrog species appear to utilize the same type of breeding habitat (Du Preez & Carruthers, 2009), this area and its pans might also provide suitable breeding habitat for Giant Bullfrog. However, only a dam along the southern boundary of the ADF yielded potential signs of this species in the form of a single froglet.

7.2.1 *Mammals*

Of the approximately 124 regionally-occurring mammal species some 89 species (with a LoO of 1, 2 or 3 in **Appendix 2**) are considered likely to occur, based on the species' known distributions and the diversity of available habitats where natural and semi-natural areas remain in and around the southern section of Medupi. MammalMap (2018) has records for 41 species from the four regional QDSs. To date a total of 43 mammal species (36 observed, seven anecdotal) has been recorded in the FGD study area (47 species for the greater Medupi premises). On a regional scale 18 Conservation Important (CI) mammal species occur naturally (i.e. excluding managed game species). Of these, eight are likely to occur in the study area, one of which was recorded on site, i.e. Serval (**NT**; **Figure 7-5)**.

The sandy substrates of the Limpopo Sweet Bushveld provide suitable habitat for the **VU** Pangolin and a host of CI carnivores. Observed species included Serval (**NT**) on the ADF site and Brown Hyaena (**NT**) further to the south-west. Local farmers reported the presence of illusive species such as Leopard (**VU**), Cheetah (**VU**), Spotted Hyaena (**NT**; captured on NSS motion camera but image is poor quality), Pangolin (**VU**) and African Wild Dog (**EN**). These are wide ranging, free-roaming species whose persistence in the region is threatened by persecution and structures that fragment their habitat and restrict their movement such as fences (electric and Bonnox), roads and mines. Other carnivore species which may occur include Black-footed Cat (**VU**), African Weasel (**NT**), Honey Badger (**PS**) and Cape Fox (**PS**).

Serval
(*Leptailurus serval*)

Caracal
(*Caracal caracal*)

Black-backed Jackal
(*Canis mesomelas*)

Black-backed Jackal with prey

African Civet
(*Civettictis civetta*)

Aardwolf
(*Proteles cristatus*)

Slender Mongoose
(*Galerella sanguinea*)

Warthog
(*Phacochoerus africanus*)

Giraffe
(*Giraffa camelopardalis*)

Plains Zebra
(*Equus quagga*)

Blue Wildebeest
(*Connochaetes taurinus*)

Kudu
(*Tragelaphus strepsiceros*)

Waterbuck
(*Kobus ellipsiprymnus*)

Impala
(*Aepyceros melampus*)

Common Duiker
(*Sylvicapra grimmia*)

Grey Rhebok
(*Pelea capreolus*)

Gemsbok
(*Oryx gazelle*)

Tree Squirrel
(*Paraxerus cepapi*)

Chacma Baboon
(*Papio ursinus*)

Aardvark
(*Orycteropus afer*)

Figure 7-6 Examples of some of the mammal species detected in the study area

Juliana's Golden Mole (**EN**), which has a very small and fragmented distribution, mainly between Pretoria and Polokwane, is considered highly unlikely to occur in Medupi. Three elephant shrew species may occur sympatrically in the area, but can be distinguished by habitat preference and size. Rock Elephant-shrew is restricted to rocky substrates, whereas the Bushveld (length 24 cm; mass 50 g) and Short-snouted (length 21 cm; mass 44 g) elephant-shrews occur in sandy substrates (Stuart & Stuart, 2007). Other insectivores that may occur in sandy habitats include the Reddish-grey and Lesser musk shrews, as well as Southern African Hedgehog (**NT**).

Table 7-12 Present and potentially occurring CI mammal species

ORDER & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[1,3,5,6]	MEDUPI*	VICINITY**	ATLAS[6]
		GLOBAL RED LIST[1]	S.A. RED LIST[2,3]	S.A. TOPS LIST[4]				
AFROSORICIDA (Golden moles)								
Neamblysomus julianae	Juliana's Golden Mole	EN (U)	EN	VU	4			
EULIPOTYPHLA (Hedgehogs & shrews)								
Atelerix frontalis	Southern African Hedgehog	LC (S)	NT	PS	3			
CHIROPTERA (Bats)								
Cloeotis percivali	Percival's Short-eared Trident Bat	LC (U)	EN	-	4			
PHOLIDOTA (Pangolin)								
Manis temminckii	Pangolin	VU (D)	VU	VU	4	x		x
RODENTIA (Rodents)								
Dasymys incomtus	Water Rat	LC (U)	NT	-	4			
CARNIVORA (Carnivores)								
Crocuta crocuta	Spotted Hyaena	LC (D)	NT	PS	4			
Hyaena brunnea	Brown hyaena	NT (S)	NT	PS	3	x	x	x
Acinonyx jubatus	Cheetah	VU (D)	VU	VU	4	x		x
Panthera pardus	Leopard	VU (D)	VU	VU	3	x	x	x
Panthera leo	Lion	VU (D)	VU	VU	5			
Felis nigripes	Black-footed Cat	VU (D)	VU	PS	4			
Leptailurus serval	Serval	LC (S)	NT	PS	1	x		
Lycaon pictus	African Wild Dog	EN (D)	EN	EN	4	x		
Vulpes chama	Cape Fox	LC (S)	LC	PS	3			
Mellivora capensis	Honey Badger	LC (D)	LC	PS	3			x
Poecilogale albinucha	African Weasel	LC (U)	NT	-	2			
PROBOSCIDEA (Elephant)								
Loxodonta africana	African Elephant	VU (I)	LC	PS	5			
PERISSODACTYLA (Zebras)								
Ceratotherium simum	White Rhinoceros	NT (I)	NT	PS	5	x	x	
Diceros bicornis	Black Rhinoceros	CR (I)	EN	EN	5			
RUMINATA (Even-toed ungulates)								
Connochaetes gnou	Black Wildebeest	LC (I)	LC	PS	5			
Damaliscus lunatus	Tsessebe	LC (D)	VU	EN	5	x	x	
Hippotragus equinus	Roan	LC (D)	EN	VU	5			
Hippotragus niger	Sable	LC (S)	VU	-	5		x	
Redunca arundinum	Reedbuck	LC (S)	LC	PS	4			x
Redunca fulvorufula	Mountain Reedbuck	EN (D)	EN	-	4		x	

ORDER & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[1,3,5,6]	MEDUPI*	VICINITY**	ATLAS[6]
		GLOBAL RED LIST[1]	S.A. RED LIST[2,3]	S.A. TOPS LIST[4]				
Pelea capreolus	Grey Rhebok	**NT (D)**	**NT**	**-**	2		x	
Ourebia ourebi	Oribi	LC (D)	**EN**	**EN**	5			

Key

Status: CR = Critically Endangered; D = Declining; EN = Endangered; I = Increasing; LC = Least Concern; NT = Near Threatened; PS = Protected Species; S = Stable; U = Unknown; VU = Vulnerable

Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low; 5 = May occur as a managed population

Sources: [1]IUCN (2017.3); [2]SANBI & EWT (unpubl.); [3]Monadjem *et al.* (2010); [4]ToPS List (2015); [5]Friedmann & Daly (2004); [6]MammalMap (2018)

*Includes records from BEC (2006) and other NSS projects at Medupi

**Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

Hedgehogs inhabit a diversity of habitats in the temperate to semi-arid interior of South Africa where there is thick, dry vegetation cover suitable for nesting, and an abundance of insects and other food items (Skinner & Chimimba 2005; Stuart & Stuart 2007). Although widespread, hedgehogs are nowhere common. Rupicolous fauna (e.g. Jameson's Red Rock Rabbit, Klipspringer, Rock Dassie) are largely precluded from Medupi by a lack of significant rocky outcrops. However, a distinct stony/rocky substrate south-west of Medupi may provide habitat for Rock Elephant-shrew and Namaqua Rock Mouse.

More or less heavily fenced game areas immediately south and south-west of Medupi support at least nine of the 22 regionally occurring large game species. These include Plains Zebra, Giraffe, Nyala, Blue Wildebeest, Red Hartebeest, Blesbok, Waterbuck, Eland and Gemsbok. The **NT** Grey Rhebok was seen just south of Medupi. Multiple fences along boundaries likely prevent access of larger species such as most carnivores, ungulates, Aardvark and Pangolin. Chacma Baboon (*Papio ursinus*) were observed jumping fences without much difficulty to drink at a water trough and as such it is likely that other primates such as Vervet Monkey and Lesser Galago are also present.

Analysis of bat acoustic data suggests the presence of Cape Serotine and Green House Bat. The latter species record may represent a 300km westwards range extension, although its presence cannot be conclusively supported without an actual capture. Monadjem *et al.* (2010), however, do highlight that the species is likely under sampled and probably occupies a broader range than currently known.

Several other bat species certainly occur in the study area but most likely comprise species that do not require specialised subterranean roosting habitat, such as Mauritian Tomb Bat (*Taphozous mauritianus*), Egyptian Free-tailed Bat (*Tadarida aegyptiaca*), Rusty Pipistrelle (*Pipistrellus rusticus*), Yellow-bellied House Bat (*Scotophilus dinganii*) and Midas Free-tailed Bat (*Mops midas*). The Rusty Pipistrelle has been recorded by NSS in the nearby vicinity (Grootegeluk Mine 2009-2010). It frequents savanna woodland where it roosts in rock crevices and under tree bark (Stuart & Stuart, 2007). Smither's, Geoffroy's, Darling's and Bushveld horseshoe bats may occur based on distribution. However, their preferred roosting habitat in the form of subterranean caves or mine shafts is distinctly lacking (although it should be noted that all of these species have, occasionally, been known to roost in trees or buildings and as such their presence in Medupi, albeit low, cannot be ruled out). Little is known regarding the ecology of the Botswana Long-eared Bat (*Laephotis botswanae*) which may occur.

7.2.2 *Birds*

Of the approximately 345 regionally-occurring bird species some 304 species (with a LoO of 1, 2 or 3 in **Appendix 3**) are considered likely to occur, based on the species' known distributions and the diversity of available habitats within the FGD study area and greater Medupi. A total of 314 species was recorded in QDSs 2327CB and 2327DA and pentads 2340_2730 and 2340_2725 covering the study area during the SABAP1 (310 spp.) and 2 (218 spp.), respectively.

To date, NSS has detected 158 bird species in and near the FGD study area (183 from all studies for the greater Medupi). Of the 20 regionally occurring CI bird species, eight are likely to occur within the study area (**Table 7-14**), two of which were found to be present namely White-backed Vulture (**EN**) and Tawny Eagle (**EN**).

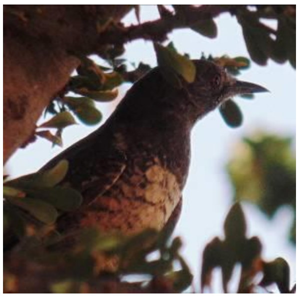
A single White-backed Vulture (**EN**) was observed flying high near the southern boundary of Medupi. A key aspect in designation of the area south of Medupi as a CBA1 in the Limpopo C-Plan is said to be its importance with regards to this species (LEDET pers. comm.). White-backed Vultures are generally associated with dry woodland and tall trees, which they are dependent upon for breeding. Although no nests were detected within the boundaries of Medupi, trees suitable for nesting (in terms of height, structure and species) do occur to the south and south-west. The species constructs large stick nests at the tops of tall trees (>5 m) particularly *Terminalia prunoides*, *Acacia nigrescens*, *Boscia albitrunca* and *B. foetida*, normally nesting in small colonies of two to six pairs. The total population of White-backed Vulture is estimated at less than 10 000 individuals and is in decline. The greatest threats include a loss of habitat and decreased food availability. Collision, electrocution, poisoning and drowning also threaten this species (Barnes, 2000).

Tawny Eagle (**EN**) was observed where the ADF is located. The species inhabits mostly wooded to lightly wooded areas but is generally scarce outside of major reserves. This once widespread raptor has suffered major range contractions having lost as much as 20% of its regional population in recent years. Currently there are probably less than 800 pairs in South Africa making it one of the most threatened eagles in the country. The fact that this species may occasionally scavenge makes it particularly susceptible to poisoning. Additionally, the species suffers from persecution mainly through shooting and gin traps but drowning in sheer-walled water reservoirs accounts for many deaths too. Other threats include collision and electrocution with transmission lines, roadkill and reduction in prey base due to habitat transformation (Barnes, 2000).

Although no longer Red Listed (Taylor *et al.* 2015), it is still worth mentioning that Red-billed Oxpeckers were observed to the south and south-west of Medupi. Although formerly widespread these birds suffered local population declines particularly in the Eastern Cape and Pilanesberg National Park as a result of hunting of game and the use of arsenic-based ‘purple label’ cattle dips which poison both ticks and oxpeckers. More recent ongoing re-introductions and the use of oxpecker-friendly green-label dips, together with the oxpecker’s adaptability to feed on domestic livestock, are bringing them back from localised extinctions (Barnes, 2000).

Other potentially occurring avifaunal CI species recorded during NSS studies in the vicinity include the **EN** Cape and Lappet-faced Vultures (motion camera at carcass, Mafutha Project, pentad 2340_2705, farm Geelbuilt), the **VU** Greater Painted-snipe (nomadic, locally scarce species with a highly fragmented population; detected twice at Matimba Power Station during summer, pentads 2335_2735 and 2340_2735), the **NT** Kori Bustard (uncommon resident especially outside reserves; motion camera, Mafutha Project, pentad 2340_2705, farm Geelbuilt), **NT** European Roller (nonbreeding Palaearctic migrant; Mafutha Project 2340_2720) and **NT** Short-clawed Lark (uncommon resident; Mafutha Project, pentad 2340_2705, farm Geelbuilt).

European Bee-eater
(*Merops apiaster*)



Barred Wren-warbler
(*Calamonastes fasciolatus*)

Pied Crow
(Corvus albus)

Brown-hooded Kingfisher
(*Halcyon albiventris*)

Red-billed Oxpecker
(*Buphagus erythrorhynchus*)

Rufous-cheeked Nightjar
(*Caprimulgus rufigena*)

Swainson's Spurfowl
(*Francolinus swainsonii*)

Tawny Eagle
(Aquila rapax)

Pearl-spotted Owlet (*Glaucidium perlatum*) | Southern Pied-babbler (*Turdoides bicolor*) | Spotted Eagle-owl (*Bubo africanus*) | Barn Swallow (Hirundo rustica)

Figure 7-7 Examples of some of the bird species detected in the study area

Provided in **Figure 7-8** is a comparison of the numbers of bird species with different feeding habits, which are listed for pentads 2340_2725 and 2340_2730 (SABAP 2, 2018), and which have been recorded in Medupi by NSS and BEC (2006). Species were categorized according to a modified version of Newman's (2002) 12 bird categories (**Table 7-13**).

Table 7-13 Newman's (2002) modified bird categories

CATEGORY	DESCRIPTION
1. Ocean birds	Albatrosses, gannets/boobies, gulls, penguins, petrels, prions, shearwaters, skimmer, skuas, subAntartctic birds, terns, & tropic-/frigatebirds.
2. Inland water birds	Pelicans, cormorants, herons, egrets, storks, hamerkop, flamingos, spoonbill, ibises & finfoot.
3. Ducks & wading birds	Ducks, geese, grebes, coot, gallinules, crakes, flufftails, snipes, plovers, lapwings, waders, jacanas, oystercatchers, curlews, avocet & stilts.
4. Large terrestrial birds	Thicknees, pratincoles, coursers, korhaans, bustards, cranes, quail, francolins, spurfowl, buttonquail, guineafowl, ostrich & secretarybird.
5. Raptors	Vultures, kites, eagles, buzzards, sparrowhawks, hawks, harriers, falcons & kestrels.
6. Sandgrouse, doves, etc	Sandgrouse, doves, pigeons, parrots, lovebirds, trogon, turacos & go-away birds (louries), cuckoos & coucals.
7. Owls & nightjars	Owls & nightjars.
8. Aerial feeders, etc	Swallows, martins, swifts, mousebirds, bee-eaters, kingfishers, rollers, hoopoes, hornbills, barbets, woodpeckers, wryneck & honeyguides.
9. Cryptic & elusive insect-eaters	Larks, finchlarks, pipits, wagtails, drongos, black flycatcher, cuckooshrikes, crows, orioles, bulbuls, tits, babblers, thrushes, chats & robins.
10. Regular insect-eaters	Warblers, apalises, titbabblers, eremomelas, carmoropteras, grassbird, cisticolas, prinias, flycatchers, batises, shrikes, boubous, tchagras, helmetshrikes & starlings.
11. Oxpeckers & nectar feeders	Sunbirds, oxpeckers, white-eyes & queleas.
12. Seedeaters	Sparrows, weavers, widow birds, bishops, finches, firefinches, waxbills, manikins, whydahs, canaries, siskins & buntings.

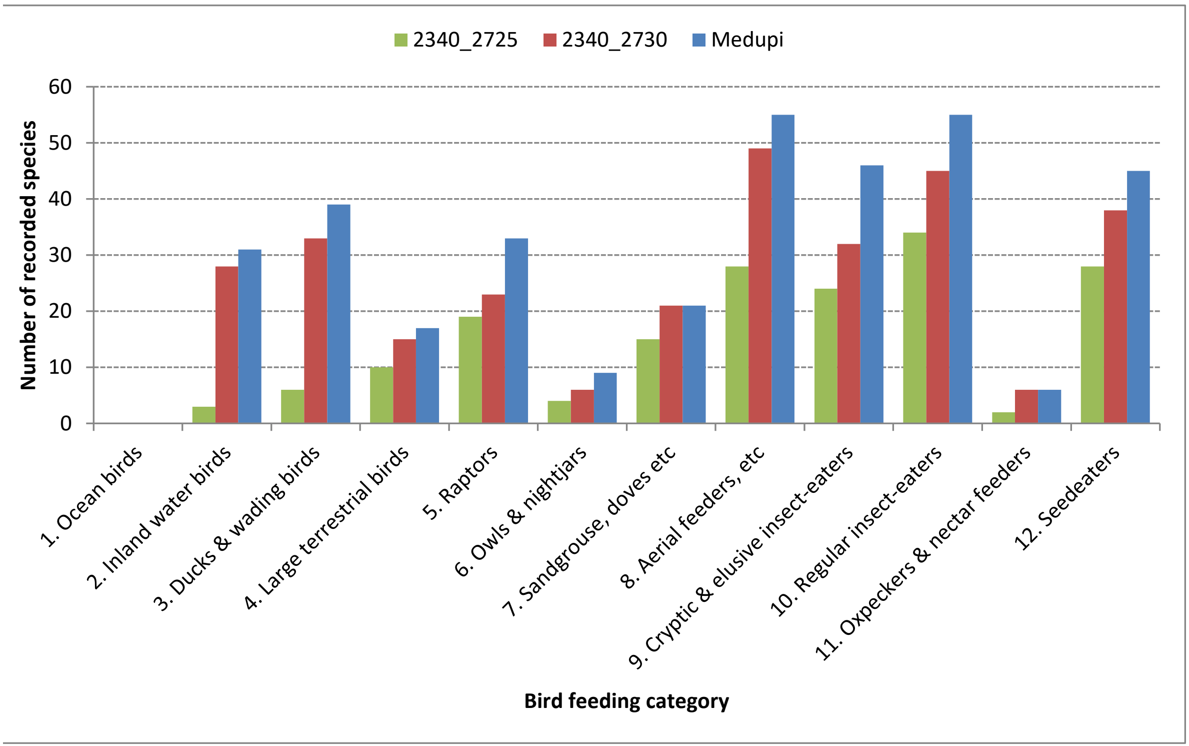


Figure 7-8 Comparison of the number of bird species with different feeding habits, recorded in pentads 2340_2725 and 2340_2730 during the SABAP 2, and in Medupi by NSS

Evidently the pattern of bird diversity recorded in Medupi is similar to that recorded in the region during the SABAP 2. The extensive tracts of relatively undisturbed Limpopo Sweet Bushveld south and south-west of Medupi supports high representations of aerial feeding, regular insect- and seed-eating species. The disproportionately high numbers of waterbird species in Medupi compared to pentad 2340_2725 is attributable to the presence of several large shallow (albeit artificial) waterbodies with extensive wading bird habitat, which is lacking southwards where very few waterbird species were detected.

Table 7-14 Present and potentially occurring CI bird species

CATEGORY & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[3]	MEDUPI*	VICINITY**	ATLAS[3]
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. TOPS LIST[2]				
2. Inland water birds								
Ciconia nigra	Black Stork	LC (U)	**VU**	-	4	4		x
Leptoptilos crumeniferus	Marabou Stork	LC (I)	**NT**	-	4	4		x
Mycteria ibis	Yellow-billed Stork	LC (D)	**EN**	-	4	4		x
Phoenicopterus roseus	Greater Flamingo	LC (I)	**NT**	-	4	4		x
Phoeniconaias minor	Lesser Flamingo	**NT (D)**	**NT**	-	4	4		x
Glareola nordmanni	Black-winged Pratincole	**NT (D)**	**NT (NB)**	-	4	4		x
3. Ducks & wading birds								
Nettapus auritus	African Pygmy-goose	LC (D)	**VU**	-	4	4		
Oxyura maccoa	Maccoa Duck	**NT (D)**	**NT**	-	4	4		x
Rostratula benghalensis	Greater Painted-snipe	LC (D)	**VU**	-	4	4	x	
4. Large terrestrial birds								

CATEGORY & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[3]	MEDUPI*	VICINITY**	ATLAS[3]
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. TOPS LIST[2]				
Sagittarius serpentarius	Secretarybird	**VU (D)**	**VU**	**-**	2	3		x
Ardeotis kori	Kori Bustard	**NT (D)**	**NT**	**PS**	4	4	x	
5. Raptors								
Gyps coprotheres	Cape Vulture	**VU (D)**	**EN**	**EN**	2	1	x	x
Gyps africanus	White-backed Vulture	**EN (D)**	**EN**	**EN**	1	1	x	x
Torgos tracheliotos	Lappet-faced Vulture	**VU (D)**	**EN**	**EN**	2	2	x	x
Aquila rapax	Tawny Eagle	LC (S)	**EN**	**EN**	1	1	x	x
Polemaetus bellicosus	Martial Eagle	**VU (D)**	**EN**	**EN**	2	2		x
Terathopius ecaudatus	Bateleur	**NT (D)**	**EN**	**EN**	4	4		x
Falco biarmicus	Lanner Falcon	LC (I)	**VU**	**-**	2	3		
8. Aerial feeders, etc								
Coracias garrulus	European Roller	**NT (D)**	**NT**	-	2	2	x	x
9. Cryptic & elusive insect-eaters								
Certhilauda chuana	Short-clawed Lark	LC (D)	**NT**	**-**	4	4	x	

Key

Status: D = Declining; EN = Endangered; I = Increasing; LC = Least Concern; NB = Non-breeding; NT = Near Threatened; PS = Protected Species; S = Stable; U = Unknown population trend; VU = Vulnerable

Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low

Sources: [1]Taylor *et al.* (2015); [2]ToPS List (2015); [3]SABAP 1 & 2 (2018)

*Includes records from BEC (2006) and other NSS projects at Medupi

**Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

7.2.3 *Reptiles*

Of some 96 regionally-occurring reptile species, 50 are considered highly likely to occur (with a LoO of 1 or 2 in **Appendix 4**), based on the species' known distributions and the diversity of available habitats in and around the FGD study area. An additional 33 species may also occur (LoO 3 in **Appendix 4**). Available atlas data include records for 47 species from the four regional QDSs (ReptileMap, 2018; Bates *et al.* 2014). At a more local scale NSS has recorded 46 species in the general vicinity (Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station). To date, a total of 20 reptile species (15 observed, four anecdotal) have been detected by NSS and / or reported anecdotally within the study area (**Appendix 4** and **Figure 7-9**).

Fossorial species, terrapins and snakes in general, are underrepresented due to the difficulties involved in their detection. Of the two regionally-occurring CI reptile species, only one, the Southern African Python, is likely to occur naturally. The other species is the Nile Crocodile, which apart from occurring in the Limpopo River, is largely restricted to managed populations within reserves in the region (**Table 7-15**). Although no pythons were detected they likely occur throughout the study region and anecdotal reports were numerous, particularly near water to the south-west of Medupi. A large individual was photographed by Mr Gavin Cronk (farm manager) eating a Bushbuck ram at a dam in the south-west (**Figure 7-9**). Although currently listed as Least Concern (LC) these large snakes are classified as **Protected** Species (ToPS, 2015). They are threatened by commercial trade and listed as a

CITES Appendix II species due to high levels of persecution for their skin which is used in the leather industry. A single Nile Crocodile (**EN**) of approximately 1.5m was reportedly observed at a dam also to the south-west of Medupi. The individual was seen approximately eight years ago and has not been seen since.

The local diversity of reptiles is largely comprised of a subset of tortoises, snakes, lizards and geckos that are generally adapted to the soft red sands that characterise the Limpopo Sweet Bushveld. Although a band of rockier substrate is present to the south-west of Medupi, it is probably too small and fragmented to support any of the locally occurring yet strictly rupicolous species such as Waterberg Dragon Lizard (recorded at the base of a small rocky ridge on a neighbouring farm to the west), Wahlberg's Snake-eyed Skink, and Southern Rock Agama.

Large trees, *Boscia* spp. in particular, proved to be important microhabitats for reptiles and frequently yielded Wahlberg's Velvet Gecko, Common Dwarf Gecko, Variable Skink, Southern Rock Monitor and Southern Tree Agama. Two tortoise species were recorded south of Medupi. Leopard Tortoise was the more widespread and ubiquitous of the two, with sightings of Speke's Hinged-back Tortoise[5] being far less frequent and more closely associated with rocky substrates. No Kalahari Tent Tortoises were detected.

Observed venomous species included Puff Adder, Boomslang and Black Mamba, but species such as Vine Snake, Snouted Cobra and various other elapids certainly occur. Some interesting, less frequently encountered species (which may occur but were not detected) include; Serrated Hinged Terrapin, Serrated Tent Tortoise, Jones' Girdled Lizard, Kalahari Dwarf Worm Lizard, Cape Worm Lizard, Bicoloured Quill-snouted Snake, Jalla's Sand Snake, Two-striped Shovel-snout, Common Shield Cobra, Sundevall's Garter Snake, Eastern Tiger Snake, Limpopo Dwarf Burrowing Skink, Common Purple-glossed Snake and Eastern Bark Snake.

c.f. Speke's Hinged-back Tortoise (*Kinixys spekii*)

Leopard Tortoise (*Stigmochelys pardalis*)

Spotted Sand Lizard (*Pedioplanis l. lineoocellata*)

Waterberg Dragon Lizard (*Smaug breyeri*)

[5] Identification tentative due to sympatry with the similar congeneric Lobatse Hinged-back Tortoise.

Southern Tree Agama (*Acanthocercus a. atricollis*)

Turner's Gecko (*Chondrodactylus turneri*)

Common Tropical House Gecko (*Hemidactylus mabouia*)

Common Dwarf Gecko (*Lygodactylus c. capensis*)

Southern Rock Monitor (*Varanus albigularis albigularis*)

Puff Adder (*Bitis arietans arietans*)

Boomslang (*Dispholidus typus*)

Western yellow-bellied Sand Snake (*Psammophis subtaeniatus*)

Southern African Python (*Python natalensis*) **Image courtesy of Gavin Cronk**

Figure 7-9 Examples of some of the reptile species detected in the study area

Table 7-15 Present and potentially occurring CI reptile species

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[1,3]	MEDUPI**	VICINITY***	ATLAS[3]
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]				
PYTHONIDAE (Python)								
Python natalensis	Southern African Python	-	LC	PS	1*	x	x	x
CROCODYLIDAE (Crocodile)								
Crocodylus niloticus	Nile crocodile	LC	VU	PS	1*	x	x	
Key								
Status: LC = Least Concern; PS = Protected Species; VU = Vulnerable								
Likelihood of Occurrence (LoO): 1 = Present								
Sources: [1]Bates *et al.* (2014); [2]ToPS List (2015); [3]ReptileMap (2018)								
*Anecdotal records only								
**Records from other NSS studies at Medupi								
***Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station								

7.2.4 *Frogs*

Combined NSS surveys at Medupi show that the power station premises support 20 frog species, representing 74% of the regional amphibian diversity. Of the 27 regionally occurring species only Natal Sand Frog and Muller's Platanna are considered unlikely to occur based on their marginal distributions. FrogMap (2018) lists 22 species for the four regional QDSs. In total 16 frog species were detected within the FGD study area (**Appendix 5 and Figure 7-10**). Both of the two regionally occurring CI species, namely African and Giant Bullfrog, were recorded in the FGD study area (**Table 7-16**).

During our December 2015 visit, a high rainfall event (38mm on 8 December 2015) triggered the emergence of exceptionally high densities of winged termites, and subsequently, African Bullfrog and various other frog species appeared en masse. The breeding frenzy that ensued, drastically increased detection rate, and emphasised the exceptional abundance of amphibian species in the study area.

Both Giant and African Bullfrog occur sympatrically in the region, with the latter generally being regarded as the more ubiquitous of the two in warm bushveld regions (Du Preez and Carruthers, 2009). Whereas the Giant Bullfrog has only been recorded once in 2327CB (C. Lotter; V. Kleynhans and N. Kleynhans) and twice in 2327DA (one VMUS record submitted by L. Verburgt and one questionable Minter *et al.* 2004 record), the African Bullfrog has been recorded in all four regional QDSs (Yetman *et al*. 2015). Indeed, African Bullfrog were found to be exceptionally abundant, and likely breed at the majority of the pans / depressions in and around the FGD study area, while in contrast, Giant Bullfrog was only potentially recorded where the ADF is situated at a small (historically natural) pan which has been deepened and widened by excavation.

Plain Grass Frog
(*Ptychadena anchietae*)

Sand Frog
(*Tomopterna* sp.)

Eastern Olive Toad
(*Amietophrynus garmani*)

Mottled Shovel-nosed Frog
(*Hemisus marmoratus*)

Bushveld Rain Frog
(*Breviceps adspersus*

Common Platanna
(*Xenopus laevis*)

Bubbling Kassina
(*Kassina senegalensis*)

Red Toad
(*Schismaderma carens*)

adspersus)


Ornate Frog (*Hildebrandtia ornata*)


Boettger's Caco (*Cacosternum boettgeri*)


Banded Rubber Frog (*Phrynomantis bifasciatus*)


Southern Foam Nest Frog (*Chiromantis xerampelina*)


Giant Bullfrog froglet (*Pyxicephalus adspersus*)


African Bullfrog (*Pyxicephalus edulis*)


African Bullfrog pair in amplexus


African Bullfrog tadpoles

Figure 7-10 Examples of some of the frog species detected in the study area

The Giant Bullfrog observation was of a single froglet (identification tentative based on absence of pale half-moon on tympanum, which is usually indicative of African Bullfrog. Specimen age precluded confirmation by labial tooth row formula or adult colouration and morphology). Species distinction among froglet bullfrogs is notoriously difficult (A. Channing pers. comm.). A recent publication by Yetman and Verburgt (2015) provides the first records of Giant Bullfrog in the Lephalale region and the greater Limpopo Sweet Bushveld. The study highlights that the species is likely more widespread and common in the region than was previously thought, and that low detection levels are likely the result of irregular emergence and breeding only during sufficiently wet summers in this dry region.

Suitable breeding habitat appears to be present for both African and Giant Bullfrogs at multiple locations, but Giant Bullfrog breeding was not detected by NSS due to timing. The presence of both of these large conservation important frog species warrants the commissioning of a specialist bullfrog study to better understand the extent and occurrence of these species in the study area, and to minimise loss of breeding sites and foraging habitat from the construction of the ADF and other infrastructure. Based on this recommendation, Medupi has commissioned NSS to assess the suitability of local wetlands for bullfrog breeding, and the Endangered Wildlife Trust to relocate bullfrogs between wetlands where necessary, in collaboration with NSS.

Table 7-16 Present and potentially occurring CI frog species

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS			LoO IN FGD[2,3]	MEDUPI**	VICINITY***	ATLAS[3]
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[*]				
PYXICEPHALIDAE (African Common Frogs)								
Pyxicephalus edulis	African Bullfrog	LC (U)	LC	**PS***	1	x	x	x
Pyxicephalus adspersus	Giant Bullfrog	LC (D)	**NT**	**PS***	1	x		x
Key								
Status: LC = Least Concern; NT = Near Threatened; PS = Protected Species								
Likelihood of Occurrence (LoO): 1 = Present; 2 = High								
Sources: [1]ToPS List (2007); [2]IUCN (2013.1); [3]Minter *et al.* (2004); [4]Du Preez & Carruthers (2009); [5]FrogMap (2015)								
***Old ToPS (2007) status, newToPS (2015) amphibian status still pending								
**Includes records from other NSS studies at Medupi								
***Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station								

7.2.5 *Terrestrial Macro-invertebrates*

The focus of this component was directed towards invertebrate groups for which there is a workable body of literature, distribution data and species conservation statuses namely butterflies, dragonflies and damselflies, baboon spiders and scorpions. Some examples of the macro-invertebrates observed in the FGD study area are presented in **Figure 7-11**.

A list of the approximately 176 regionally occurring and observed butterfly species is provided in **Appendix 6**. Atlas records from the ADU's LepiMap (2018) list 88 species for the QDS covering the study area. Nine butterfly species were recorded in the study area bringing the list for the greater Medupi premises to 26 species representing 15% of the regional diversity. Clearly there is considerable scope for detection of other species with blues, tips and acraeas being particularly under-represented.

Barbet Percher (*Diplacodes luminans*) male

Barbet Percher female

Banded Groundling (*Brachythemis leucosticte*)

Natal Browns (*Coenyropsis natalii*)

Large Striped Swordtail (*Graphium antheus*)

Solifuge (order: Solifugae)

Opistacanthus asper under UV light

Opistacanthus asper

Giant Longhorn
(*Tithoes confinis*)

Figure 7-11 Examples of some of the invertebrate species detected in the study area

Distribution data for dragonflies and damselflies provided in Samways (2008) suggests that some 66 odonata species have the potential to occur in the region **Appendix 7**. However, the vast majority of these species are likely precluded by the absence of significant rivers and lakes with suitable substrate and vegetation. As such, only a subset of just less than 50 species that are frequently found away from water and / or require only temporarily inundated areas are considered highly likely to occur (see **Appendix 7**). Of the seven regionally occurring CI species[6] only five, namely the Sudan Sprite, Little Wisp, Black Emperor, Strong Skimmer and Silhouette Dropwing are considered more or less likely to occur in the FGD study area (**Table 7-17**). The Makabusi Sprite (**VU**) and Spined Fairytail (**NT**) are likely precluded by a lack of sluggish perennial rivers in the study area. The greater diversity of wetland habitat immediately south of Medupi is expected to support the greatest diversity of odonata. Three dragonfly species were identified during the NSS site visit namely Banded Groundling, Green Hooktail and Barbet Percher.

Table 7-17 Present and potentially occurring CI terrestrial macro-invertebrate species

SPECIES	COMMON NAME	STATUS	LoO IN FGD	MEDUPI	VICINITY
Dragonflies					
Chlorolestes fasciatus	Mountain Malachite	-	4		
Chlorolestes tessellatus	Forest Malachite	-	4		
Pseudagrion makabusiense	Makabusi Sprite	**VU**	4		
Pseudagrion sudanicum	Sudan Sprite	LC	3		
Agriocnemis exilis	Little Wisp	-	3		
Anax tristis	Black Emperor	-	3		
Lestinogomphus angustus	Spined Fairytail	**NT**	4		
Orthetrum stemmale	Strong Skimmer	-	3		
Trithemis donaldsoni	Denim Dropwing	-	4		
Trithemis hecate	Silhouette Dropwing	-	3		

6 Red listed species or those species with a Dragonfly Biotic Index score of 4 or higher are considered here to be of conservation importance.

SPECIES	COMMON NAME	STATUS	LoO IN FGD	MEDUPI	VICINITY
Beetles					
Manticora spp.	Monster Tiger Beetles	**PS****	2		
Scorpions					
Opistacanthus asper	Creeping scorpions	**PS****	1	x	
Hadogenes troglodytes	Flat rock scorpions	**PS****	4		
Opistophthalmus glabifrons	Burrowing scorpions	**PS****	3		
Opistophthalmus carinatus	Burrowing scorpions	**PS****	3		
Opistophthalmus whalbergii	Burrowing scorpions	**PS****	3		x
Spiders					
Ceratogyrus bechuanicus	Starbust Horned Baboon Spider	**PS****	3		
Ceratogyrus brachycephalus	Rhino Horned Baboon Spider	**PS****	3		
Pterinochilus junodi	Soutpansberg Starburst Baboon Spider	**PS****	4		
Pterinochilus pluridentatus	-	**PS****	4		
Harpactira sp.	Common Baboon Spiders	**PS****	3		x
Key					
Status: LC = Least Concern; NT = Near-threatened; PS = Protected Species; VU = Vulnerable					
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low					
Sources: BEC (2006); Samways (2006); ToPS (2007); Leeming (2003); Dippenaar-Schoeman (2002); Mecenero *et al.* (2013)					
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station					
**Old ToPS (2007) status					

The distribution ranges of 11 scorpion species (**Appendix 8**) overlap Medupi and its immediate surrounds (Leeming, 2003). Under the old (2007) ToPS list, five of these species were classified as **Protected** species (one *Hadogenes,* three *Opistophthalmus* and one *Opistacanthus* species; **Table 7-17**). However, the latest (2015) ToPS list no longer recognises these species as **Protected**. The lack of rocky substrates in the FGD study area precludes *Hadogenes troglodytes* and potentially *Parabuthus transvaalicus and P. mossambicensis*. During our surveys only one species namely *Opistacanthus asper* was detected.

Dippenaar-Schoeman (2002) lists four baboon spiders for Limpopo Province namely *Ceratogyrus bechuanicus*, *C. brachycephalus*, *Pterinochilus junodi* and *P. pluridentatus* but *Harpactira* sp. may also occur. Of these, only the horned baboon spiders *Ceratogyrus bechuanicus* and *C. brachycephalus* and common baboon spiders of the genus *Harpactira* are likely to occur in the FGD area (**Table 7-17**). No baboon spiders were detected (**Appendix 9**). As with the scorpions none of these are now recognised as **Protected** species in the latest (2015) ToPS list. However the Limpopo Environmental Management Act (Act No 7 of 2003) still lists baboon spiders of the genera *Ceratogyrus*, *Harpactira* and *Pterinochilus* as requiring permits for capture, hunting or trade.

7.3. Watercourses, Wetlands and Ephemeral Systems

The Study area (**Figure 3-1**) is situated on a watershed and comprises both northwards and southwards draining systems. The hot semi-arid plains of the Limpopo Sweet Bushveld covering the study area are characterised by a series of ephemeral pans and drainage features, which we have termed Semi-Ephemeral Washes (SEWs). The southern boundary of the study area is intruded by a series of these SEWs, which all form part of a greater alluvial fan draining into the Sandloop.

The upper reaches of this system diagonally bisects the south western corner of the study area and is classified as a FEPA in recognition of its reference site suitability as an upper foothill ephemeral system that is still in a largely natural state. Results of the wetland assessment are summarised in **Table 7-18 –**
Table 7-22. The sampling points and the delineated wetlands are depicted in **Figure 7-12.** A DEM derived catchment model and channel analysis produced by NSS overlayed with the 1:100 year floodline produced by Zitholele (2016) is shown in **Figure 7-14**. Additionally **Figure 7-15** depicts the soils as classified by ESS (2015).

Four HGM units were identified, which include two south–east and one north–east draining Washes (SEW 1 – 3), and multiple inward-draining depressions (D1). In addition, two excavated areas were encountered on site (**Figure 7-17**). It should be noted that portions of the SEW 1 HGM unit forms part of the Sandloop FEPA system. As a consequence, a large portion of the HGM unit is classified as being of Highest Biodiversity Importance and Risk for Mining according to the SANBI Mining and Biodiversity Guidelines. Within these areas the MBG stipulates a 1km buffer on all FEPA listed systems. The same is true for the FEPA guidelines which state that a 1km buffer is required.

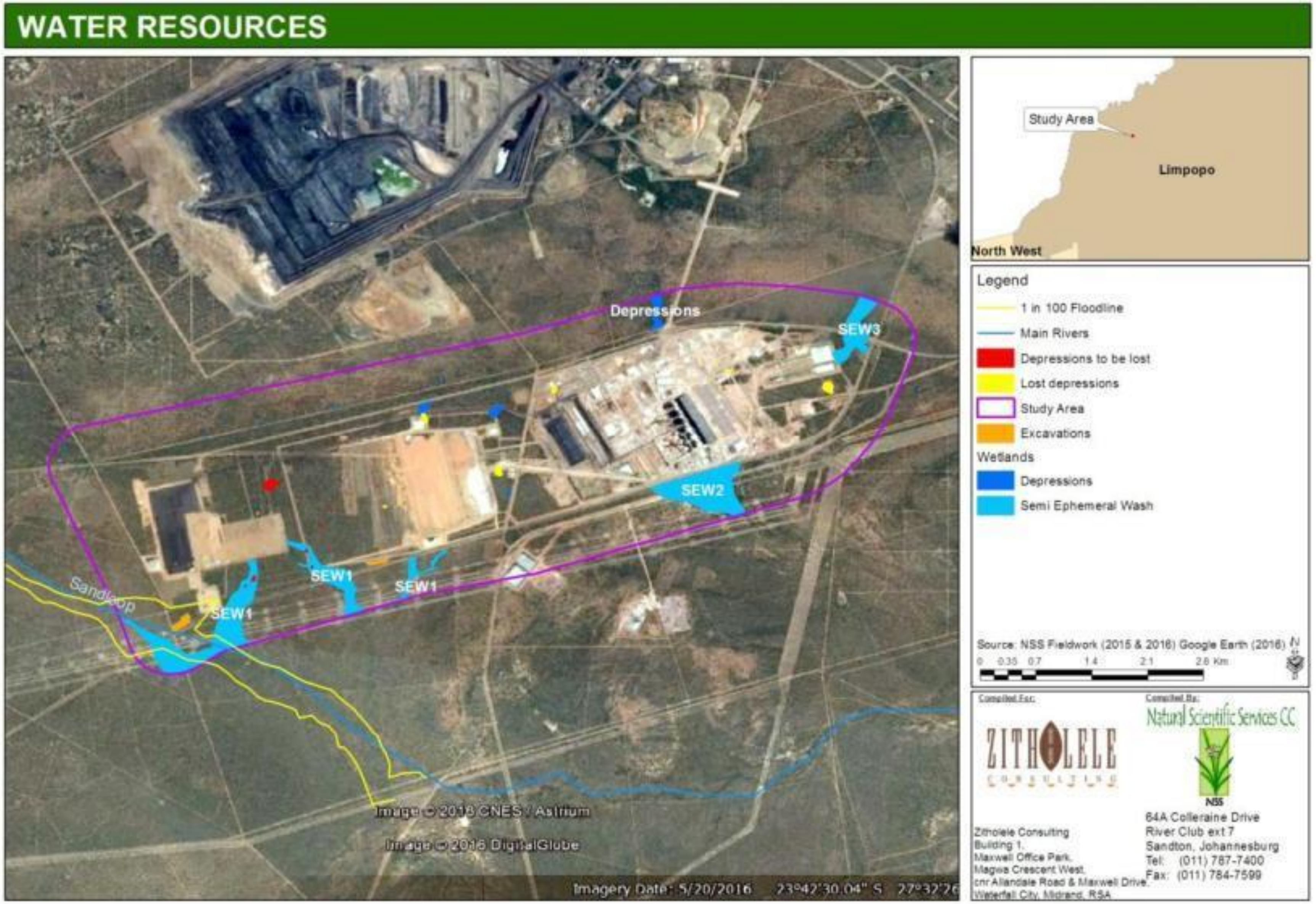


Figure 7-12 Wetland extent

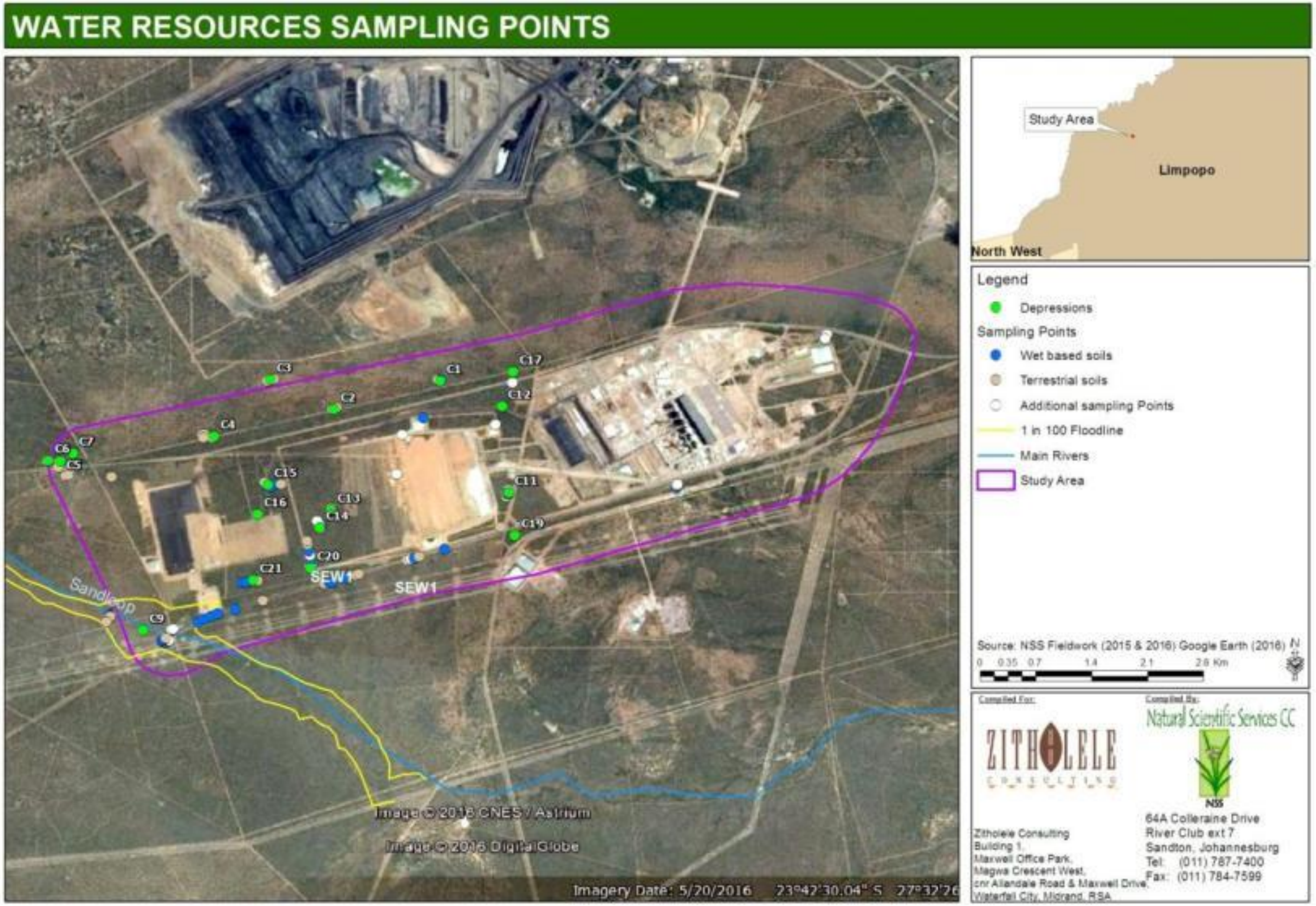
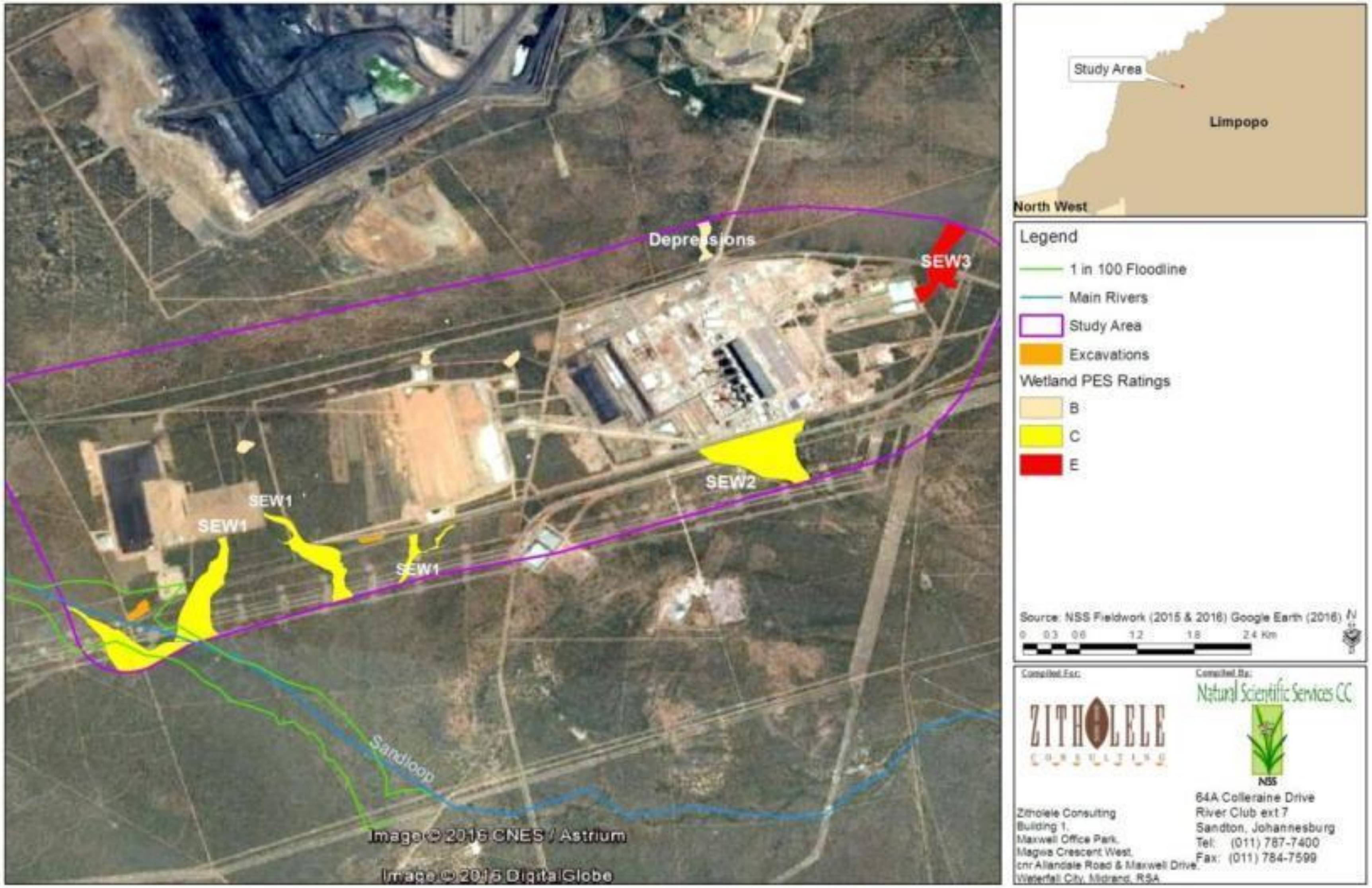


Figure 7-13 Wetland sampling points

WETLAND PES RATINGS



Wetland HGM unit overall PES ratings

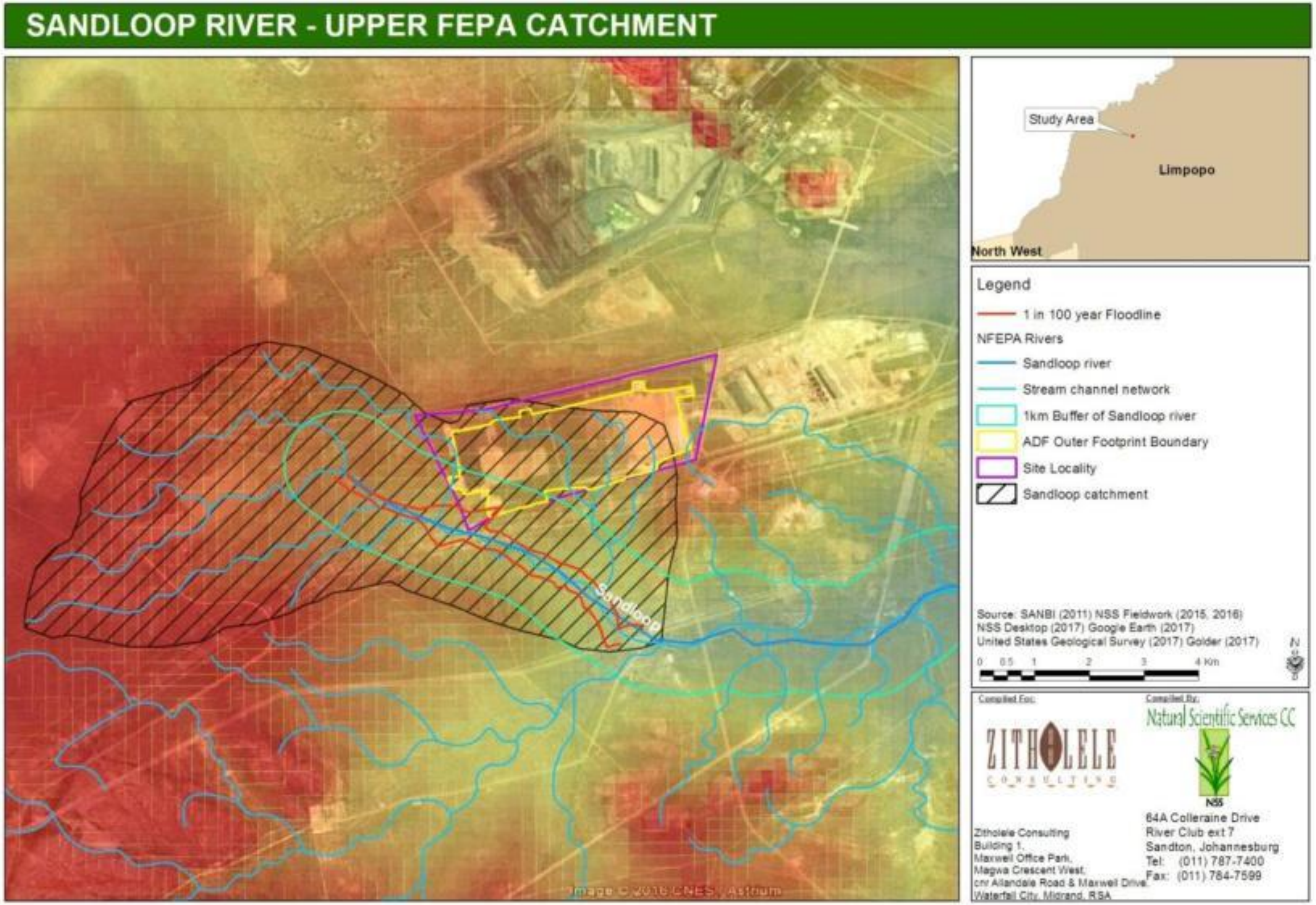


Figure 7-14 USGS DEM derived catchment and channel model showing Golder (2017) 1:100 year floodline delineation

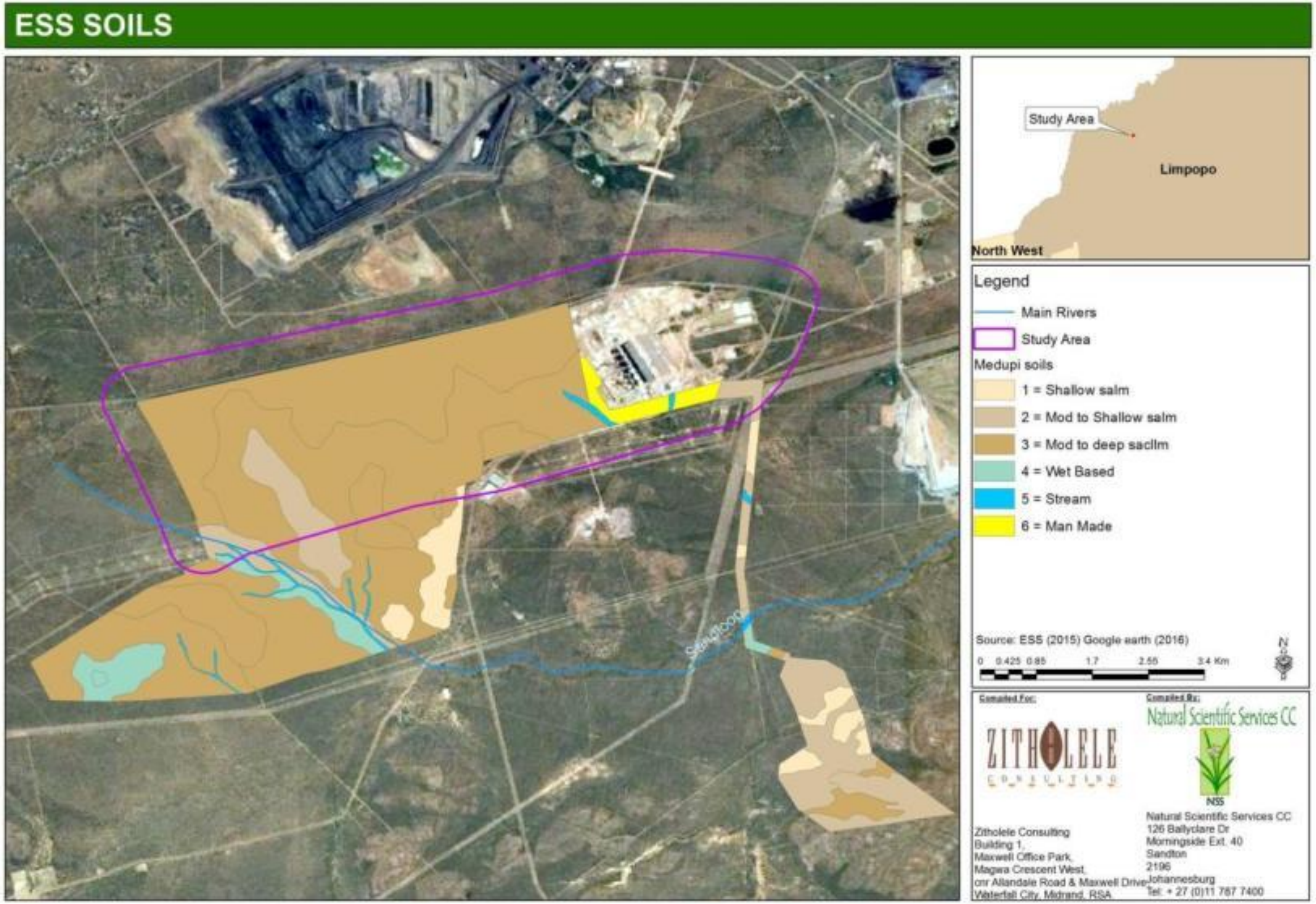


Figure 7-15 ESS (2015) soil classification map

Table 7-18 Wetland summary HGM Unit 1

HGM Unit 1 – Semi-arid Ephemeral Wash 1

HGM Unit 1 and sampling points

SETTING			
Coordinates (Centroid)	23°43'49.57"S 27°30'34.76"E	Area- 500m buffer of site (ha)	71.5
Alt (m a.s.l.)	908	Level 1: System	Inland
Aspect	South-east	Level 2a: Ecoregion	1.03
Regional vegetation	SVcb 19 LSB	Level 2b: NFEPA WetVeg	CBG 4
Quaternary catchment	A42J	Level 3: Landscape unit	Plain
Limpopo BCPLAN V2	CBA 1 and ESA 1	Level 4a:	CBG 4 Flat: **LT NP**
Waterberg TCBA	CBAI; CBAO and ON	Level 4b:	NA
MBG	B: Highest NB and risk	FEPA:	Start of Sandloop FEPA

SITE DESCRIPTION	
Overview	Semi-ephemeral washes, with pockets within the drainage showing wetland characteristics (pooling).
Wetland indicators	Terrain relatively flat and difficult to determine slope. The soil indicators were present along some points of each system and in these areas the herbaceous vegetation layer was dense in comparison to the surrounds. Within the more permanent pooling areas, species such as *Scirpus* and *Cyperus* were evident
Impacts	Clearing of the vegetation within the ash dump has resulted in increased exposed and hardened surface within catchment. During high flow culverts concentrate flow. Some borrow pits evident along the systems.
Dominant species	*Non wetland species: Acacia nigrescens, A erubescens, Terminalia sericea* (taller and more leaf composition within the drainage evident); *Grewia bicolor* and *Grewia flava.* Stands of *Spirostachys africana* (Tamboti) are present along the system.
Soil characteristics	Mixture of wet-based, and shallow, shallow-moderate, and moderate-deep sandy loamy soils

Present Ecological State (PES)		
Hydrology	Geomorphology	Vegetation
C	**B**	**B**

Wetland Ecosystem Services

Maintenance of biodiversity; Phosphate trapping; Sediment trapping; Toxicant removal; Nitrate removal

Wetland Importance and Sensitivity		
Hydrological	Ecological	Cultural
Moderate (2.2)	**Very High (4.0)**	**Moderate (1.5)**

MBG: Mining & Biodiversity Guidelines; LSB: Limpopo Sweet Bushveld; CBA: Critical Biodiversity Area; ESA: Ecological Support Area; CBG4: Central Bushveld Group 4; FEPA: Freshwater Ecosystem Priority Area; ON:

Table 7-19 Wetland summary HGM Unit 2

HGM Unit 2 – Semi-arid Ephemeral Wash 2			
			
HGM Unit 2 and sampling points			
SETTING			
Coordinates (Centroid)	23°42'44.20"S 27°33'57.96"E	Area Within Site (ha)	38.0
Alt (m a.s.l.)	902	Level 1: System	Inland
Aspect	South-east	Level 2a: Ecoregion	1.03
Regional vegetation	SVcb 19 LSB	Level 2b: NFEPA WetVeg	CBG 4
Quaternary catchment	A42J	Level 3: Landscape unit	Plain
Limpopo BCPLAN V2	ESA 1	Level 4a:	NA
Waterberg TCBA	ON	Level 4b:	NA
MBG	E: Low NB and risk		
SITE DESCRIPTION			
Overview	Semi-ephemeral wash, with pockets within the drainage showing wetland characteristics (pooling).		
Wetland indicators	Terrain relatively flat and difficult to determine slope. The soil indicators were present along certain points of the system. A number of pools found along system before entering the Sandloop.		
Impacts	Likely a fair amount of water is diverted into the system compared to natural flow. MPS acts as a large hardened surface with surface / catchment area runoff increasing flood peaks substantially during high rainfall events but two natural depressions, a borrow pit and a road assist to attenuate flow, create depositional environments, and stem flow. Some excavations have formed more permanent dams. Increased roughness, saturation and nutrient loading. Pits (excavation), tailings (infilling), tailing sediment are washing onto system.		
Dominant species	*Non wetland species: Acacia nigrescens, A karoo, Dichrostachys cinerea*; *Grewia bicolor* and *Grewia flava.* Denser Grass Sward in places		
Soil characteristics	Mixture of wet-based and man-made soils		

Present Ecological State (PES)		
Hydrology	Geomorphology	Vegetation
C	**C**	**D**
Wetland Ecosystem Services		
Maintenance of biodiversity; Toxicant removal; Phosphate trapping; Sediment trapping; Flow attenuation		
Wetland Importance and Sensitivity		
Hydrological	Ecological	Cultural
Moderate (2.1)	**Very High (4.0)**	**Low (1.4)**

Table 7-20 Wetland summary HGM Unit 3

HGM Unit 3 – Semi-arid Ephemeral Wash 3			
			
HGM Unit 3 and sampling points			
SETTING			
Coordinates (Centroid)	23°41'39.64"S 27°34'59.20"E	Area Within Site (ha)	18.2
Alt (m a.s.l.)	891	Level 1: System	Inland
Aspect	North-north-east	Level 2a: Ecoregion	1.03
Regional vegetation	SVcb 19 LSB	Level 2b: NFEPA WetVeg	CBG 4
Quaternary catchment	A42J	Level 3: Landscape unit	Plain
Limpopo BCPLAN V2	ESA 1	Level 4a:	NA
Waterberg TCBA	ON	Level 4b:	NA
MBG	E: Low NB and risk		
SITE DESCRIPTION			
Overview	Semi-ephemeral washes flowing north eastward. Currently fed by MPS overflow of treated water		
Wetland indicators	Terrain indicator present; limited vegetation indicators		
Impacts	Storm water from MPS is channelled into this system but does not appear to significantly increase inundation below the control dams. High run-off from MPS's hardened surfaces during rainfall events but seems attenuated by storm water dams and the tar road. Under normal conditions effects of increased flood peaks are expected to be negligible, but because all MPS's storm water is diverted to this point *freak* high rainfall events have the potential to cause a serious impact on the systems downstream. Earth-moving impacts are also evident. A large storm water control dam in the drainage way headwaters is *starving* the system of sediment and influencing natural flow patterns. However, the intensity of this impact does not seem high, possibly due to ephemeral nature of system. Road impedes flow slightly and further traps sediment from reaching downstream reaches. There is some evidence of erosion. Flat topography and the tar road appear to prevent erosion downstream during high rainfall events. Signs that water flows fast in reach between dam outlet and tar road. Storm water dam and road reduce sediment inputs from MPS to downstream system.		
Dominant species	*Non Wetland species: Dominated by Acacia nigrescens, A karroo, etc in the wooded component*		
Soil characteristics	Mixture of man-made, wet-based, and shallow-deep sandy loamy soils		

Present Ecological State (PES)		
Hydrology	Geomorphology	Vegetation
F	**C**	**D**
Wetland Ecosystem Services		
Maintenance of biodiversity; Toxicant removal; Phosphate trapping; Sediment trapping; Erosion control; Flood attenuation		
Wetland Importance and Sensitivity		
Hydrological	Ecological	Cultural
Moderate (1.7)	**High (2.7)**	**Low (1.0)**

Table 7-21 Wetland summary HGM Unit 4

HGM Unit 4 – Depressions

HGM Unit 4 and sampling points

SETTING

Coordinates (Centroids); Alt (m a.s.l.)		Area Within Site (ha)	9.7
23°41'58.34"S 27°32'9.96"E; 913 23°42'57.53"S 27°31'21.30"E; 914 23°42'10.23"S 27°31'26.90"E; 918 23°42'11.11"S 27°32'32.16"E; 915 23°42'15.55"S 27°30'56.53"E; 919 23°42'51.10"S; 27°31'25.61"E; 916	23°42'44.48"S 27°32'37.87"E; 915 23°42'40.87"S 27°31'1.01"E; 918 23°42'10.83"S 27°32'2.64"E; 916 23°42'20.94"S 27°30'33.70"E; 922 23°41'30.86"S 27°33'37.69"E; 900	Level 1: System	Inland
		Level 2a: Ecoregion	1.03
Regional vegetation	SVcb 19 LSB	Level 2b: NFEPA WetVeg	CBG 4
Quaternary catchment	A42J	Level 3: Landscape unit	Plain
Limpopo BCPLAN V2	ESA 1	Level 4a:	NA
Waterberg TCBA	CBAO and ON	Level 4b:	NA
MBG	E: Low NB and risk		

SITE DESCRIPTION

Overview	Scattered, small, isolated depressions
Wetland indicators	Soil indicators evident in most of these systems -showing signs of wetness (mottling). Vegetation shows more cover, but hydrophytes are generally lacking. There is also limited change to the terrain.
Impacts	Cattle trampling of the depressions, which affects species such as frogs that remaining in the cracks until rain
Dominant species	In most cases these depressions are devoid of vegetation. Where there is vegetation, it is merely denser cover of the surrounding terrestrial environment.
Soil characteristics	Mostly moderate-deep sandy loamy soils

Present Ecological State (PES)

Hydrology	Geomorphology	Vegetation
B	**B**	**C**

Wetland Ecosystem Services

Maintenance of biodiversity; Tourism and recreation; Phosphate trapping; Toxicant removal

Wetland Importance and Sensitivity

Hydrological	Ecological	Cultural
Low (1.4)	**Very High (4.0)**	**Moderate (1.6)**

Table 7-22 Summary information for excavations (artificial systems)

Excavations			
Excavations			
SETTING			
Coordinates (Centroids); Alt (m a.s.l.)		Area Within Site (ha)	West: 2.2ha; East: 0.9ha
West: 23°43'37.82"S 27°30'24.69"E; 909 East: 23°43'12.59"S 27°31'44.29"E; 910		Level 1: System	Inland
		Level 2a: Ecoregion	1.03
Regional vegetation	SVcb 19 LSB	Level 2b: NFEPA WetVeg	CBG 4
Quaternary catchment	A42J	Level 3: Landscape unit	Plain
Limpopo BCPLAN V2	ESA 1	Level 4a:	NA
Waterberg ACBA and TCBA	ESA and ON, respectively	Level 4b:	NA
MBG	B: Highest NB and risk		
SITE DESCRIPTION			
Overview	Old borrow pits or excavations now filled with water and providing a biodiversity hotspot in the greater area		
Wetland indicators	No indicators were assessed for these pits		
Impacts	Potentially limiting the inputs *of* sediment into the system and influencing natural flow patterns		
Dominant species	Limited to no vegetation within the pits, on the edges show typical Bushveld Habitat		
Soil characteristics	Mixture of wet-based, and shallow-moderate, and moderate-deep sandy loamy soils		
Present Ecological State (PES)			
NA			
Wetland Ecosystem Services			
NA			
Wetland Importance and Sensitivity			
NA			

7.4. Wetland Classification

HGM units SEW1 to 3 were classified following Ollis *et al* (2013) up to Level 3. However, did not fit with any of the Level 4 classifications. These systems are ephemeral with no channels and not considered valley bottom systems. The best description for these systems is a Wash. Washes are dry land drainage ways where water flows after heavy rainstorms, but which are otherwise dry. Washes usually indicate that there is no local groundwater connection to the valley bottom. However, they sometimes mark areas where groundwater is closer to the surface than in the surrounding landscape (”recharge windows” where a portion of the surface flow seeps down through to the groundwater aquifer), or a layer such as ferricrete is providing an impermeable layer allowing soils to become saturated above and presenting wetland characteristics. This is true to the description on the soils of the area, provided by ESS (2015). This was evident in the fieldwork where, within the larger system, water was pooling and showing signs of wetland characteristics such as soil mottling and a change in vegetation structure (denser grass swards and taller potentially more productive wooded component) (**Figure 7-18**). During the drier period of the year these trees kept their leaves for longer than the surrounding areas potentially being fed by groundwater. The denser grass swards indicate more availability of water subsurface.

The various pans were classified following Ollis *et al* (2013) up to Level 4 as Endorheic Depressions without Channelled Outflow. Pans (depressions) within South Africa are mainly characteristic of the drier parts of the country but do occur within the wetter areas (Allan *et al*. 1995). The conditions within the study site are all conclusive with the formation of pans: the area is arid (i.e. receives approximately 400mm of rainfall, with evapo-transpiration higher than rainfall), the area is underlain mainly by sandstones, and the slope is less than 1 degree. The depressions identified within the study area are small in extent and ephemeral in nature. Depressions are defined by Ollis *et al* (2013) as “a wetland or aquatic ecosystem with closed (or near closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water accumulates.” Due to the large number of depressions within the CBG4 vegetation type, they are classified as Least Threatened. In terms of delineating the systems, it is the catchment of the depression that should be demarcated as sensitive. The available contour data were used to demarcate the pans, however, due to the flat terrain the scale of the contours was not fine enough for an accurate delineation. The Level 1 – 4 wetland classification (Ollis et al 2013) for the four HGM units on site is given in **Table 7-23.**

Table 7-23 Wetland classification

HGM UNIT NAME	LEVEL 1	LEVEL 2				LEVEL 3	LEVEL 4		
	System	Eco - region	NFEPA WetVeg			Landscape Unit	4a	4b	4c
			Type	Status	Protection				
SEW1	Inland	1.03	CBG4	LT	MP	Plain	N/A	N/A	N/A
SEW2	Inland	1.03	CBG4	LT	MP	Plain	N/A	N/A	N/A
SEW3	Inland	1.03	CBG4	LT	MP	Plain	N/A	N/A	N/A
D1	Inland	1.03	CBG4	LT	MP	Plain	Depression	Endorheic	Without Channelled Outflow

* Central Bushveld Group 4

Pans inundated after sufficient rainfall

SEW – Flow Patch clearly visible *Flow path for an SEW*

Figure 7-16 Flow paths and water inundation

Figure 7-17 Artificial systems

7.5. Wetland Extent

The spatial distribution of the wetlands in the study site and the 500m survey buffer) was determined using a combination of standard in-field delineation techniques including terrain, soil and vegetation indicators (DWAF, 2005), available contour data, satellite imagery over a 10 year period (Google Earth). The separate and collective extent (in hectares and percent) of the four identified HGM units is presented in

Table 7-24.

Table 7-24 Wetland extent

HGM Unit	HGM Type	Ha	Extent (%)*
SEW 1	Semi-ephemeral Wash	71.5	52
SEW 2	Semi-ephemeral Wash	38.0	28
SEW 3	Semi-ephemeral Wash	18.2	13
Depressions	Depressions	9.7	7
Total		**137.3**	**100**

Soil Mottling -Depressions

Dense Vegetation within the Depressions

Soil Mottling- SEW Units

Depression

Figure 7-18 Wetland Indicators

7.6. Present Ecological State of the Wetlands

A summary of the PES of each HGM units on site is provided in **Table 7-25** and discussed in greater detail under **Table 7-18 -**

Table 7-22. The PES for SEW 1, 2 and D4 show a relatively stable and natural to moderately modified state. Whereas SEW 3 in the north eastern section of the site showed a more modified system. This is potentially due to the seepage and/ or overflow during high rainfall events of MPS clean and dirty water into the system.

Table 7-25 Summary of the overall health of the wetland based on impact score and change score

HGM Unit	Ha	Extent (%)	Hydrology Impact Score	Hydrology Change Score	Geomorphology Impact Score	Geomorphology Change Score	Vegetation Impact Score	Vegetation Change Score	Overall Impact Score
SEW 1	72	52	3	-2	1.7	-1	1	-1	2.1
SEW 2	38	28	3.5	-1	3	-1	4.2	-1	3.6
SEW 3	18	13	9.5	-1	3.9	-1	5.8	-1	6.8
Depressions	10	7	1	-1	1	-1	2	-1	1.3
Scores									
SEW 1			**C**	↓↓	**B**	↓	**B**	↓	**C (Lower)**
SEW 2			**C**	↓	**C**	↓	**D**	↓	**C (Upper)**
SEW 3			**F**	↓	**C**	↓	**D**	↓	**E**
D 4			**B**	↓	**B**	↓	**C**	↓	**B**
Area weighted impact scores*			**3.9**	**-1.5**	**2.3**	**-1**	**2.6**	**-1**	
PES Category (See Table 6.1)			**C**	↓↓	**C**	↓	**C**	↓	

* The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

7.7. Sediment

Due to the semi-ephemeral nature of the systems on site, sediment samples were collected to determine the metal concentrations within the sediment of the systems. The results give an indication of the contamination levels within the water when the systems are flowing.

7.7.1 *Sediment Sampling Sites*

Six sediment sampling sites were chosen based on their location in 2015, upstream and downstream from the ADF and MPS, with a further two sites within two remaining depressions in the ADF footprint. The sampling sites are summarised in **Table 7-26** and illustrated in **Figure 7-19**.

7.7.2 *Metal Analysis*

The results of the total sediment metal concentrations for the high flow assessment at the eight sampling sites are presented in **Table 7-27**. Currently, no sediment quality guidelines (SQGs) exist for freshwaters in South Africa. Therefore, the shaded values in **Table 7-27** indicate any increased concentrations compared to the available international SQGs. A study by Botes & Van Staden (2005) on a site in the Olifants River, in Limpopo Province, is also provided as a comparison. No sediment data for the Sandloop was available for comparison. Therefore, this data will serve as a reference for future surveys and can be compared against to determine increasing or decreasing concentrations. The water quality samples were taken at the same sampling sites as the sediment samples for comparison. The WQ data was provided by Zitholele consulting. Only the exceeding concentrations of both the metals in the sediment and water quality data are presented in **Table 7-28**.

Table 7-26 Sediment Sampling Sites

Sampling Site	Description	Latitude (S)	Longitude (E)
MD1	Upstream site on the Sandloop River. Upstream of all three proposed site alternatives.	-23.722876°	27.490132°
MD2	Sandloop River. Located in Site 12 but downstream of Site 13.	-23.731668°	27.514446°
MD3	Pan. Located south of the ADF.	-23.747372°	27.504599°
MD4	Unnamed tributary of the Sandloop River. Located south of MPS	-23.727258°	27.528442°
MD5	Unnamed tributary of the Sandloop River. Downstream.	-23.738966°	27.548697°
MD6	Sandloop River. Downstream	-23.745971°	27.572112°
MD7	A Pan situated in close proximity to the ADF (South of the ADF)	-23.722098°	27.514976°
MD8	A Pan situated in close proximity to the ADF	-23.716043°	27.522619°

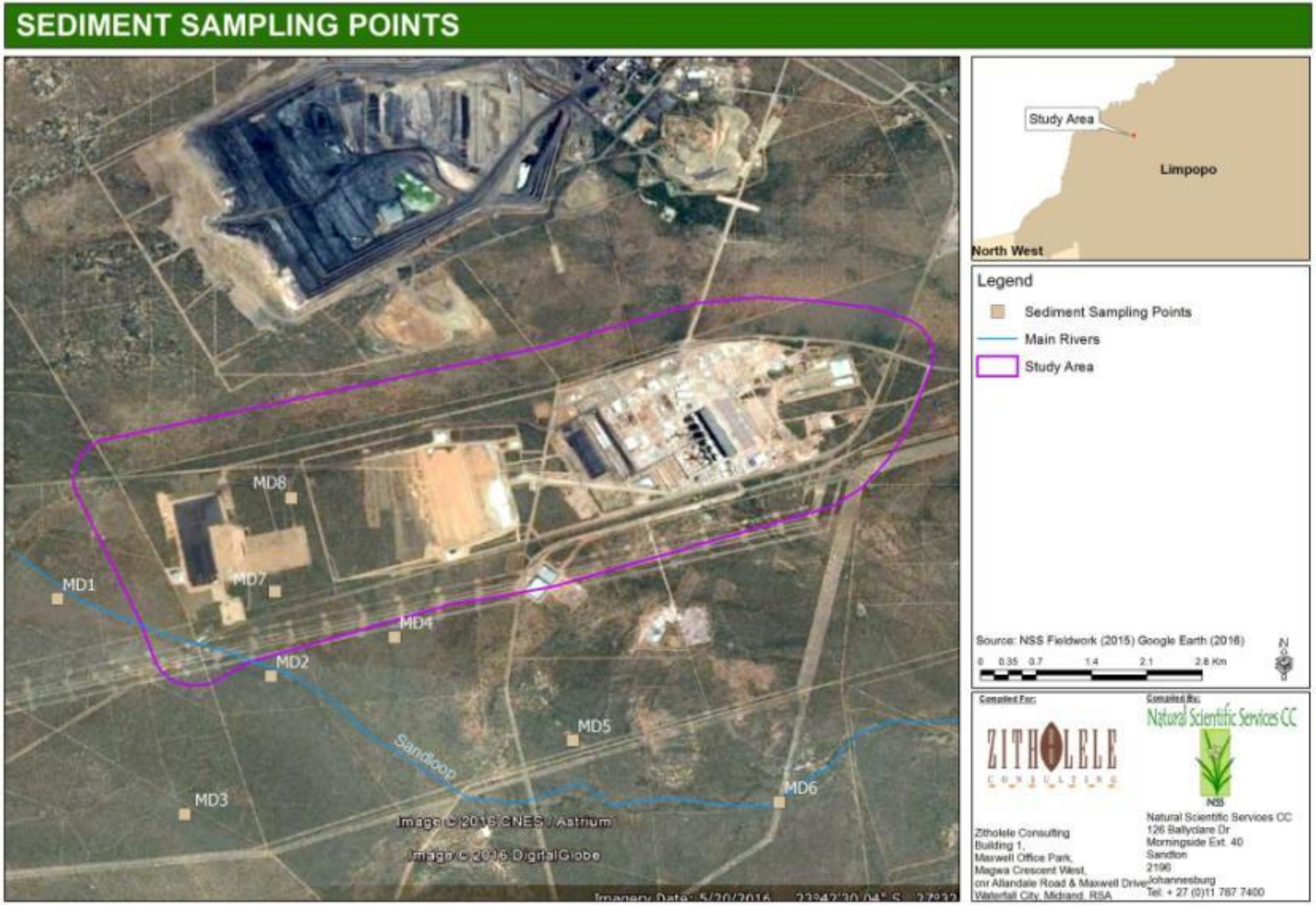


Figure 7-19 Sediment Sampling Sites

Table 7-27 Metal concentrations in the sediment samples from the study area during December 2015

Constituents	Chemical symbol	Unit	Guideline Value	Olifants River#	MD1	MD2	MD3	MD4	MD5	MD6	MD7	MD8
					Dec 2015	Dec 2015	Dec 2015	Dec 2015	Dec 2015	Dec 2015	Nov 2016	Nov 2016
Metals												
Aluminium	Al	mg/kg	n/a	-	16451.38	26148.15	4497.26	7585.38	8775.56	4901.48	54119.3	34604.8
Arsenic	As	mg/kg	5.9	3.33	1.35	0.89	0.36	0.70	0.80	0.37	1.63	1.26
Boron	B	mg/kg	n/a	-	6.77	5.79	BD	0.11	0.92	BD	20.32	18.33
Barium	Ba	mg/kg	n/a	24.27	120.27	126.94	25.49	50.10	71.85	32.59	346.51	250.6
Beryllium	Be	mg/kg	n/a	-	0.55	0.62	0.11	0.20	0.23	0.15	1.47	1.00
Cadmium	Cd	mg/kg	0.57	BD	0.03	0.04	0.01	0.01	0.01	0.00	0.07	0.06
Chromium	Cr	mg/kg	26	38.83	31.76	44.81	27.05	24.89	23.34	17.17	87.11	57.86
Cobalt	Co	mg/kg	20	7.57	3.96	4.27	0.87	1.91	2.72	1.72	9.72	7.78
Copper	Cu	mg/kg	16	BD	12.99	10.97	3.01	4.64	6.27	3.64	26.00	17.51
Iron	Fe	mg/kg	n/a	16090	11008.71	13629.63	3135.89	5529.10	6588.21	4071.43	22773.6	18013.3
Manganese	Mn	mg/kg	460	249.1	161.39	106.79	21.62	73.30	66.43	56.11	220.38	208.18
Molybdenum	Mo	mg/kg	10	BD	0.03	0.10	BD	0.04	0.09	BD	0.22	0.26
Nickel	Ni	mg/kg	18	10.89	13.70	18.05	3.53	6.00	8.51	5.09	39.11	33.22
Lead	Pb	mg/kg	35	BD	22.29	10.85	4.10	7.56	5.51	2.36	18.11	33.91
Selenium	Se	mg/kg	0.08	-	0.58	0.49	0.12	0.24	0.28	0.08	0.93	0.58
Silver	Ag	mg/kg	1	-	1.25	1.08	1.00	BD	0.43	0.65	4.16	7.18
Strontium	Sr	mg/kg	n/a	-	13.30	13.40	2.19	4.83	6.43	5.77	21.32	17.79
Titanium	Ti	mg/kg	n/a	-	193.18	241.95	62.27	113.76	97.43	55.17	231.66	144.93
Uranium	U	mg/k	2.50	-	0.61	0.55	0.12	0.23	0.32	0.20	0.95	0.61
Vanadium	V	mg/kg	n/a	47.46	21.97	26.22	8.08	12.80	15.03	9.29	50.5	33.31

n/a – not available; BD = Below detection limit; #Botes & Van Staden (2005).
Guideline values derived from Australia-New Zealand (ANZECC, 2000), Netherlands (Friday, 1998) and Canada (Friday, 1998; Hamilton, 2004; Sheppard *et al.* 2005);
Constituents shaded in red exceeded the guideline concentrations.

Table 7-28 Comparison between metal concentrations in the sediment and water samples (excluding MD7 and 8)

	Constituents	Chemical symbol	Unit	Guideline Value	MD1	MD2	MD3	MD4	MD5	MD6
					Dec 2015	Dec 2015	Dec 2015	Dec 2015	Dec 2015	Dec 2015
	Metals									
Sediment	Aluminium	Al	mg/kg	n/a	16451.38	26148.15	4497.26	7585.38	8775.56	4901.48
Water	Aluminium	Al	mg/ℓ	0.005	10.25	1.42	7.43	5.36	6.84	20.43
Sediment	Chromium	Cr	mg/kg	26	31.76	44.81	27.05	24.89	23.34	17.17
Water	Chromium	Cr	mg/ℓ	0.007	0.025	<0.01	0.013	<0.01	<0.01	0.026
Sediment	Iron	Fe	mg/kg	n/a	11008.71	13629.63	3135.89	5529.10	6588.21	4071.43
Water	Iron	Fe	mg/ℓ	0.1	11.445	0.897	7.836	2.740	3.669	4.588
Sediment	Manganese	Mn	mg/kg	460	161.39	106.79	21.62	73.30	66.43	56.11
Water	Manganese	Mn	mg/ℓ	0.18	0.252	0.013	0.048	0.015	0.132	0.447
Sediment	Selenium	Se	mg/kg	0.08	0.58	0.49	0.12	0.24	0.28	0.08
Water	Selenium	Se	mg/ℓ	0.002	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sediment	Silver	Ag	mg/kg	1	1.25	1.08	1.00	BD	0.43	0.65
Water	Silver	Ag	mg/ℓ	n/a	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

n/a – not available; BD = Below detection limit;

Guideline values derived from Australia-New Zealand (ANZECC, 2000), Netherlands (Friday, 1998) and Canada (Friday, 1998; Hamilton, 2004; Sheppard *et al.* 2005);

Constituents shaded in red exceeded the sediment guideline concentrations whilst constituents shaded in blue exceed the WQ guideline concentrations for aquatic ecosystems (DWAF, 1996).

Metals like **aluminium** (Al) and **iron** (Fe) are found at high concentrations in the natural geology and as such often occur in high concentrations in the sediment. Both these metals are common and no guideline values are described for it. In this study, both the aluminium and iron concentrations were also high in the water and exceeded the guideline values (**Table 7-28**). Aluminum is one of the more toxic metals within a water ecosystem and is associated with numerous biochemical effects on aquatic biota. For example, aluminum can cause neuromuscular dysfunction in fish (Colvin *et al*. 2011) and effects on fish are only usually evident at concentrations greater than 0.1 to 3.2 mg/l (Dallas & Day, 2004). At five of the sites i.e. MD1, MD3, MD4, MD5 and MD6, the aluminium concentrations were high than 3.2 mg/l, ranging 5.36 to 20.43 mg/l. However, the pH levels for these sites were neutral and may slightly limit the toxicity of aluminium. Iron is an important micronutrient but toxic at high concentrations and inhibits various enzymes. Iron compounds easily oxidize and the high concentrations observed at all the sites can result in oxygen depletion in these pans.

Many other metals do not have any recommended sediment guideline limits and include beryllium (Be), boron (B), titanium (Ti), vanadium (V), strontium (Sr) and barium (Ba). These metals do not have guidelines due to a lack of research in their occurrences in South African sediment or a lack of information on its toxicity within the sediment environment.

The metals that did have international guideline values indicated that manganese (Mn), cobalt (Co), zinc (Zn), arsenic (As), molybdenum (Mo), cadmium (Cd) and lead (Pb) did not exceed the guideline concentrations. Manganese, cadmium, molybdenum, zinc and cobalt concentrations were significantly lower than the guideline values. **Manganese** often occurs at high concentrations in the natural environment in South Africa as the geology contains high concentrations especially in the Highveld. Soluble manganese mostly occurs under low dissolved oxygen conditions, which are more than likely in these pans. The manganese concentrations in the water exceeded the guidelines at MD1 and MD6. Very little known about the effects on aquatic organisms but elevated levels of manganese are toxic to fish (Heal, 2001). **Cadmium** has the potential to be hazardous to aquatic biota and can be considered toxic and relatively accessible to aquatic organisms (DWAF, 1996). For example, Oligochaeta (earthworms) and other important soil organisms are very susceptive to cadmium poisoning and can die at very low concentrations. When cadmium concentrations in the soil are high it will impact on the soil processes, soil structure and threaten the whole soil ecosystem (Lenntech, 2016).

The **chromium** (Cr) concentrations exceeded the guideline concentration at site MD1, MD2 and MD3 from the December 2015 survey. The chromium concentrations at site MD7 and MD8 during the November 2016 survey also exceeded the guideline concentrations. However, site MD4 and MD5 also contained chromium concentrations that were close to the 26 mg/kg guideline. In natural ecosystems, chromium is generally a scarce metal and the concentrations are low in aquatic ecosystems. When the chromium levels are elevated it generally is a consequence of industrial activities (DWAF, 1996). A study by Botes & Van

Staden (2005) on the Lower Olifants River, known to be exposed to metal pollution, indicated concentrations of 38 mg/kg and sites MD2, MD7 and MD8 had higher concentrations in this study than the aforementioned study. Disposal of chromium-containing commercial products and coal ash from electric utilities and other industries are major sources of chromium releases into the soil (Nriagu & Pacyna, 1988). In addition, consumer products such as fertilizer may also contain chromium (Pellerin & Booker, 2000). The chromium concentrations in the water samples were high at MD1, MD3 and MD6. Chromium is an essential element that can be toxic to aquatic organisms at elevated levels. It exists in two oxidation states in aquatic systems including hexavalent chromium i.e., Cr^{6+} and trivalent Cr^{3+}, of which Cr^{6+} is the most toxic. Hexavalent chromium is allowed to cross biological membranes of aquatic organisms and thus readily penetrate gill membranes and concentrate at higher levels in various tissues (Avenant-Oldewage & Marx, 2000)

The **nickel** concentration at site MD2 exceeded the guideline value of 18 mg/kg by 0.05 mg/kg. The nickel concentrations of 10.89 mg/kg in the Botes & Van Staden (2005) study were exceeded by site MD1 and MD2 in this current study. The nickel guideline was also exceeded by the nickel concentrations measured at site MD7 and MD8 during November 2016. Nickel is a natural constituent of soil and levels vary depending on local geology and anthropogenic input but typical concentrations range from 4 to 80 mg/kg (ATSDR, 2005). Nickel content in soil can also be as low as 0.2 or as high as 450 mg/kg in some clay and loamy soils with an average of around 20 mg/kg (Lenntech, 2016). Organic matter has a strong ability to absorb the metal which is why coal and oil contain considerable amounts (ATSDR, 2005), and may indicate why these sites have exceeding concentrations in the soil.

Silver (Ag) is a naturally occurring element. It is found in the environment combined with other elements such as sulfide, chloride, and nitrate. The major source of elevated silver levels in soils is from the application of sewage sludge and sludge effluents as agricultural amendments. Additional anthropogenic sources of silver in soil include atmospheric deposition (especially from ore processing), landfilling of household refuse, sewage sludge, or industrial wastes, and leaching of metal tailings (ATSDR, 1990). The **silver** concentrations at site MD1, MD2, MD3, MD7 and MD8 exceeded the international guideline value. However, the guideline is set at 1 mg/kg while all the results from these sites ranged from 1.05 – 7.18 mg/kg. Not much is known about silver pollution within sediment in South Africa and little comparative data are available. However, silver is toxic to soil microorganisms and inhibits bacterial enzymes (ATSDR, 1990) and in solution it is extremely toxic to aquatic plants and animals (Lenntech, 2016). However, currently the silver concentrations in the water samples are below detection limits.

Lead (Pb) is a naturally occurring metal and can be found, in small amounts, in all parts of our environment. However, much of it comes from human activities including burning fossil fuels, combustion of coal and oil, mining and manufacturing (Lenntech, 2016). Lead released to air and water ultimately is deposited in soil or sediment. It is strongly adsorbed to soil and therefore it is generally retained in the upper layers of soil and does not leach appreciably into the subsoil and groundwater (ATSDR, 2007). The natural lead content of soil typically ranges from 10 to 30 mg/kg. However, lead levels in the top layers of soil vary widely due to deposition and accumulation of atmospheric particulates from anthropogenic sources (ATSDR, 2007). Lead concentrations in the sediment did not exceed the 35 mg/kg guideline value but it was measured at 22 mg/kg at site MD2 and very close to the Guideline for MD8 (33mg/kg) which are significantly higher than measured at the other sites. Lead concentrations were not detected above the concentrations in the Botes & Van Staden (2005) study. Lead can potentially be hazardous and toxic to aquatic biota and is relatively accessible to aquatic organisms (DWAF, 1996) if high concentrations are present in the environment. Lead is toxic in high concentrations and sub-lethal concentrations result in the regression of the physiological or behavioural processes of the aquatic organism, and therefore reducing its overall fitness.

According to ATSDR (2003), **selenium** occurs naturally in the environment and can be released by both natural and manufacturing processes. It also enters water from rocks and soil, and from agricultural and industrial waste. Some selenium compounds will dissolve in water, and some will settle to the bottom as particles. Weathering of rocks and soils may result in low levels of selenium in water, which may be taken up by plants. Disposal of selenium in commercial products and waste could also increase the amount of selenium in soil. Selenium that may be present in fossil fuels combines with oxygen when burned, which may then react with water to form soluble selenium compounds (ATSDR, 2003). Selenium is most likely to enter the air through coal and oil combustion, as selenium dioxide (Lenntech, 2016) or airborne particles of selenium, such as in ash, can settle on soil or surface water (ATSDR, 2003). Due to irrigation run-off, concentrations of selenium tend to be very high in aquatic organisms in many areas (Lenntech, 2016). The forms and fate of selenium in soil depend largely on the acidity of the surroundings and its interaction with oxygen. In the absence of oxygen when the soil is acidic, the amount of selenium that can enter plants and organisms should be low. Various studies estimated natural selenium concentration of most soils to be between 0.01 and 0.2 mg/kg (Lenntech, 2016). Selenium concentrations exceeded the guideline value at all of the sites in the study area. The selenium concentrations ranged from 0.08 to 0.57 mg/kg which is above the guideline value of 0.08 mg/kg. The selenium concentrations were the highest at site MD1, MD7 and MD8. The concentrations decreased from site MD1 towards site MD6. Sites MD1, MD7 and MD8 had similar concentrations. Selenium is a necessary trace element in animals for some enzyme processes. However, elevated levels can interfere in biological substances containing sulphur due to selenium’s similarity to sulphur. This can cause toxic effects in fish and invertebrates. In addition, aquatic animals absorb or accumulate extremely high concentrations of selenium that will be passed up through the food chain that can cause reproductive failure and birth defects in animals and humans (Lenntech, 2016).

The copper concentrations at site MD7 and MD8 were above the international guideline concentration of 16 mg/kg. In general, the copper concentrations at site MD7 and site MD8 were higher than the concentrations measured at site MD1 to site MD6.

In summary, the metal analysis indicated that five metals showed increased concentrations above the international guideline values. The general trend within the results indicated that the highest concentrations of the majority of the metals were seen at site MD1 and MD2 during the December 2015 survey. The concentrations of metals at the other sites were in most cases significantly lower. The November 2016 survey indicated that the metal concentrations in the samples within the ADF footprint, which exceeded guidelines values, were chromium, copper, selenium, nickel, and silver. The concentrations were generally higher than seen at sites sampled during the December 2015 sampling sites.

Anthropogenic contaminants such as metals take various pathways once they have entered the aquatic environment. These pathways include the adsorption of contaminants to the surfaces of sediments and colloids and deposition into organic debris contained in silts (ATSDR, 2012a; 2012b & 2013). These sediments then become potential sources of contamination of the water column and subsequently biota, as they play a role in the remobilisation of contaminants in these systems (Yohannes *et al.* 2013). Contaminants trapped in sediments tend to have long residence times and these sediments may serve as a constant supply of contaminants to the surrounding environment (Filgueiras *et al.* 2004). Metals are generally subject to immobilisation and deposition, and changes in properties such as pH, conductivity, temperature, dissolved oxygen and turbidity affect the speciation and distribution of many metals. The solubility of metals is found to increase under changing pH and as a result increase these metals' potential to become bioavailable as they move from sediments into the water column.

Although some of the metal concentrations were high in the sediment i.e. chromium, selenium and silver, these metal concentrations in the water samples were generally low (**Table 7-28**). This could potentially indicate that the metal concentrations measured in the sediment could be natural background concentrations and exceeding the international guidelines does not necessarily indicate pollution. However, those samples with exceeded concentrations were closest to the ADF and Coal Stockpile area. This was further confirmed with the two pan samples (MD7 and MD8) in the November 2016 analysis. In addition, the concentrations of aluminium, chromium, iron and manganese were high in the water samples. It is recommended to continue monitoring the metal concentrations at the selected sampling sites for a minimum of one survey per year if the proposed waste disposal project, near any of these sites, will be continued.

7.7.3 *Invertebrate within the Sediments*

Hot semi-arid areas such as the Lephalele region, are characterized by an abundance of small temporary or ephemeral pans, which depend on rain for their existence. These habitats are distinguished by fluctuating and unpredictable changes in their hydrological regime and of physical and chemical conditions (Lahr, 1996). Their existence, extent and duration therefore depend on climatic factors and on morphometric and sediment characteristics. They contain a uniquely adapted fauna that copes in different ways with changing and often extreme temperatures, oxygen levels, pH, salinity and turbidity. The typical ephemeral pan is a shallow, closed basin (Belk and Cole, 1975) that usually contains a well-adapted fauna. Characteristic groups include large Branchiopoda: Anostraca or fairy shrimps, Notostraca or tadpole shrimps, and Spinicaudata and Laevicaudata (formerly grouped together as Conchostraca) or clam shrimps. These three groups of crustaceans are often referred to as phyllopods. Assemblages of species of these groups are found all over the world in hot arid and semi-arid regions.

The main strategies for these fauna are dormancy (escape in time) and dispersal (escape in space). However, these adaptations or strategies may affect the impact of toxicants on individuals, populations and communities of temporary ponds. The physiological adaptations of species found in temporary ponds are likely to alter the sensitivity to pollutants of characteristic species. According to Lahr (1996), results from laboratory experiments, for example, suggest that fairy shrimp (Branchiopoda, Anostraca) may react differently to heavy metals as the standard test species *Daphnia*. Life history strategies influence recovery rates of populations after exposure to acutely toxic substances such as heavy metals. It is also suggested that slow growth and decreased reproductive capacity of organisms caused by toxicants may, in ephemeral pans, result in the failure of annual recruitment.

According to Lahr (1995), increased agriculture and mining are likely to increase environmental contamination by pesticides, fertilizers, heavy metals and other pollutants on these sensitive and important systems. An overview in an ecotoxicological context of the adaptations of one group of temporary pond inhabitants from (semi-) arid zones, fairy shrimps (Branchiopoda,Anostraca), in particular *Streptocephalus proboscideus* (Streptocephalidae), has been presented by Brendonck & Persoone (1993). They showed that the life history traits of these animals make them attractive for application in cost-effective, cyst-based toxicity.

The aim of the invertebrate hatching within two small pans on site was to determine if any invertebrate resting eggs were present in the sediment. Initial hatchlings were identified as Anostraca, fairy shrimp; however, no further identification was possible as the hatchlings did not survive for them to be identified to a lower taxonomic level. The other taxa that hatched in the following days were mostly Daphnidae and one Notostraca, tadpole shrimp, from site MD8. The Notostraca is most probably *Triops granarius* as only two species are found in South Africa. It is important to note that during the early stage of an ephemeral pan filling with water, populations are usually below the carrying capacity of the system. Species that are r-selected will be more successful in this nonlimiting environment, which is relatively free of competition and predation (Brendonck and Persoone 1993). They grow rapidly, mature early, and produce many offspring. However, if pools are more long-lived, the community may shift towards the K-end of the r-K continuum. Crustaceans that rapidly colonize newly filled pans from dormant stages are typical r-species. More competitive, K-selected predators, such as hemipterans and coleopterans, arrive later by aerial migration. At this stage many crustaceans disappear.

Due to the extreme rarity of ecotoxicological studies in these habitats, the impact of chemicals on temporary ponds and its inhabitants are not well known. Crisinel *et al*. (1994) compared the acute toxicity of sixteen chemicals (four heavy metals, eleven organic compounds and one organometallic compound) to nauplii of the *Streptocephalus* fairy shrimps with results from the standard test with *Daphnia magna* (Branchiopoda, Cladocera). The sensitivity of the *Streptocephalus* species to heavy metals was slightly higher than that of *D. Magna.* Mizutani *et al.* (1991), while determining the uptake of heavy metals by the fairy shrimp *Branchinecta longiantenna* (Branchinectidae), found that animals exposed to 1.0 mg L-1 zinc or cadmium expired after two days. This also seems in agreement with the results of Crisinel et al. (1994), and may explain the short lived nature of the shrimp that were hatched from MD8 and MD7.

Overall, the initial screening for invertebrate egg banks within site MD7 and MD8 were positive and it is recommended that detailed hatching studies be completed on the pans surrounding the ADF and MPS, in the long term, if any impact to these systems are predicted.

7.8. Eco-system Services

Despite their recognised importance, the scientific understanding of the functioning of wetlands in arid environments and their associated ecosystem services is incomplete (Tooth, 2015). Although the ecosystem services were not suppose to be assessed, due to the systems not being palustrine systems (Kotze *et al*, 2008), Levick *et al* (2008) highlights the services offered by these systems:

> *Semi-ephemeral and non-perennial systems provide the same ecological and hydrological functions as perennial systems by moving water, nutrients, and sediment throughout the watershed. When functioning properly, these provide landscape hydrologic connections; stream energy dissipation during high-water flows to reduce erosion and improve water quality; surface and subsurface water storage and exchange; ground-water recharge and discharge; sediment transport, storage, and deposition to aid in floodplain maintenance and development; nutrient storage and cycling; wildlife habitat and migration corridors; support for vegetation communities to help stabilize stream banks and provide wildlife services; and water supply and water-quality filtering. They provide a wide array of ecological functions including forage, cover, nesting, and movement corridors for wildlife*.

In addition to the Semi-Ephemeral Washes (SEWs) identified on site, a number of pans were identified. The presence of pans within the moisture stressed environment of the study area means that these wetlands are key providers ('hotspots') of ecosystem services, including water and food supply (Tooth, 2015). The Millennium Ecosystem Assessment (2005) and the UNEP's Global Deserts Outlook (Acura, 2006) both highlighted that in moisture stressed environments such as the study area wetland ecosystem services are unbalanced and may provide the only supply of fundamental water and food resources.

The concern with pans is that they perform few of the functions normally associated with wetlands and could therefore be seen as less important systems (Ferreira, 2012), which is not the case. In addition to the provision of water, these depressions provide a unique habitat in terms of biodiversity maintenance, precipitation of minerals and the distribution of accumulated salts and nutrients during the dry months.

In general pans can provide the following services (Kotze *et al*., 2008):

- Flood attenuation. The opportunity for attenuating floods is limited by the position of pans in the landscape, which are generally isolated from stream channels. However, they do capture runoff because of their inward draining nature, and thus they reduce the volume of surface water that would otherwise reach the stream system during storm flow conditions.
- Precipitation of minerals. Temporary pans allow for the precipitation of minerals, including phosphate minerals due to the concentrating effects of evaporation.
- Nitrogen cycling is likely to be important with some losses due to denitrification, and volatilization in the case of high pH.
- The penology, geology and climate influence the response of these pan systems to nutrient inputs. In pans that dry out completely at some stage or another (non-perennial pans), some of the accumulated salts and nutrients (such as organic nitrogen, and various phosphate and sulphate salts) can be transported out of the system by wind and be deposited on the surrounding slopes. Those remaining may dissolve again when waters enter the system again as the pan fills after rainfall events.

As a guide, NSS utilised the WET EcoServices tool to obtain an understanding on how the four HGM units would provide such services. In summary, with all four units, the main service is Biodiversity Maintenance. This is evident during high rainfall events when these areas become inundated and provide breeding and foraging habitat for an array of species. In addition to this, the Semi-Ephemeral Washes also provided services for toxicant and nitrate removal as well as phosphate and sediment trapping.

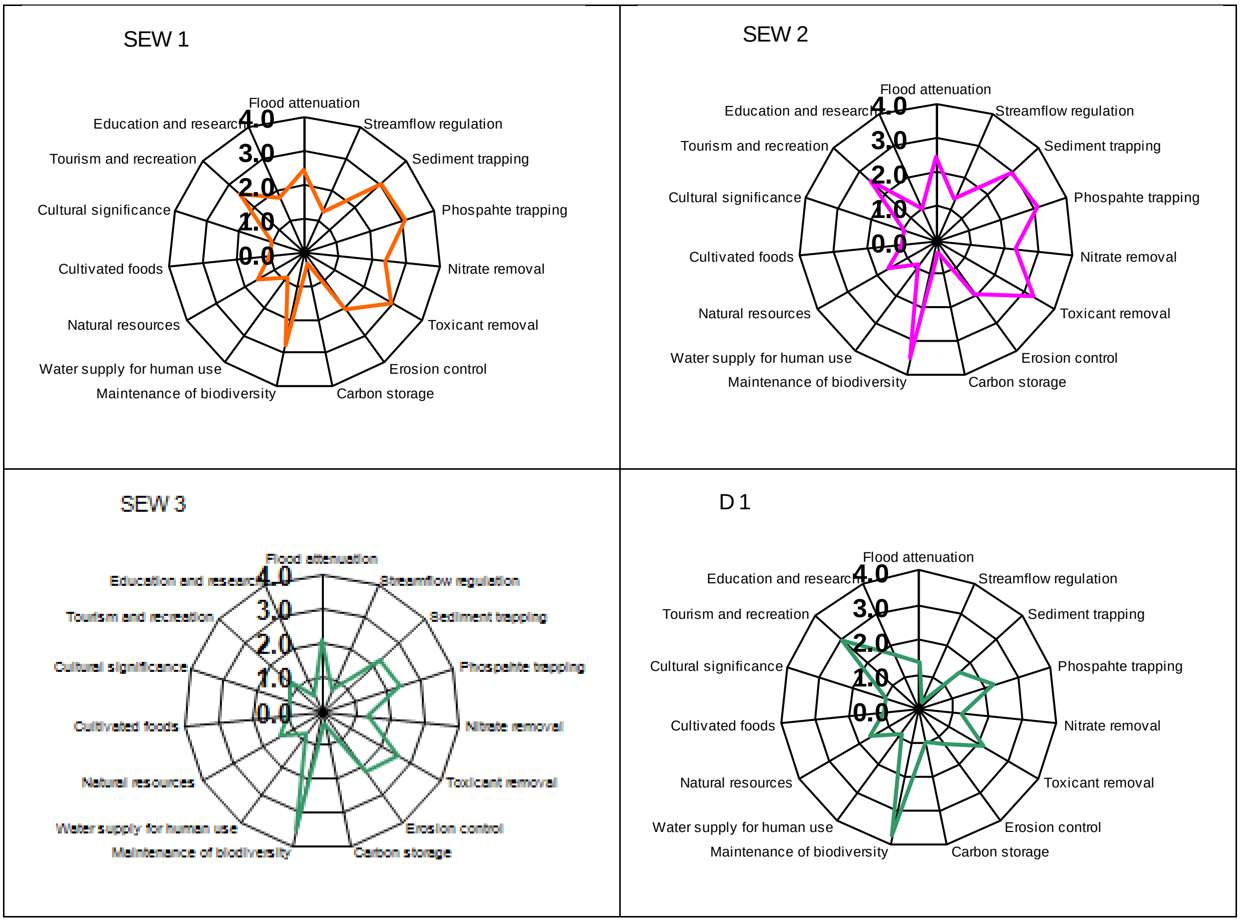


Figure 7-20 Estimated - Ecosystem Services

Combined NSS surveys shows that the MPS and ADF sites (including 500m buffer) support 20 frog species, representing 74 % of the regional amphibian diversity. During high rainfall events, NSS recorded 16 species in total within the study area (**Figure 7-10**). Both of the 2 regionally occurring CIS namely African and Giant Bullfrog were recorded in the study area. A high rainfall event (38 mm in early December 2015) during the second NSS visit triggered the emergence of exceptionally high densities of winged termites and subsequently African Bullfrog and various other species en masse around the pools within the drainage features. The breeding frenzy which insued drastically increased detection rate, and emphasised the exceptional abundance of amphibian species in the study area. Both Giant and African Bullfrog occur sympatrically in the area with the latter generally being regarded as the more ubiquitous of the two in warm bushveld regions (Du Preez and Carruthers, 2009). Indeed African Bullfrog were found to be exceptionally abundant and likely breed at the majority of the pans / depressions within the study area, while in contrast, Giant Bullfrog was only potentially recorded at one locality in the ADF footprint, a small (historically natural) pan which has been deepened and widened by excavation. The observation was of a single froglet (identification tentative based on absence of pale half moon on tympanum usually indicative of African Bullfrog but age precluded confirmation by labial tooth row formula or adult colouration and morphology). Species distinction among froglet bullfrogs is notoriously difficult (A. Channing *pers comm*.). A recent publication by NSS and Enviro-Insight (Yetman and Verburgt, 2015) provides the first records of Giant Bullfrog in the Lephalale region and the greater Limpopo Sweet Bushveld. The study highlights that the species is likely more widespread and common in the region than was previously thought and that low detection levels are likely the result of irregular emergence and breeding in this dry region only during sufficiently wet summers. Suitable breeding habitat appears to be present for both African and Giant Bullfrog along the washes and around the depressions within the study area and it is likely that Giant Bullfrog breeds at more localities within the study area but was not detected due to timing.

Along with the emergence of frogs, comes the emergence of their predators. Numerous snakes were also detected during the surveys at a number of pools and depressions. One species dependant on these systems is the Southern African Python (*Python natalensis*) (**Figure 7-9**).

Distribution data for dragonflies and damselflies provided in Samways (2008) suggests that approximately 50 species have the potential to occur. These species are frequently found away from water and / or require only temporarily inundated areas. Of the seven regionally occurring CIS[7] only five namely Sudan Sprite, Little Wisp, Black Emperor, Strong Skimmer and Silhouette Dropwing are considered likely to occur.

In summary these semi-ephemeral systems are providing an important foraging, breeding and migration habitat for a diverse array of species and are therefore considered extremely important.

7.9. Wetland (Ecological) Importance and Sensitivity

In accordance with a recent study by the DWS (2014) on the PES, Ecological Importance (EI) and Ecological Sensitivity (ES) per Sub Quaternary Reaches for Secondary Catchments in South Africa, the Sandloop PES is moderately modified (C category) where the loss and change of natural habitats and biota have occurred but the basic ecosystem functions are still predominately unchanged. According to the DWS (2014), this river is seriously influenced by cattle grazing and land-use. The moderate EI of the Sandloop is due to the one wetland and two riparian habitat types, 12 different types of vegetation cover and three endemic species in this sub-quaternary catchment with a taxon richness of at least 25 species (wetland, riparian and aquatic vegetation). The size of stream, morphology and geomorphic habitat units determine the ES. The Sandloop has a low sensitivity to modified flow conditions and water level changes because this is an ephemeral system and has a natural lack of surface water (DWS, 2014).

[7] Red listed species or those species with a Dragonfly Biotic Index score of 4 or higher are considered here to be of conservation importance.

A summary of the Wetland Importance and Sensitivity is highlighted in **Table 7-29**. The Ecological Importance and Sensitivity of HGM scored High on a national scale given the presence of the Sandloop FEPA and its importance from a biodiversity maintenance perspective. HGM Units SEW 2 and D 4 scored a Very High whereas SEW 3 scored High. Further discussions on this are highlighted in **Section 7.1.4** above. The hydrological/functional importance or SEW1 and SEW 2 scored a Moderate due to the scores received for water quality enhancement. Direct Human Benefits for all four units received a Low/Moderate score. These systems provide little in the way of subsistence benefits but may provide benefits in terms of tourism etc., due to the number of game farms around the ADF.

Table 7-29 A Summary of the EIS for the Site

WETLAND IMPORTANCE AND SENSITIVITY		
SEW 1	**Importance**	***Confidence***
ECOLOGICAL IMPORTANCE & SENSITIVITY	**4.0**	*4.2*
HYDROLOGICAL/FUNCTIONAL IMPORTANCE	**2.2**	*4.0*
DIRECT HUMAN BENEFITS	**1.5**	*3.5*
SEW 2	**Importance**	*Confidence*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**4.0**	*4.2*
HYDROLOGICAL/FUNCTIONAL IMPORTANCE	**2.1**	*4.0*
DIRECT HUMAN BENEFITS	**1.4**	*3.5*
SEW 3	**Importance**	*Confidence*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**2.7**	*4.2*
HYDROLOGICAL/FUNCTIONAL IMPORTANCE	**1.7**	*4.0*
DIRECT HUMAN BENEFITS	**1.0**	*3.5*
D 4	**Importance**	*Confidence*
ECOLOGICAL IMPORTANCE & SENSITIVITY	**4.0**	*4.2*
HYDROLOGICAL/FUNCTIONAL IMPORTANCE	**1.4**	*4.0*
DIRECT HUMAN BENEFITS	**1.6**	*3.5*

8. Conservation Important Areas

Different levels of significance: - National, Provincial and Local for the study area and surrounds are highlighted within this section.

8.1. National Significance

8.1.1 *National Water Act (NWA; Act 36 of 1998)*

All wetlands / watercourses are protected within South Africa, with their legal protection extended to include buffer zones (Ferrar & Lotter, 2007). As highlighted in **Section 4**, South Africa has various pieces of legislation governing activities in and around wetlands under International, Regional and National legislation and Guidelines. The National Water Act, 1998, (Act 36 of 1998) (NWA) is the principle legal instrument relating to water resource management in South Africa. All wetlands are protected under the NWA. The NWA acknowledges:

> "*the National Government's overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial use, the redistribution of water, and international water matters."*

As per Chapter 3 of the NWA: Protection of Water Resources:

> *"The protection of water resources is fundamentally related to their use, development, conservation, management and control. Parts 1, 2 and 3 of this Chapter lay down a series of measures which are together intended to ensure the comprehensive protection of all water resources. "*

The Sandloop River, the Washes and Depressions are ephemeral in nature but are still considered drainage features (watercourses) and would therefore be protected under the NWA.

8.1.2 *National Freshwater Ecosystem Priority Area*

National Freshwater Ecosystem Priority Areas (NFEPAs) provides guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition. It supports the implementation of the National Water Act (NWA), the Biodiversity Act (NEMBA) and the Protected Areas Act (NEMPAA).

For the study area, the NFEPA Project recognises the Sandloop System as a **FEPA River** (**Figure 8-1**). This system is rated regionally as having a Moderately Modified (or C) PES. The NFEPA guidelines indicate that FEPAs should be regarded as ecologically important and as generally sensitive to changes in water quality and quantity, owing to their role in protecting freshwater ecosystems and supporting sustainable use of water resources.

Wetland and river FEPAs currently in a good ecological condition should be managed to maintain this condition. Those currently not in a good condition should be rehabilitated to the best attainable ecological condition. Land-use practices or activities that will lead to deterioration in the current condition of a FEPA are considered unacceptable, and land-use practices or activities that will make rehabilitation of a FEPA difficult or impossible are also considered unacceptable.

"Applications for mining and prospecting in FEPAs and associated sub-quaternary catchments should be subject to rigorous environmental and water assessment and authorisation processes, as mining has a widespread and major negative impact on freshwater ecosystems" (Driver *et al*. 2011). Furthermore: mining in any form should not be permitted in FEPAs, or within 1km of a riverine FEPA buffer. No prospecting should occur in FEPAs or within 1km of a riverine FEPA buffer. Care should be taken to reduce the risks of aquifer penetration when drilling, wherever this occurs.

8.1.3 *Priority Areas*

During the National Spatial Biodiversity Assessment (NSBA), nine Priority Areas were identified for biodiversity conservation in South Africa (Driver *et al*. 2004). Priority Areas were allocated where broad-scale habitat remained unprotected or was inadequately conserved. There are no listed SANBI Priority Areas within the study area.

8.1.4 *Threatened Ecosystems*

A list of Threatened Ecosystems within the nine national Priority Areas was gazetted on 9 December 2011 in NEM: BA (Act 10 of 2004). The identified Threatened Ecosystems occupy 9.5% of South Africa and were selected according to six criteria including: 1) irreversible habitat loss; 2) ecosystem degradation; 3) rate of habitat loss; 4) limited habitat extent and imminent threat; 5) threatened plant species associations; and 6) threatened animal species associations. The purpose of listing threatened ecosystems is primarily to reduce the rate of ecosystem and species extinction. This includes preventing further degradation and loss of structure, function and composition of threatened ecosystems.

There are currently no Threatened Ecosystems within the larger region around the study site. The closest vegetation type under threat is the Springbokflats Thornveld.

8.1.5 *Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector (2003).*

The Mining and Biodiversity Guidelines document (MBG) (DEA *et al.* 2013), was consulted for this project, as a number of activities on site are defined within GN704 (GG20119, June 1999) as a mining related activity. The MBG highlights the Sandloop River and surrounding habitat as having **Highest Importance** for Biodiversity (**Figure 8-4**).

8.2. Provincial Significance

8.2.1 *Limpopo Biodiversity Conservation Plan (C-Plan 2)*

According to the Limpopo C-Plan, the study area is situated within a provincial Ecological Support Area (ESA) and Critical Biodiversity Area 1 (CBA). CBA's *"are the portfolio of sites that are required to meet the region's biodiversity targets, and need to be maintained in the appropriate condition for their category.* ESAs "*are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas (CBA) and/or in delivering ecosystem services."* Landscape Corridors provide the best landscape connectivity to support and enable biodiversity to adapt to the impacts of climate change. Local corridors represent "*fine scale connectivity pathways that contribute to connectivity between climate change focal areas*." Species-specific ESAs are "*required for the persistence of specific species*".

8.2.2 *Waterberg Bioregional Plan*

The Waterberg District Bioregional Plan (WDBP; Desmet *et al.* 2016) was developed from the Limpopo Conservation Plan (C-Plan) version 2 (Desmet *et al*. 2013) together with input from stakeholders and available integrated spatial planning tools for the District. Consequently, some differences exist between Terrestrial and Aquatic Critical Biodiversity Areas (CBAs) that have been identified in the WDBP, and similar areas that were identified in the Limpopo C-Plan. Draft WDBP data for the Medupi study area are depicted in **Figure 8-3**. The primary conservation concern should be the preservation of a buffer around the Sandloopspruit FEPA (where the C-Plan CBA 1 and the WDBP Aquatic ESA and Terrestrial CBA 1 are indicated), whilst preservation of terrestrial habitat (where the C-Plan ESA and the WDBP Terrestrial CBA 2 are indicated) should be regarded as a secondary priority.

8.3. Local Significance

Areas of local significance are those areas within the study area that have been highlighted because of their:

- Ecological Sensitivity (including renewability/success for rehabilitation);
- Level/Extent of Disturbance.
- Presence of CI species, (identified at the vegetation unit/habitat level); and
- Conservation Value (at a regional, national, provincial and local scale);

The identified vegetation units within the study site were qualitatively assigned Low to High biodiversity conservation importance or significance. This was based on results of the different sampling runs over the years (as highlighted in the methodology), previous assessments in the area, and our collective professional experience with ecological systems and processes.

It is important to bear in mind the 1:100 year floodline as delineated by Golder (2017) - see **Figure 7-12**. As all wetlands are deemed Protected and Important (Sensitive), this map therefore also highlights the following:

- All Wetland Areas are marked as High
- A 1km Medium-High Buffer is provided to the Sandloop System (in line with FEPA; MBG and the Limpopo C-Plan).

As the area is so flat a 100m Buffer is placed on all Washes and Depressions – This is marked as Medium-High

The qualitative assessment criteria are summarized in **Table 8-1** and mapped in **Figure 8-5.**

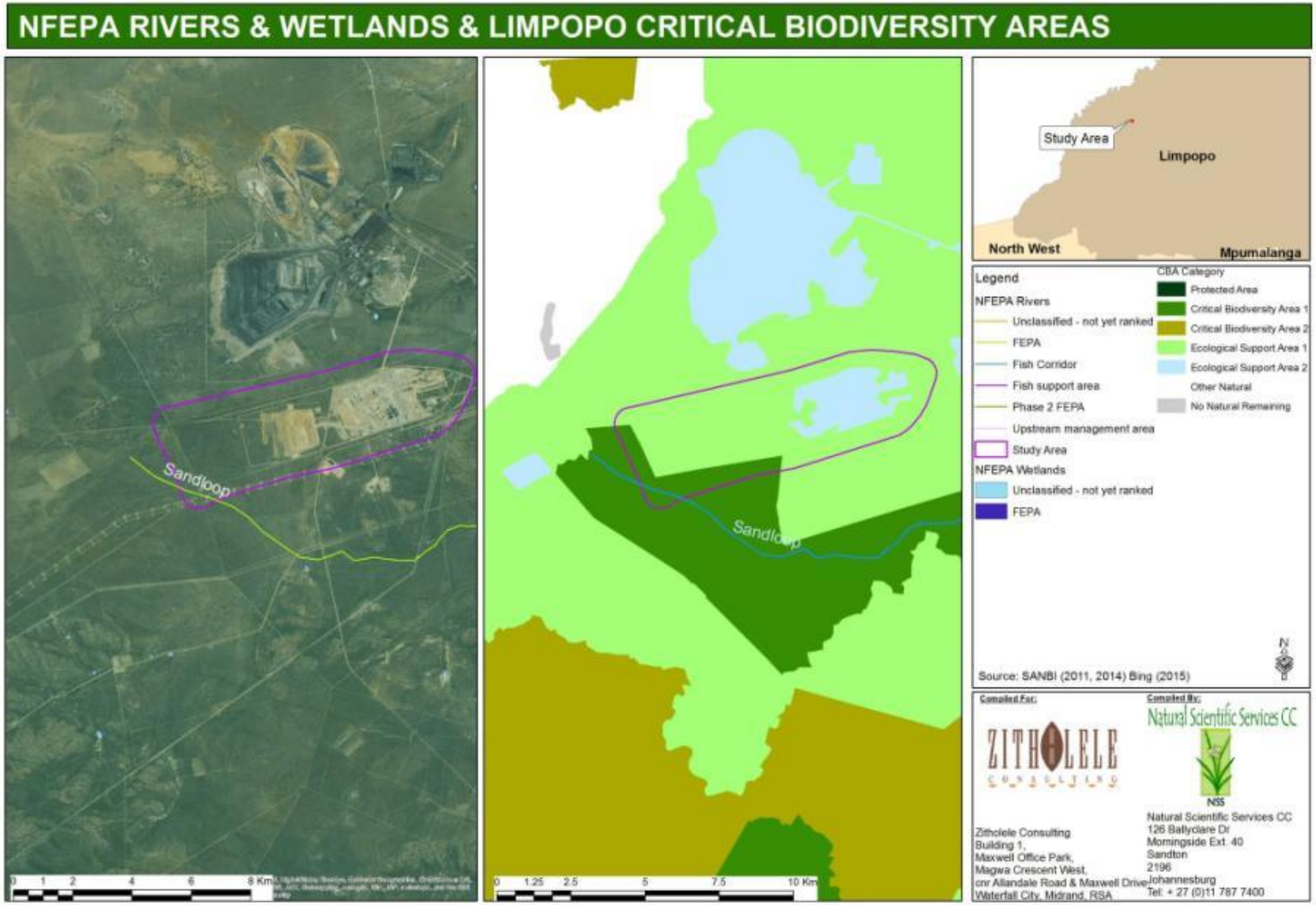


Figure 8-1 **Freshwater Ecosystem Priority Areas and Limpopo Cplan for the greater study area**

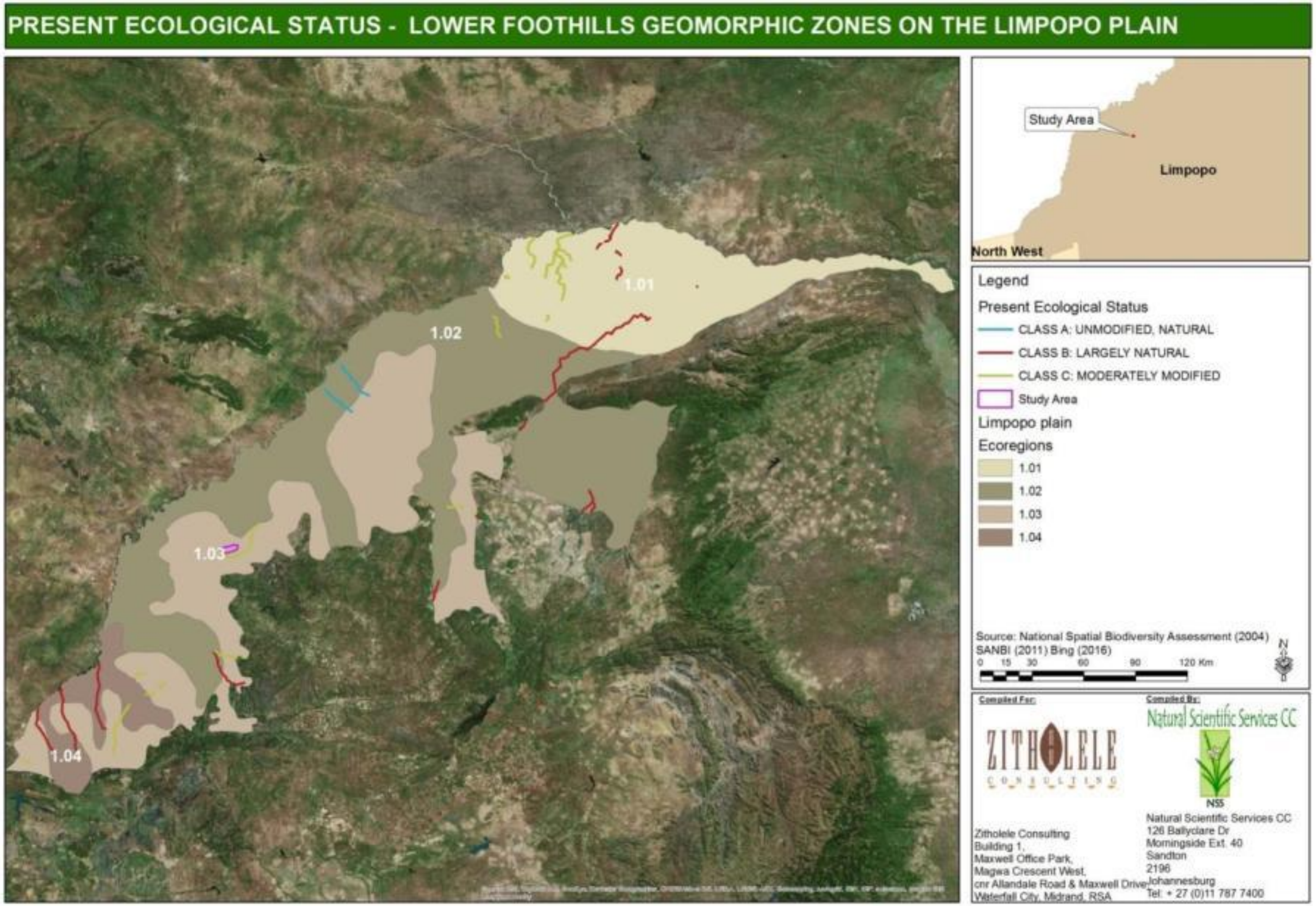


Figure 8-2 Limpopo Plains Ecoregions and Present Ecological State

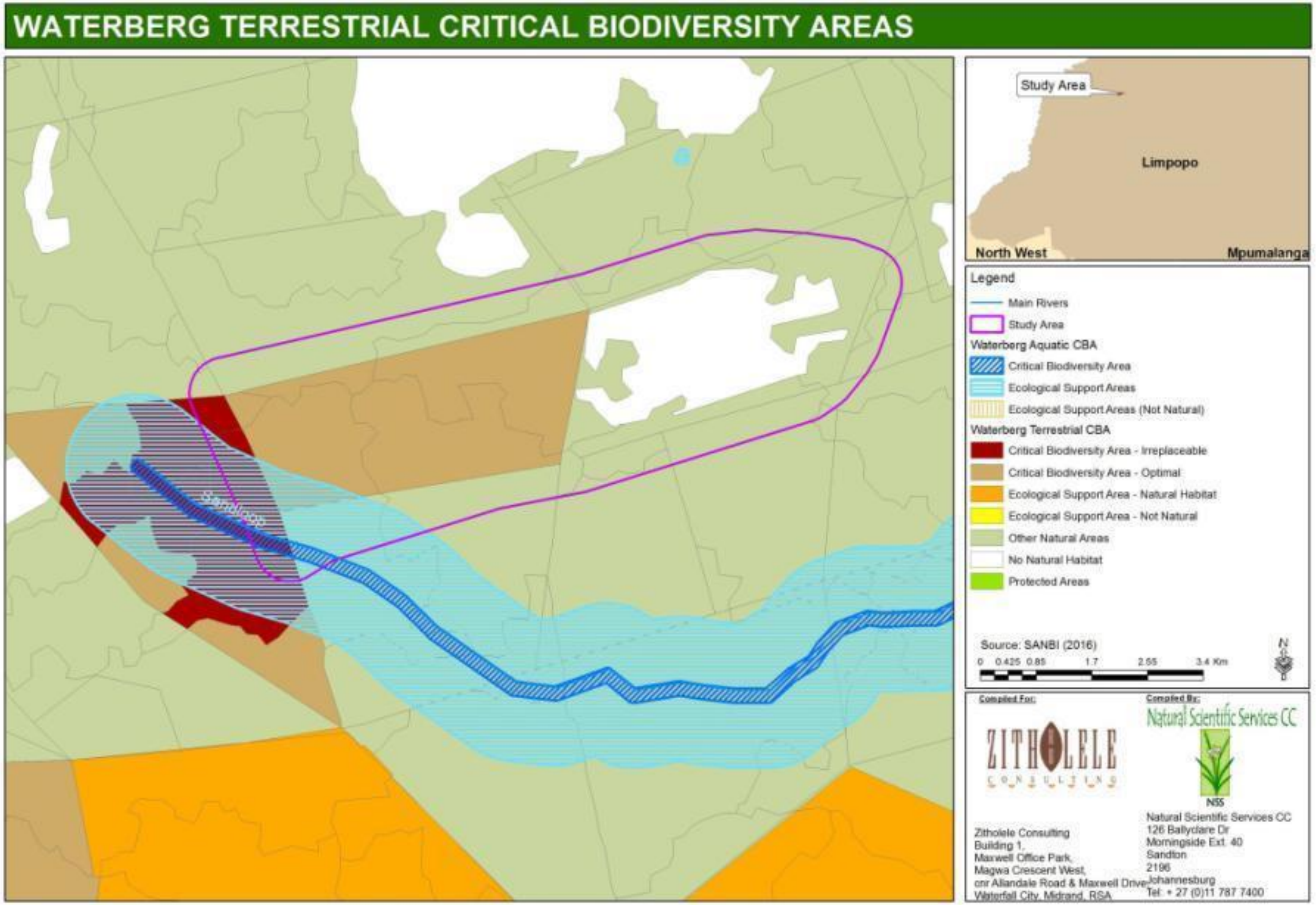


Figure 8-3 **Waterberg Critical Biodiversity and Ecological Support Areas**

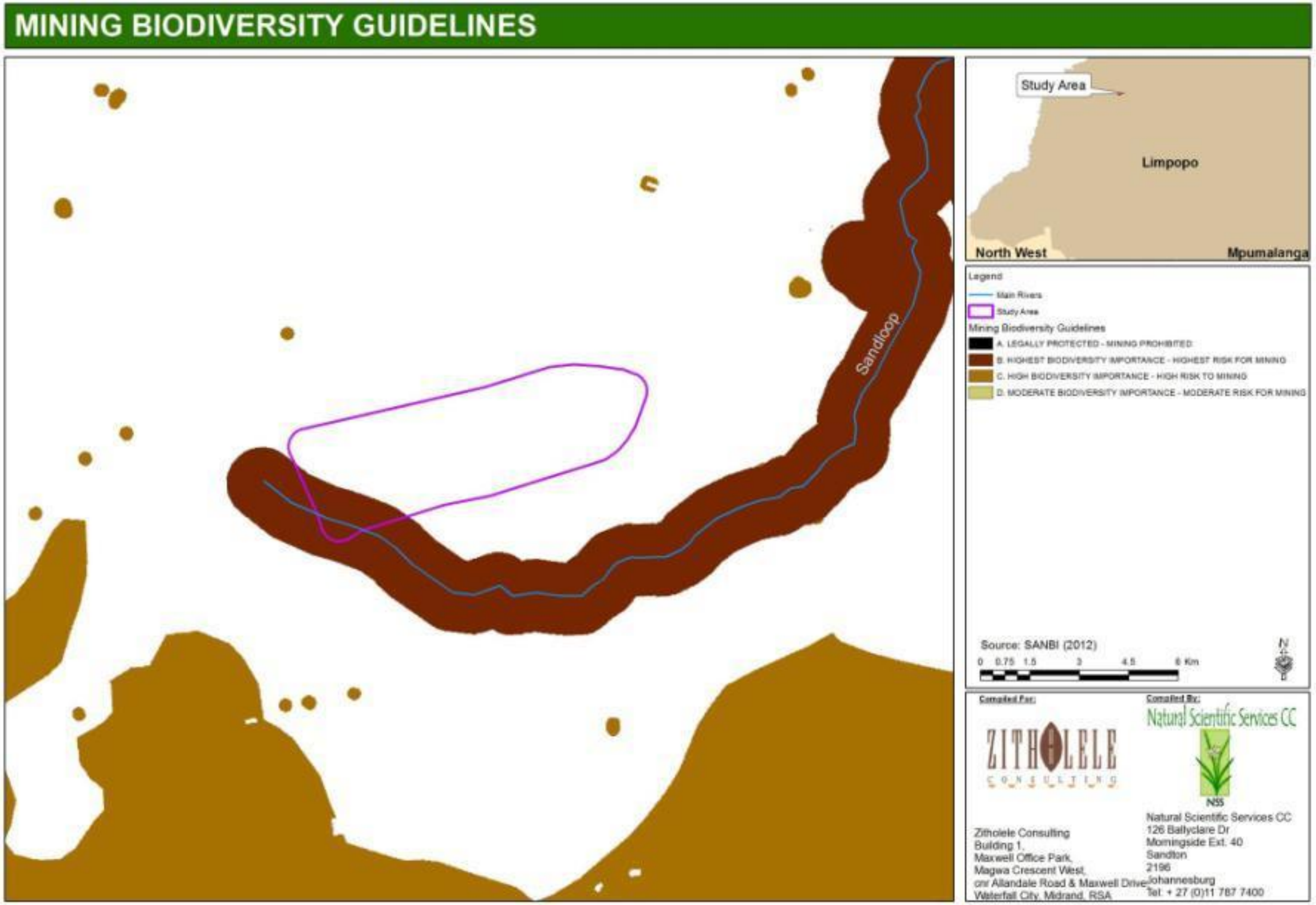


Figure 8-4 **Mining and Biodiversity Guidelines for the greater study area**

Table 8-1 Sensitivity rating of different habitats / floral communities in the study area.

UNIT	HABITAT & FLORAL COMMUNITY	CURRENT CONDITION & IMPACTS	SUCCESS FOR REHABILITA-TION	CI SPECIES	REGIONAL CONSERVATION VALUE	OVERALL SIGNIFICANCE *
Natural Areas						
	Acacia erubescens - Grewia Thornveld	• Understorey has limited herbaceous cover (sampling in the mid summer season) – only tree cover dominant. • Limited cover for faunal species and limited floral diversity • 2.26% of the study area	Difficult to rehabilitate to a similar natural state due to the soil structure and arid conditions. Extended effort will be required to ensure successful rehabilitation. According to Kevin *et al* (2010), moisture is the most important ecological factor necessary for successful rehabilitation of denuded patches in semi-arid environments.	• Limited Herpetofauna and avifaunal species utilise this area • Scattered PT species	• Least Concern Vegetation Unit • Limpopo C-Plan – CBA and within FEPA buffer	**MEDIUM**
	Acacia nigrescens - Grewia Open Veld	• Typical Habitat for the region with a diversity of tree, grass and forb species • Understorey –grass layer more dominant than shrub • Limited alien invasives present • Fragmentation is occurring • 9.19% of the study area		• Habitat utilisation for numerous faunal species. • Potential foraging area for Giant Bullfrog • PT floral species present	• Least Concern Vegetation Unit • Limpopo C-Plan - ESA	**MEDIUM**
	Acacia nigrescens – Combretum apiculatum dominated woodland	• Typical Habitat for the region with a diversity of tree, grass and forb species • Limited alien invasives present • Fragmentation is occurring • 22.87% of the study area		• Habitat utilisation for numerous faunal species. • Potential foraging area for Giant Bullfrog • PT floral species present	• Least Concern Vegetation Unit • Limpopo C-Plan – CBA and ESA	**MEDIUM-HIGH**
	A nigrescens- Dicrostachys- Grewia fragmented Thornveld	• Although fragmented similar to the *Acacia nigrescens –Combretum apiculatum* dominated woodland • Limited alien invasives present • Fragmentation is strong • 8.27% of the study area		• Habitat utilisation for numerous faunal species. • Potential foraging area for Giant Bullfrog • PT floral species present	• Least Concern Vegetation Unit • Limpopo C-Plan – CBA and ESA	**MEDIUM-LOW**
	Acacia mixed woodland	• Highly fragmented • Alien Invasives present – edge effects occurring • Increase in species such as *Dichrostachys cinerea* • 6.59% of the study area		• Potential foraging area for Giant Bullfrog • PT floral species present	• Least Concern Vegetation Unit • Limpopo C-Plan - ESA	**MEDIUM-LOW**
Wetland Areas						
	Acacia	• Similar habitat to the *A nigrescens*	The flats will be difficult to	• Most faunal species rely on	• Least Concern Vegetation	**VERY HIGH**

UNIT	HABITAT & FLORAL COMMUNITY	CURRENT CONDITION & IMPACTS	SUCCESS FOR REHABILITA-TION	CI SPECIES	REGIONAL CONSERVATION VALUE	OVERALL SIGNIFICANCE *
	dominated Wetland Flat Depressions Artificial water points / Waterbodies	dominated woodlands. Depressions lack vegetation cover • +4% of the study area	rehabilitate, however, NSS in association with Eskom Engineers will be looking at reconstruction depressions outside of the FGD Study Area	these systems in such an arid environment • Breeding area for African and Giant Bullfrog as well as a range of other species • PT floral species present	Unit • NFEPA • CBA (Limpopo and Waterberg); as well as Limpopo C-Plan - ESA	
Transformed Areas						
	Conveyor and associated areas; ADF, MPS, Cleared areas and stockpiles; Gravel road and fence line	• Highly transformed • High human presence/activity • 46.61% of the study area	As per statement above	• *Sclerocarya birrea* seedlings present on edges of soil stockpile areas. • Potential for CI species to occur are limited	• Least Concern Vegetation Unit • Limpopo C-Plan - ESA	**LOW**

KEY: ESA – Ecological Support Area; PT: Protected Tree

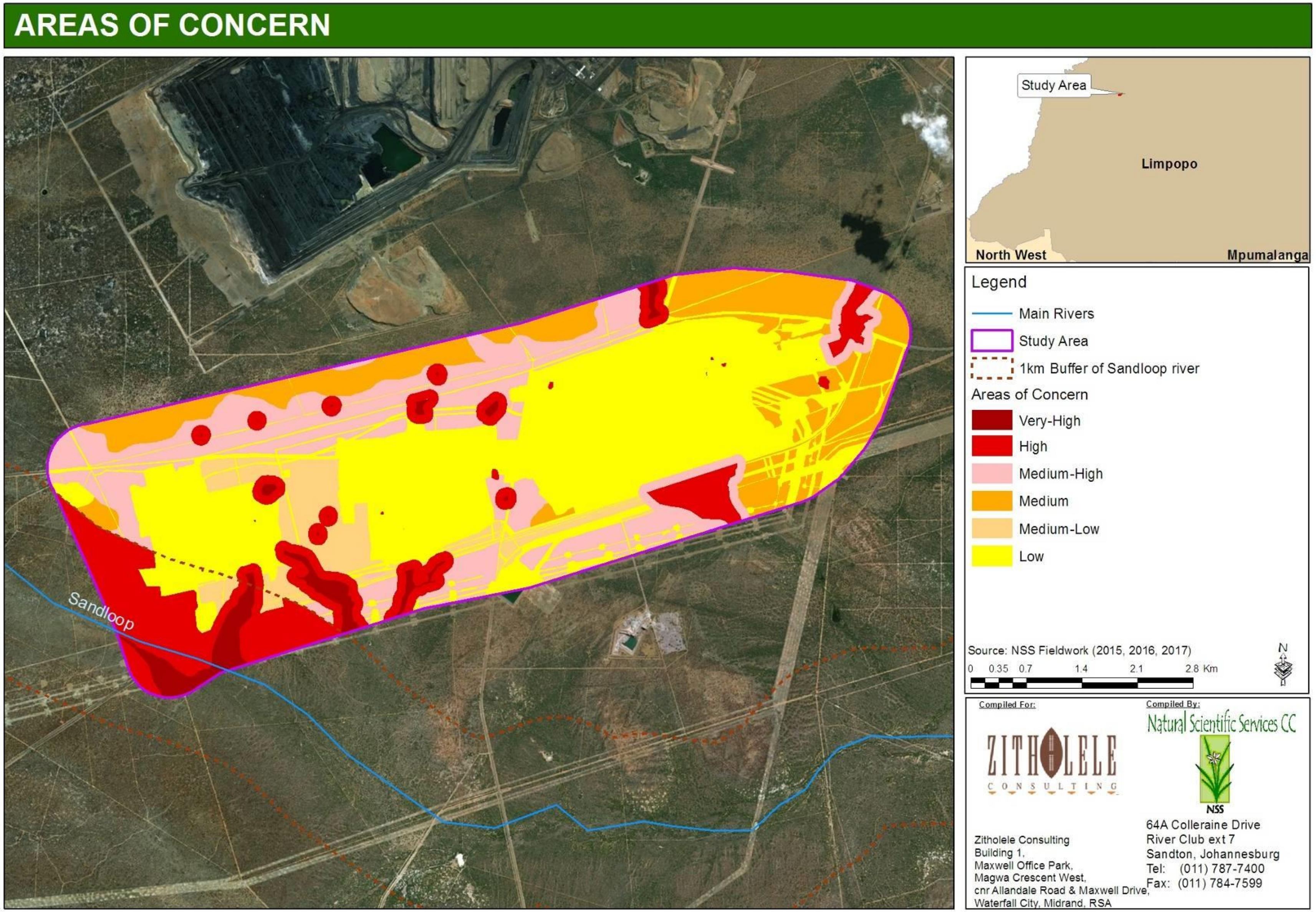


Figure 8-5 Local Significance (Areas of Concern shown only within the study area)

9. Impact Assessment

This impact assessment covers both the ADF and FGD plant and associated infrastructure areas at Medupi Power Station as it pertains to wetlands and aquatic biota, as well as terrestrial fauna and flora. Our assessment was completed according to the methodology prescribed by Zitholele, and in the context of:

- Various meetings with Zitholele and Eskom.
- Meetings with DWS.
- A workshop at Zitholele with all relevant specialists and engineers.
- Results from the desktop and field based investigations of fauna, flora, wetlands and aquatic invertebrates conducted over a period spanning 2014 to the present.
- Based on request from Eskom Medupi Management this included the amalgamation of three separate studies which included:
    - Terrestrial Biodiversity Assessment for the ADF Site Alternatives.
    - Medupi PowerStation: Railway Yard Ecological Assessment.
    - Wetland Assessment for the Proposed Ash Disposal Facility at Medupi Power Station.
- Relevant international, national and provincial legislation and policies.
- The national and provincial significance of wetlands and their local biodiversity, as highlighted e.g. by the NFEPA, the Mining and Biodiversity Guideline, etc.
- Significance Rating for the wetlands and associated buffer zones.

It is important to note that a number of mitigation measures have been specified in conceptual engineering plans to prevent contamination of the environment as a result of the FGD plant (refer to engineering reports). Additionally the design philosophy of the ADF and associated infrastructure has incorporated a number of measures aimed at reducing adverse effects to the environment. These are outlined in a number of reports as relevant to the ADF from Jones & Wagner (PTY) LTD (Report Numbers.: JW057/10/B754; JW68/14/D650 – Rev B; JW253/14/E009 – Rev0). Key mitigation measures as relevant from these reports are summarised below:

- The MPS ADF will be the first of Eskom's ash disposal facilities to be lined. Additionally the PCD and storm water management systems will be lined.
- An amendment application by Eskom has been submitted to the respective authority for the installation of a Class C liner system. This liner design is set in terms of the norms and standards.

It should be noted that Eskom's MPS received a Record of Decision (Ref: 12/12/20/695) on 19 September 2006 for the Construction of Medupi Power Station (MPS), that specifically excluded Environmental Authorisation (EA) for the above-ground ashing facility, pending further investigation. On 23 October 2009 (Ref:12/9/11/L50/6), through further inputs requested by DEAT, Eskom was granted EA for the Ash Disposal Facility (ADF). However, the EIA process conducted in 2006 and in 2008 did not identify the presence of wetlands on site. Subsequent investigations conducted by NSS in 2014 as part of the site selection for the FGD waste disposal facility revealed the possibility for the presence of wetlands within the current ADF area. NSS was commissioned to conduct a wetland assessment for this area. Fieldwork in 2015 and again in late 2016 confirmed the presence of a number of depressions and semi-arid ephemeral wash wetlands within the area earmarked for the construction of the ADF. Discovery of wetlands within the proposed infrastructure footprint at such a late stage, during site clearance and construction of the ADF, has obviously presented a number of challenges regarding the protection of these water courses. Areas of current disturbance are shown in **Figure 9-8**.

Ideally no development should occur within the 1:100 year floodline and 1 km buffer on the Sandloop FEPA. However, given the circumstances NSS suggested that MPS should develop several infrastructure design alternatives from an engineering perspective that seek to primarily avoid development within this area altogether or, if impossible, illustrate designs that minimise the extent and impact of the footprint on the various HGM units identified as well as the 1:100 year floodline and Sandloop buffer. Since the initial drafting of this report Eskom has commissioned a study by Golder to revisit the 1:100 year floodline which has subsequently been reduced in extent and now only marginally clips the south western boundary of Site 13. In terms of changes to the ADF design some changes have been made but these are very small and still encroach similarly on the FEPA buffer and would still see the loss of pans C20 (bullfrog breeding site) and C21 (possible bullfrog breeding site). Encouragingly however, C11 appears to have been spared based on the current layout supplied to NSS.

NOTE: The methodologies for this impact assessment require that impacts are grouped according to activities. Therefore the most conservative risk rating for each activity has been provided.

Definitions for the Existing, Cumulative and Residual impacts are provided below:

- *Existing impacts* – The Coal stockpiles and associated traffic movement, the initial construction of the Medupi ADF (including Earthworks, clearing of vegetation etc) as well as the MPS.
- *Cumulative impacts* - These include the *Existing* defined impacts as well as the completion of the ADF, the FGD retrofit and the disposal of ash and gypsum at the ADF, as well as the transport of sludge and salts to an existing licensed facility.
- *Residual impacts* – This relates to post mitigation considering the *Cumulative Impacts* and assumes that mitigation has been effectively implemented.

Immense vegetation clearing

Coal deposition on roads and surrounds

Clearing of vegetation and topsoil

Seepage from the Pollution Control Dams

Berms and impeded flow

Unnecessary destruction of surrounding vegetation

Storm water collection southern portion of the ADF

Coal spills on railway

Vegetation clearing

Vegetation clearing

Large earthen trench around Site 13

Sources of sedimentation

Figure 9-1 Impacts in the Study Area

9.1. Activity: Site clearing

9.1.1 *Impact: Loss of wetland systems*

Description: Clearing of vegetation can result in the destruction of wetland habitat and ecosystem services. Although it is evident that a large portion of the vegetation has already been cleared and potentially a number of Depressions (pans) and extensions to the Semi-Ephemeral Washes, further loss of the systems that remain within the boundary is inevitable, specifically within the current area set aside for the ADF Footprint (Alternative 5). The existing overall impact risk of the historical clearing of vegetation is, therefore, rated as Very High (or flawed). Without mitigation, the overall cumulative impact risk of clearing vegetation for the ADF is rated as Very High (or flawed).

Mitigation: With effective mitigation, the overall residual impact risk of clearing vegetation could be reduced to High. The following mitigation is recommended:

- Alternatives 1 and 3 present the least amount of wetland loss compared to Alternatives 2, 4 and 5. Alternative 5 is the current proposed footprint area which is not an ideal situation but is currently said to be the only practical solution after some realignment of the ADF design in the south-western corner.
- Within Site 13 efforts should be made to situate tools, materials and infrastructure so as to minimise loss of wetland resources.
- Continue to stockpile topsoil and avoid mixing with deeper layers to retain viability of the seed bank.
- Eskom's EO should regularly monitor progress and implementation of mitigation measures.
- Vegetation should preferably be cleared during winter, when many fauna are less active or have migrated. If this is not possible a faunal specialist should be on site during clearing processes.
- Clear approved areas only. Site visits reveal that this has the potential to spill over into other areas very easily.
- Demarcate and restrict anthropogenic disturbances to the construction area.
- Where possible in the removal process, species such as geophytes should be collected and stored in a nursery for future rehabilitative efforts around the mine. Grass seeds can also be collected and stored and used during operation in a number of rehabilitation exercises.
- Construction crews should be informed about the importance of biodiversity through an induction process. Awareness of potentially harmful animals such as snakes should also be raised. The appointed EO on site should be trained to handle snakes.

9.1.2 *Impact: Loss of ephemeral pan habitat for bullfrogs and aquatic biota*

Description: Potentially the most direct, adverse and tangible impact on biodiversity as a result of the development of this project involves the loss of ephemeral wetland habitat upon which a diverse group of amphibians and a unique assemblage of aquatic invertebrates depend. These systems also provide a valuable source of water and refuge in an otherwise arid landscape and, based on our motion camera evidence, are regularly visited by a wide diversity of terrestrial fauna of which many are considered to be conservation important species. Additionally of high significance in this regard would be the potential unearthing of Giant or African Bullfrogs the likelihood of which is deemed to be moderate to high given the proximity to known bullfrog breeding sites situated inside and outside of the site. This impact is most applicable to the ADF as, due to the high degree of fragmentation and disturbance, bullfrogs have likely already been extirpated from the railway yard / FGD area.

STATUS	EXTENT (ha)
Depressions already lost	3.9
Current depressions	12.1 ha
Depressions to be lost	2.4

Mitigation: With effective mitigation, the overall residual impact risk of clearing vegetation could be reduced to Moderate. The following mitigation is recommended:

- It was originally suggested in the first drafts of this report that efforts should be made to carefully design and install infrastructure (including tools and materials) so as to minimise the loss of wetland resources particularly Pans C11, C21 and C20 (known bullfrog breeding site) and the eastern tributary of SEW 1. At the time the conceptual ADF design cut pan C20 in half and the middle of the three proposed PCD footprint areas covers pan C21. It was suggested that a northerly shift in the geometry of the southern ADF boundary could spare C20 and that a shift in PCD positioning should be considered in earnest to conserve these pans.
- It has subsequently emerged following the workshop held at Zitholele with the Eskom engineers that this would not be feasible.
- It was previously recommended that should this be the case i.e. that pans C11, C20 and C21 are to be destroyed, a bullfrog specialist should be commissioned to capture and relocate bullfrogs to a nearby secure pan with full Eskom labour support. Any other overwintering bullfrogs unearthed during clearing activities should also be relocated to a nearby pan (preferably within Site 12).
- These measures (to commission a bullfrog study and relocate bullfrogs to new artificially engineered habitats) were strongly supported and in fact recommended during a meeting (30 November 2017) with P. Ackerman at DWS head office as well as by discussions with Dr Caroline Lötter an authority on bullfrogs.
- At the time of writing this updated and consolidated report NSS has been commissioned to conduct a wetland rehabilitation and offset plan. A significant

portion of this plan involves close collaboration with Eskom's amphibian specialist from EWT with the overarching aim of relocating bullfrogs to newly created pan habitat outside of the site. Exact methodologies and mitigation measures in this regard will be outlined in the reports which emanate from this relocation project.

- At least some of the larger relocated individuals should be tracked through radio telemetry or GPS data loggers.
- Bullfrogs are explosive breeders that emerge for brief periods of the year following strong downpours. As such the overall success of relocation efforts relies heavily on diligent and accurate rainfall monitoring by Eskom and the issuing of prompt alerts of high rainfall events to the relevant specialists (NSS and Eskom's amphibian specialist from EWT).
- Any overwintering bullfrogs unearthed during clearing activities (or otherwise) should be reported to the appointed EWT amphibian specialist or if unavailable NSS.
- The appointed EO and several other staff members on site should be trained to handle bullfrogs and snakes.
- Any bullfrogs found after the relocation efforts should be relocated to one off the newly created pans that have shown signs of bullfrog establishment (consult EWT or NSS for advice if necessary).

9.1.3 *Impact: Loss of Acacia Woodland Habitat*

Description: Clearing activities during construction will result in the direct loss of remaining vegetation within the ADF and FGD. However, the area in which the rail yard is to be constructed (eastern section) is already disturbed and contains soil stockpiles. This section of the site has largely been transformed already and therefore the impact is expected to be of low significance here. However, following the workshop held at Zitholele it was suggested that a conservative approach should be taken that the entire railyard / FGD area would be cleared. The potential loss of these more natural pockets of Limpopo Sweet Bushveld within the railway yard / FGD area as well as that within the much larger ADF area this impact is considered to have a high cumulative impact and a moderate residual impact.

Mitigation: The following mitigation applies:

- Clearing needs to occur only within the footprint of the proposed ADF (Alternative 5) and the FGD / railway yard area. If at all possible vegetation in the western corner of the railway yard area must remain intact and undisturbed.
- The area of construction should be fenced to prevent encroachment into surrounding vegetation.
- Any bulbous species or PT species that can be transplanted must be removed.
- Alien species must be controlled under the MPS Alien Control Programme.

Figure 9-2 **Existing clearing of *Acacia* woodland for the ADF**

9.1.4 *Impact: Potential increase in alien vegetation species*

Description: Clearing activities during construction will result in an initial decline in the alien species that are currently on disturbed areas. This, although positive may only last for the clearing phase of construction. During construction and operation alien species can increase due to all the disturbances. Furthermore, seedbanks for species such as *Nicotina glauca* have already established on site.

Mitigation: The following mitigation applies:

- Clearing needs to occur only within the footprint areas and all Category species must be removed during this process.
- Alien species must be monitored and controlled under the MPS Alien Control Programme.
- Construction crew must be made aware of the species that occur on site specifically Category 1 species and must be trained in the basics for recognition and removal.

9.1.5 *Impact: Potential loss of CI floral species*

Description: Clearing activities during construction will result in the direct loss of remaining vegetation and therefore specific CI species. There are a number of Protected Tree species present in the area including *Sclerocarya birrea* subsp. *caffra* (marula)*, Boscia albitrunca and Spirostachys Africana. Sclerocarya birrea* is a keystone plant species, which is rated as one of the most highly valued indigenous trees because of its multiple uses. It is identified as a key species to support the livelihood of rural communities and it is central to various commercial activities. It is also widely used by game in protected areas and by humans in communal areas for its fruit, wood and medicinal properties (Tshimomola, 2017). As a keystone large tree species in southern Africa it has been recorded as declining at an unprecedented rate in areas such as the Kruger National Park (KNP) (Helm & Witkowski, 2012)). Studies conducted in the KNP showed the loss of adult marula trees in some areas over the last decade exceeded 25%, with rainfall having a strong influence on mortality rates temporally and spatially. Overall, marula populations continue to decline and further local extinctions are possible, not just in the KNP. Given the clearly unacceptable trends of decline, it is imperative that these Protected species be conserved across the country where possible.

Boscia albitrunca was not recognised as a Protected tree species in South Africa in terms of section 12 of the National Forests Act, 1998 (Act No. 84 of 1998), but has more recently been added due to its role as a Keystone species. This was clearly evident during the NSS surveys where this species was providing browse to livestock and game, shade and food and shelter to other species including invertebrates and birds.

Mitigation: MPS has removed tree species successfully during the construction phase of their MPS. Therefore the same would apply here. The Environmental Officer (EO), or trained botanist will be required to tag all Protected Trees within the footprint for removal and relocation. These individual plants will need to be monitored over the long term. Permits will be required for the removal process with DAFF. Any other species that may be identified as CI must either be translocated (if possible) or specific mitigation must be compiled by a qualified botanist in collaboration with the MPS EO.

9.1.6 *Impact: Potential loss of CI faunal species (excluding bullfrogs and raptors)*

Description: This impact relates to CI vertebrate species other than bullfrogs and raptors. Impact to these faunal groups are discussed in isolation elsewhere in the impact assessment. Clearing activities during construction may potentially result in the direct mortality of CI faunal vertebrates or result in their displacement. Although a wealth of CI species has been found to occur in the properties to the south of the FGD study area (Site 12 and 2) the impact as it relates to the ADF and FGD infrastructure is expected to be of Low significance. This is due to the area’s high degree of vegetation and sensory disturbance levels which appears to have resulted in a low diversity and conservation status of potentially occurring CI vertebrate species (other than bullfrogs) within the FGD study area. This impact on the loss of CI invertebrate species is deemed to have a low significance as well. This is because although there is some chance of losing CI baboon spider and scorpion species during clearing, the severity at a regional scale is low given the expansiveness of similar remaining bushveld habitat.

Mitigation: Clear in winter. It is recommended that immediately prior to clearing that a walk down be conducted by in conjunction with a suitable specialist, preferably one with expertise in arachnids, to intensively search the site preferably in the height of the rainy season (December) to detect and relocate any baboon or trapdoor spiders or scorpions frogs, tortoises. If any of these species are encountered during development the specialist with should advise upon and oversee oversee relocation.

9.1.7 *Impact: Potential loss of CI raptor species.*

Description: This impact is deemed to be of low significance due to the very low likelihood as no nests were observed on within the FGD study area. Although suitable nesting structure (Trees > 5m) was present (but limited), disturbance levels from the power station and current clearing activities is probably too high. However if nests were overlooked and are destroyed the significance of this impact would be high given the high (Vulnerable) conservation status of these raptors. Loss of foraging habitat is considered to be of low significance due to small extent and fragmented nature of the site that currently supports low game densities.

Mitigation: Mitigation is limited and likelihood is very low. However if a nest of CI raptor species is encountered, its location should be marked, and it should be reported to the relevant authorities before construction continues. Normally a minimum 1km radius buffer or exclusion zone should is applied to such points but given the complex nature of this project would require in depth consultation with an appropriately experienced ornithologist. As far as possible large trees above 5m should be marked and safeguarded in the unaffected areas.

9.1.8 *Impact: Loss of foraging habitat for game species.*

Description: This is an impact with greatest relevance to the rail way yard area. It is considered to be of low likelihood but has the potential to be problematic if managed incorrectly. The extent of remaining natural vegetation is already highly fragmented and barely large enough to support viable herds of game without significant grazing supplementation. Currently the proposed disturbance footprint within the railway yard area does not encroach appreciably into the main patch of natural vegetation but if it ends up exceeding this area the Kudu and Impala present on site may be left with too little foraging habitat and would need to be captured and relocated.

Mitigation: Clearly demarcate the footprint area. Minimise disturbance footprint and restrict construction and operation activities to within the proposed footprint area. The

EO must monitor the carrying capacity relative the game within the Railyard area and act accordingly to ensure that there is enough grazing land for the existing game within this area, otherwise implement capture and relocation. If the game are to be kept then standard game keeping management principles must be adhered to and a management plan drawn up for the game. All relevant permits must then also be in place.

9.2. Activity: Construction and operation of the ADF and FGD infrastructure

9.2.1 *Impact: Loss of catchment area and consequent decrease in water inputs as a result of the necessary containment of dirty water runoff*

Description: Currently the MPS project as a whole has displaced a large proportion of wetland catchment area and has undoubtedly acted to reduce water inputs. Flows which do remain have been largely concentrated and directed into wetlands south of the greater project area. This situation is likely to be exacerbated in the future under the construction of the storm water infrastructure which is required to prevent dirty water from the FGD and ADF from entering the environment. The ephemeral depressions, washes and Sandloop FEPA in the focal area rely heavily on diffuse source water inputs from surface and subsurface flows following rainfall events that are in turn governed by the region's erratic and intense summer rainfall patterns. The contents of the ADF are classified as hazardous waste and therefore any water runoff directly from the facility, by necessity (due to, *inter alia*, water quality implications), will be contained within a closed system and separated from clean water and the receiving environment. An unavoidable consequence of this is the loss of a significant portion of the catchment area for the depressions and wash wetlands on site, and the upper reaches of the Sandloop FEPA. The catchment of these systems was modelled by NSS using USGS derived digital elevation data together with a channel analysis. The resultant catchment area was calculated as 4320.5 ha. It should be noted that our estimate on catchment area is largely congruent with that of the surface water study (4467 ha) conducted by Zitholele (2016). This report includes catchment losses as a result of the MPS which increases catchment losses to 49.5 % (Zitholele, 2016). Our estimates are thus more conservative in that they deal with catchment losses directly as a result of the construction of the ADF alone. Results of the extent of catchment loss for the various infrastructure alternatives are given in **Table 9-1**. This table shows that regardless of the alternative (Alternative 5) opted for, the degree of catchment loss as a result of the construction of the ADF remains high with the current footprint resulting in a loss of 584.93 ha (13.54%). This level of catchment loss will likely result in a reduction in surface water inputs to these wetland systems and should be regarded as significant especially in light of the arid, water stressed nature of the receiving environment.

Table 9-1 Extent of catchment loss for the various infrastructure alternatives

INFRASTRUCTURE ALTERNATIVE	CATCHMENT LOSS
Alt 1	526.2 ha (12.2 %)
Alt 2	602 ha (13.9)
Alt 3	586.1 ha (13.6)
Alt 4	625.58 ha (14.5)
Alt 5	584.93 (13.54)

Mitigation: The mitigation with regards to catchment loss is limited and the residual impact risk remains High. Efforts should be centred on minimising catchment loss by minimizing the ADF, PCD, coal stockpile and other associated infrastructure to as small an area as possible. Particularly, efforts should be made to minimise any further encroachment into the Sandloop 1:100 year floodline and 1 km buffer. Release of clean water into the environment needs to be carefully engineered such that it enters the watercourses in a diffuse not concentrated flow to prevent erosion. This involves the use of flow attenuation and spreading structures at outlet points. The large earthen trench around the site compounds this issue and requires re-thinking from an engineering perspective. If found to be of value it should constructed so as to handle surface runoff in high rainfall events such as was observed during the previous site visit. If its purpose cannot be convincingly motivated it should be removed, re-landscaped and revalidated.

9.2.2 *Impact: Increased faunal mortality*

Description: Particularly relevant for species with low dispersal abilities e.g. fossorial species, tortoises, chameleons and various other reptile and frog species. During construction clearing will likely dispatch any species in the path of clearing. During operation, continued mortality is expected as vehicle and train activity increases but the effects of this are deemed to have Moderate impact..

Mitigation: The site should be searched prior to clearing by an appropriately qualified specialist and any less mobile fauna relocated. Maintain existing tortoise road signs and insert new ones where necessary. Continue to enforce speed regulation controls such as speed humps and limits.

9.3. Activity: Harvesting of hillwash material (topsoil) within the ADF footprint

9.3.1 *Impact: Potential loss of wetlands and deterioration in downstream Sandloop wetland drivers*

Description: These somewhat cryptic wetlands were originally not identified by the appointed specialists during the environmental authorisation process for the MPS and subsequently the ADF. An EA was granted in 2009 (Ref12/9/11/L50/6). Some of the depressions and washes were consequently lost through construction activities. Nevertheless a number of these systems still remain and have the potential to retain much of their integrity and ecological functioning. The main impact associated with the harvesting of hillwash material is the potential direct loss of depressions and semi-arid ephemeral wash wetlands and their vegetation as well as deterioration in the downstream hydrological and geomorphological drivers of the Sandloop through changes in water distribution and retention patterns and increased sedimentation respectively. Without mitigation this impact has the potential to significantly impact water courses on a national scale with legal ramifications but also the potential loss of charismatic species such as bullfrogs.

Mitigation: Following mitigation measures and recommendations made in this report these impacts can be reduced from a High to a Medium and construction could conceivably occur without detrimentally damaging the ecological integrity and biotic functioning of these systems. With effective mitigation, the overall cumulative negative impact risk due to earth works could be reduced to Moderate. The residual impact is rated as Medium and not Low as there is still the potential for a loss in water inputs (due to a collection in scraped areas) to the depressions and washes which rely so heavily on surface water inundation following rainfall events as well as the ever present potential for increased sedimentation and biotic isolation and fragmentation of these systems as connecting vegetation is cleared around them. The following mitigation measures are recommended:

- Harvesting of hill wash material must be prohibited within at least 100 m of the delineated edge of all identified depressions and semi-arid ephemeral wash wetlands.
- Harvesting of hillwash material should not encroach upon the delineated 1:100 year floodline boundary and the 1 km buffer on the Sandloop FEPA).
- Ensure that harvesting of hill wash material does not take place within a 500 m radial buffer of the identified bullfrog breeding site (Depression C 20) and within a 100 m of C20 and C11.
- Ensure that the responsible on site personnel have the delineated wetlands and their associated buffers on their GPSs.
- Make sure that these areas are clearly demarcated with high visibility fencing and prohibit all activities within these areas with signage that indicates it is an environmentally sensitive area. Keep scraping neat and systematic.
- Stockpile topsoil in an area situated as far as possible from all identified wetlands to avoid sedimentation.
- Ensure that measures are taken to contain topsoil during rainfall events and prevent it washing into the environment. Attempt to maintain the natural stratigraphy of the topsoil when stockpiling.

- Ensure that all guidelines and standards are met with regards to the stockpiling of topsoil.
- The stipulations within the ROD (12/12/20/695) must be adhered to as well as the EA (Ref: 12/9/11/L50/6).
- Additionally a Risk Assessment performed by a suitably qualified professional will need to be conducted that takes cognisance of the identified wetlands and the national importance of the Sandloop FEPA.

9.4. Activity: Earth Works (associated with construction of the ADF)

9.4.1 *Impact: Deterioration in wetland drivers*

Description: Current impacts associated with the earth works specifically during the current construction of the ADF were rated as **High** and include:

- The clearing of the ADF which has displaced a number of pans and portions of the upper Sandloop tributaries but also encroaches on the Sandloop FEPA buffer. Additionally soil berms created adjacent to the ADF are impeding flow - see **Figure 9-2** above.
- Erosion and sedimentation. Large V-drains have been dug around the ADF. As these are not lined with concrete or other stabilising structures some breakthrough has taken place along the southern boundary. Indeed some of these breakthroughs have been facilitated by earthmoving equipment in an attempt to drain the flooded trenches into one of the eastern-most tributary of HGM unit 1. Currently these berms are not adequate for heavy rainfall and at certain points, these trenches have failed with sediments etc been washed downstream.
- An increase in herbaceous alien flora is transported along these channels and washes towards the Sandloop system.

Future impacts from excavating, levelling, compacting and dumping material can cause:

- Further dust, erosion and sedimentation downstream;
- Further loss of fossorial fauna such as many of the frogs shown in **Figure 7-10**.
- Proliferation of alien flora and therefore an increase in competition with indigenous species.

As these activities are already underway the Cumulative Impact is seen to remain as High. In terms of positive impacts, the earthworks through excavations etc have created “wetland” habitat for faunal species such as the African and Giant Bullfrog. These areas also are deep enough to stay wet for longer and provide a source of drinking water to small animals. This is, however, considered of Moderate significance (both current and cumulative).

Mitigation: With effective mitigation, the overall cumulative negative impact risk due to earth works could be reduced to Moderate.

- The ultimate aim of the construction of the ADF and associated infrastructure would have been to attempt to ideally remain outside of or at least opt for infrastructure layout that minimises the disturbance footprint within the 1:100 year floodline and the 1 km FEPA buffer.
- Eskom's EO to be on site regularly, and to monitor progress and implementation of mitigation measures.
- Daily wetting of exposed surfaces during earth works to control dust (refer to Air Quality IA for further mitigation measures).
- Erosion Management Plan to be compiled and implemented. Measures that could be considered include:
  - Placing biodegradable sand bags around stockpiles, the construction footprint, etc. As the topography is flat, these are recommended as opposed to berms.
  - Re-investigate the design of the Storm Water Management, specifically the canals within the southern section of the current ADF footprint. These are failing in large rainstorm events. The stormwater management and water balance calculations need to be consulted or revisited to ensure that the volumes of surface water floodpeaks have not been not underestimated. The water entering channel immediately around the ADF must be a closed system. The outer channel surrounding the entire ADF needs to be reinforced with erosion protection measures such as concrete or ground reinforcing materials like Terratame 2, particularly along the southern and western boundaries of the ADF site. If this structure is not deemed necessary by J&W following the installation of the planned stormwater management infrastructure then it should be removed and rehabilitated. Ideally design alternatives of the ADF, stormwater and associated infrastructure by the engineers that takes cognisance of the large erratic storm flows volumes and the sensitivity of pans, washes and Sandloop FEPA needs to be conceived and presented to the relevant specialists for comment.
  - Prevent further overflow of water from the dams to the east of MPS.
  - Rehabilitation of areas disturbed both inside and outside of Site 13, these areas should be identified in the rehabilitation plan.
  - Once an infrastructure footprint area has been finalised ensure rehabilitation of all remaining disturbances outside this area, for example removal of berms, infill and re-vegetation of borrow pits (Only locally indigenous flora should be used for re-vegetation of disturbed areas).
  - During earthwork sessions a faunal specialist should be on hand for any species that will require translocation during the construction phase.

- The new ADF ideally should be designed according to the Waste Classification and Management Regulations and Supporting Norms and Standards 2013.

9.5. Activity: Increased Traffic, Machinery & Human Activity

9.5.1 *Impact: Increased sensory disturbance to fauna*

Description: Increased sensory disturbance from lights, traffic, railway noise and increased human activity is likely to displace a wide range of faunal species. Given the site's proximity to the heavily lit and noisy power station this impact is likely to have a moderate effect on local fauna.

Mitigation: Keep lighting to a minimum during construction but most significantly during operation. Lights should be angled downwards and hooded to lower light pollution. Restrict unnecessary access to the remaining patches of natural vegetation.

9.5.2 *Impact: Construction related increases in the deposition of residues and dust as well as roadkill of wetland dependant fauna*

Description: Current and future impacts in the study area include:

- Coal transport and deposition of coal on the road and side surfaces. As the topography is relatively flat, with heavy rains this material is transported by the Semi-ephemeral Washes downstream towards the Sandloop. The sediment sample analysis suggests potential links between the high heavy metal content in a number of the samples close to or on site with the coal operations.
- Collision of vehicles with fauna, in particular, many of the frogs, which migrate between their burrow and breeding sites following heavy rainfall.
- An increase in dust and ultimately an increase in sedimentation towards the NFEPA Sandloop system. It is important to note that the railway line that runs adjacent to the southern boundary of the proposed ADF is subject to coal spills. Although this is not a fault on Eskom Medupi's part, the MPS staff do proactively take measures to clean these spills on occasion (F. Sono, Eskom *pers. comm*).

The existing overall impact risk from traffic and human activity was rated as Moderate. Increased traffic, machinery and human activity, especially during construction of the ADF, will likely cause increased pollution (refer to the sediment analysis of the depressions on site), dust and erosion. Impacts from increased traffic, machinery and human activity will be of greatest magnitude during the short-term construction phase. The overall cumulative impact risk from traffic and human activity was rated as High.

Mitigation: With effective mitigation, the overall cumulative impact risk from increased traffic and human activity could be reduced to a Moderate rating. To mitigate impacts from traffic and human activity the following should be applied:

- Remain outside of the Sandloop buffer area;
- Service and maintain vehicles regularly;
- Eskom must ensure that all trucks before leaving the storage area shall be completely covered with a tarpaulin or any other effective measure/device. Trucks must not be over-loaded to ensure no spillage during transportation;
- Reduce coal movement as much as possible during high wind events;
- Proper drainage system shall be provided in the coal storage area so that water drained from sprinkling and runoff is collected at a common tank and can be reused after treatment.
- Traffic and construction activities should be limited to daylight hours.
- Regular surface wetting is required;
- Demarcate and restrict anthropogenic disturbances to the construction area.
- Measures such as speed humps, signage and fines should be implemented to reduce speeding and any off-road driving.
- Off-road driving must be prohibited in all surrounding natural areas as this could increase the risks of erosion.

9.6. Activity: Construction clearing and resultant increase in exposed surfaces during construction of the FGD plant, ADF and associated infrastructure.

9.6.1 *Impact: Increase in floodpeaks, sediment loads and erosion to wetlands*

Description: Construction of the FGD, ADF and associated infrastructure is likely to increase the extent of bare soil surfaces. Runoff from these large areas during high rainfall events may significantly increase sediment loads into the receiving wetland systems (mainly SEW 1 and 2). Soil erosivity associated with the aeolian sands on site is high. Consequently any concentration in flow from the construction sites during high rainfall events is likely to cause some erosion of the head of the wash systems.

Mitigation: The mitigation in this regard centres on stormwater management and minimising the extent of unnecessarily cleared ground. It is important that earthen drain around the outer boundary of Site 13 is improved to prevent break through as was observed following heavy rains in December 2015. This drain should be lined and reinforced. If any outlet or overflow points are made to release water accumulated in this trench during construction then it should be done so at multiple points, each fitted with flow attenuation structures and should tie in with the natural drainage patterns and not at arbitrary points (See **Figure 7-12**). Regarding the FGD and associated infrastructure to the east it would be preferable if the planned stormwater infrastructure could be constructed first. In any event attempt wherever possible to conduct the majority of construction during winter. The design philosophy of rehabilitation following the advancing face of the ADF should be implemented, with the primary goal being to establish a stable, indigenously vegetated topsoil cap as soon as possible.

- Erosion and Storm Water Management Plan must be revised to allow for heavy rainfall events.
- Pamphlets should be designed and included into induction processes. These should include as a minimum:
    - Wetlands and their importance.
    - The role of the nearby FEPA and surrounding habitat;
    - General environmental management processes such as recycling; littering, species (e.g. bullfrog) harvesting, etc.

9.7. Activity: Trucking Waste to Holfontein

9.7.1 *Impact: Spills, roadkills and other traffic associated impacts*

Description: There are no current impacts on this activity and the waste is yet to be transported to a waste Disposal Facility. "*The trucking of Type 1 wastes to Holfontein will be carried out for a limited period, until the second EIA is approved and the salts and sludge can be disposed of at Site 13 and the additional site*" (*pers.comm*. Zitholele). The cumulative impact risk from trucking the waste was rated as Moderate. Potential future impacts could include:

- Spills of this waste from trucking.
- Collision of vehicles with fauna, in particular, many of the frogs, which migrate between their burrow and breeding sites following heavy rainfall.
- Vehicle accidents along the route, and potential spills.

Mitigation: With effective mitigation, the overall cumulative impact risk from increased trucking could be reduced to Moderate. To mitigate impacts from trucking the following should be applied:

- Service and maintain vehicles regularly;
- Drivers must undergo regular testing in terms of drivers skills etc;
- Waste in the trucks must be sealed for the transportation;
- Trucking should be limited to daylight hours, with frequent stopping along the route to allow for rest breaks;
- A Hazard Plan must be compiled with the procedure following a spill clearly defined. This Plan must include the relevant 'Clean-Up' companies and their contact details.

9.8. Activity: Storage of substrates and by-products associated with the ADF and FGD operation.

9.8.1 *Impact: Contamination of wetlands from storage facilities associated with the ADF and FGD– Consequences for bullfrogs and aquatic invertebrates.*

Description: The cumulative impact is rated as High while the residual impact may be reduced to Moderate. We have adopted a precautionary approach in not dropping it to low given observed stormwater infrastructure and coal PCD failure and overtopping respectively and given the increasing intensity of rainfall events that has been observed.

The existing impacts of contamination to bullfrogs, aquatic invertebrates and other biota dependant on the ephemeral pans and washes within the study area centre on elevated coal and heavy metal concentrations within the sediments and water column. Sediment analysis revealed heavy metal deposition within the ephemeral systems particularly at pans closest to the current activities on the MPS and ADF sites. In addition to this, the invertebrate hatching procedure yielded Fairy Shrimp within the first three days. However, these hatchlings did not survive. Past studies have shown that heavy metals have affected the population dynamics of this genus. With the high levels recorded within the sediment samples, this may be the cause of the hatchlings not surviving. Poor operation and maintenance of the FGD and ADF could lead to further heavy metal deposition in the ephemeral systems and thereby altering and reducing invertebrate population dynamics within these systems. A cumulative effect on altering and reducing invertebrate population dynamics within the ephemeral systems was also rated as High.

In the near future the flue gas desulphurisation process poses a potential contamination hazard to nearby water courses (SEW 2) and associated biota. Potential contaminants include the limestone which is used as a sorbent, gypsum the by-product of the desulphurisation process and manganese a substance present in the limestone. Although the limestone and gypsum themselves are not regarded as toxic, the high pH levels associated with lime slurry (pH 12.5) may be lethal to aquatic biota. Increased water hardness is an additional impact. SEW 2 is highly ephemeral and likely does not support fish however it does support a number of amphibian and aquatic invertebrate species. Effects to these organisms from highly alkaline waters may include death, damage to outer surfaces such as eyes and skin and an inability to dispose of metabolic wastes. Frog embryo development, in particular, has been to shown to be drastically impaired at pH levels above 11.5 (Padhye & Ghate, 1988). High pH may also increase the toxicity of other substances. For example, the toxicity of ammonia is ten times more severe at a pH of 8 than it is at pH 7. Ammonia is toxic to aquatic life when it appears in alkaline conditions.

It emerged from the workshop held at Zitholele on 11 December 2017 that the exact source for the limestone and therefore its exact composition was thus unknown. It was further noted, however, that the limestone used usually comprises a high manganese content. Manganese generally occurs at high concentrations in the natural environment in South Africa especially in the Highveld. Our readings of manganese from downstream pans taken prior to construction of the FGD show acceptable levels within the sediments and slightly exceeding levels in the water column. The manganese concentrations in the water exceeded the guideline at MD1 and MD6. Very little known about the effects on aquatic organisms but elevated levels of manganese are toxic to fish (Heal, 2001). A thesis by Reimer (1999) investigated the effects of manganese on aquatic fish, macroinvertebrates and algae in British Columbia using lethal dose (LD_{50}) testing for acute and chronic levels. The author found that acute levels range between 0.6 mg/L to 3.8 (exposure less than 95 minutes) and chronic levels range between 0.6 to 1.9 mg/L but importantly that the actual LD_{50} concentration decreased with increasing water hardness. Manganese becomes biologically active when it enters its soluble state. Soluble manganese mostly occurs under low dissolved oxygen conditions. Therefore the naturally low dissolved oxygen levels and high water hardness within the regions pans together with the potential for increased water hardness from the stockpiles of limestone (calcium carbonate) to be stored within the FGD project area provide an environment conducive to manganese toxicity. However the concentrations of manganese that have the potential to be leached from the limestone stockpiles and slurry are unknown and need to be established.

One of the potential sources for contamination includes spillages of gypsum during transportation via the conveyor system from the waste water treatment plant to the storage area and in turn from the storage area to its ultimate destination be it the ADF or a prospective buyer. Under this scenario the main mitigating factor is likely to be the dirty water system which feeds into the MPS dirty water dam. Another potential source for contamination is spillages from trucks. Lastly the slurry / sorbent dams themselves may be a source for contamination due to overtopping (mis-calculated water balance and extreme rainfall events). The gypsum offtake structure itself is another potential source for contamination following high rainfall events. Oil transformer and pit areas pose a risk of hydrocarbon contamination. In the event of a spill oil and other hydrocarbons are likely to have the most significant and long lasting impact. Gypsum is not likely to a have a major toxicological impact although it may be associated with increase pH levels as will be the case for lime slurry. However the likelihood of such a contamination event is expected to be low given the proposed mitigation in the design philosophy (KnightPiesold, 2017) together with the arid nature of the site, the ephemeral nature of the wetland systems and the distance of the storage areas from SEW 2 (ca. 800 m) hence this impact has been given a Moderate significance rating.

Mitigation: A number of mitigation measures are proposed from an engineering perspective (KnightPiesold, 2017) which may assist in preventing such contaminants from entering the receiving wetland (SEW 2):

- Measures to reduce the risk of contamination from the trucking spills include a concrete slab layer beneath roads and kerb inlets to the dirty water system.
- It is however imperative that spilt material is regularly cleaned up and that all drains inlets and stormwater infrastructure is regularly inspected for blockages and cleared out.
- The gypsum offtake structure may be a problem following high rainfall events, however a concrete bunding and a central depression is proposed to prevent spills. Again it is important to ensure this area is kept tidy and regularly cleaned out.
- At the oil transformer areas the pits are proposed to be bunded and have a concrete base of 100 mm thick. These pits need to be emptied regularly.
- Additionally manganese levels in the stockpiles as well as the environment should be monitored through regular water quality testing at the pans immediately south of the FGD and compared to current baseline levels.
- All of these measures, however, are designed to cope with a 1 in 50 year peak 24 hour rainfall event. However should an extreme rainfall event occur that exceeds this estimate or if maintenance (clearing drains etc.) has been inadequate these structures may fail and contaminants may enter SEW 2.

Other recommended mitigation includes:

- Regular surface and ground water quality monitoring is required to be continued at the current sediment sampling sites.
- Investigate remediation options for current and potential future surface and groundwater contamination e.g. phytoremediation.
- Sediment analysis of depressions and the ephemeral washes must be conducted yearly and compared with the current results for the site. This will then indicate whether heavy metal concentrations are increasing during the Operation Phase of MPS and its ADF.
- Annual monitoring of the aquatic invertebrate assemblage should be conducted at the various remaining sediment sampling sites.
- Amphibian assemblages should be monitored at key sediment sampling sites as well as the newly created pans once a year by means of acoustic, visual encounter transects.

- Measures should be implemented to minimise erosion on site, and potential sedimentation and contamination of the downstream ephemeral watercourse and associated dams;
- It is advised that water quality at local boreholes (if present) be monitored before and during construction of the site. The exact duration, frequency and positioning of the sampling points should be determined from the geohydrological studies commissioned for the site.

Table 9-2 Impact ratings – Construction Phase

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Site clearing	Direct Impact: Loss of wetland systems.	Existing	1	5	16	1	22 - FLAW	With effective mitigation, the overall residual impact risk of clearing vegetation could be reduced to High. The following mitigation is recommended: • Efforts should be made to situate tools, materials and infrastructure so as to minimise loss of wetland resources. • Continue to stockpile topsoil and avoid mixing with deeper layers to retain viability of the seed bank. • EO should regularly monitor progress and implementation of mitigation measures. •Clear during winter. If this is not possible a faunal specialist should be on site during clearing processes. • Clear approved areas only. Site visits reveal that this has the potential to spill over into other areas very easily. • Demarcate and restrict disturbances to the construction area. • Where possible geophytes should be collected and stored in a nursery. Grass seeds can also be collected and stored. • Construction crews should be informed about the importance of biodiversity. The appointed EO on site should be trained to handle snakes and bullfrogs.	Loss of Wetlands and Watercourses/Washes on site for both MPS and the existing cleared area for the ADF and the impact on the NFEPA (Sandloop) is seen as a loss on a National scale.
		Cumulative	3	5	16	1	24 - FLAW		With the further construction of the ADF and loss of more wetlands/ washes and pans, this will remain a Very High Impact
		Residual	3	4	8	1	15 - HIGH		With mitigation (FGD) the residual impact will be slightly reduced due to a portion of the ADF staying out of the Sandloop buffer and implementing a wetland offset and rehabilitation plan.
Site clearing	Direct Impact: Loss of ephemeral pan habitat for bullfrogs	Existing	2	5	4	1	11 - HIGH	• It was previously recommended that pans C11, C20 and C21	To date operations at Medupi have seen the loss of 3.9 ha of suitable pan habitat.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
	and aquatic biota.	Cumulative	2	5	8	1	15 - HIGH	should be conserved but if not possible, a bullfrog specialist should be commissioned to capture and relocate bullfrogs to a nearby secure pan with full Eskom labour support. Any other overwintering bullfrogs unearthed during clearing activities should also be relocated to a suitable nearby pan off site.. • Follow the mitigation that will arise from the bullfrog relocation project by NSS and EWT. • It is recommended that some of the larger relocated individuals be tracked through radio telemetry or GPS data loggers. • The overall success of relocation efforts relies heavily on diligent and accurate rainfall monitoring by Eskom and the issuing of prompt alerts of high rainfall events to the relevant specialists (NSS and Eskom's amphibian specialist from EWT). • Any overwintering bullfrogs unearthed during clearing activities (or otherwise) should be reported to the appointed EWT amphibian specialist or if unavailable NSS. • The appointed EO and several other staff members on site should be trained to handle bullfrogs and snakes or a trained specialist be contracted to execute this role. • Any bullfrogs found after the relocation efforts should be relocated to one of the newly created pans that have shown signs of bullfrog establishment (consult EWT or NSS for advice if	The construction of the ADF, based on the provided infrastructure layout will result in the loss of a further 2.4 ha bringing the total pan loss as a result of Medupi operations to 6.3 ha.
		Residual	1	2	4	1	7 - MOD		With the implementation of the mitigation and relocation project which involves the creation of new pan habitat this impact may be reduced to Moderate as favoured habitat will still be lost and there is no guarantee of the success of relocation.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
								necessary).	
Site clearing	Direct Impact: Potential loss of vegetation units.	Existing	1	5	2	1	8 - MOD	• Clearing needs to occur only as necessary for the footprint of the ADF (Alternative 5) and the FGD / railway yard area. If at all possible vegetation in the western corner of the railway yard area must remain intact and undisturbed. • The area of construction should be fencedto prevent encroachment into surrounding vegetation. • Any bulbous and PT species that can be transplanted must be removed. • Alien species must be controlled under the MPS Alien Control Programme.	Clearing has already commenced.
		Cumulative	1	5	2	1	8 - MOD		Loss of vegetation will continue to increase within infrastructure footprint area.
		Residual	1	5	2	1	8 - MOD		Mitigation is limited regarding the loss of vegetation.
Site clearing	Direct Impact: Potential increase in alien vegetation species.	Existing	1	3	4	1	8 - MOD	• Clearing needs to occur only as necessary for the footprint areas and all Category species must be removed during this process. • Alien species must be monitored and controlled under the MPS Alien Control Programme. • Construction crew must be made aware of the species that occur on site specifically Category 1 species and must be trained in the	Exists and is extensive (weedy annuals) particularly in disturbed areas within the railway yard area.
		Cumulative	3	5	4	1	12 - HIGH		Likely to increase without mitigation

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
		Residual	1	1	2	0.5	2 - LOW	basics for recognition and removal.	With mitigation can be largely reduced and further spread prevented.
Site clearing	Direct Impact: Potential loss of CI floral species.	Existing	1	5	4	1	10 - HIGH	MPS has removed tree species successfully during the construction phase of their power station. Therefore the same would apply here. The Environmental Officer (EO) or trained botanist will be required to tag all Protected Trees within the footprint for removal and relocation. These individual plants will need to be monitored over the long term. Permits will be required for the removal process with DAFF. Any other species that may be identified as CI must either be translocated (if possible) or specific mitigation must be compiled by a qualified botanist in collaboration with the MPS EO.	Many CI trees have been felled already.
		Cumulative	1	5	4	1	10 - HIGH		Situation likely to continue.
		Residual	1	5	2	1	8 - MOD		Loss is permanent.
Site clearing	Direct Impact: Potential loss of CI faunal species (excluding bullfrogs and raptors).	Existing	1	5	4	0.5	5 - MOD	Clear in winter if possible. It is recommended that immediately prior to clearing that a walkdown be conducted by Eskom and a suitable specialist, preferably one with expertise in arachnids, to intensively search the site preferably in the height of the rainy season (December) to detect and relocate any baboon or trapdoor spiders or scorpions frogs, tortoises. If any of these species are encountered during development the specialist the expertise should advise upon and oversee relocation.	Several species have likely been killed / extirpated as a result of current clearing activities.
		Cumulative	1	5	8	0.5	7 - MOD		Will be exacerbated.
		Residual	1	5	4	0.2	2 - LOW		Can be reduced to low if efforts are taken to construct in winter and safely relocate any CI specie encountered.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Site clearing	Direct Impact: Potential loss of CI raptor species .	Existing	1	5	4	0.5	5 - MOD	Mitigation is limited and likelihood is very low. However if a nest of CI raptor species is encountered its location should be marked and it should be reported to the relevant authorities before construction continues. Normally a minimum 1 km radius buffer or exclusion zone should is applied to such points but given the complex nature of this project would require in depth consultation with an appropriately experienced ornithologist. As far as possible large	Nests may have been destroyed already.
		Cumulative	1	5	8	0.5	7 - MOD		If raptor nests are destroyed it would be of a Moderate significance.
		Residual	1	5	4	0.2	2 - LOW		Following mitigation may be reduced to low.
Site clearing	Direct Impact: Loss of foraging habitat for game species.	Existing	1	5	2	1	8 - MOD	Mitigation: Clearly demarcate the footprint area. Minimise disturbance footprint and restrict construction and operation activities to within the proposed footprint area. The EO must monitor the carrying capacity relative the game within the Railyard area and act accordingly to ensure that there is enough grazing land for the existing game within this area, otherwise implement capture and relocation. If the game are to be kept then standard game keeping management principles must be adhered to and a management plan drawn up for the game. All relevant permits must then also be in place.	Currently infrastructure is encroaching on grazing habitat for the game in the railway yard.
		Cumulative	1	5	4	1	10 - HIGH		Should this continue unabated the consequence would be high for the game resulting in mortalities.
		Residual	1	5	2	0.2	2 - LOW		If the game and their grazing are appropriately managed the impact can be reduced to low.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Construction and operation of the ADF and FGD stormwater infrastructure	Direct & Indirect: Loss of catchment area and consequent decrease in water inputs as a result of the necessary containment of dirty water runoff.	Existing	2	3	2	0.5	4 - MOD	Mitigation with regards to catchment loss is limited and the residual impact risk remains High. Efforts should be centred on minimising catchment loss by minimizing the ADF, PCD, coal stockpile and other associated infrastructure to as small an area as possible. Particularly, efforts should be made to minimise any further encroachment into the Sandloop 1:100 year floodline and 1 km buffer. Release of clean water into the environment needs to be carefully engineered such that it enters the watercourses in a diffuse not concentrated flow to prevent erosion. This involves the use of flow attenuation and spreading structures at outlet points. The large earthen trench around the ADF site compounds this issue and requires re-thinking from an engineering perspective. If found to be of value it should be constructed so as to handle surface runoff in high rainfall events such as was observed during the previous site visit. If its purpose cannot be convincingly motivated it should be removed, re-landscaped and revalidated.	Some loss of catchment area has already occurred due to construction activities. A large tar road and a railway bisect the catchment. Additionally earthen trenches around the ADF site impede inputs to a degree although a break in the south-western corner allows outflow. The pans washes and Sandloop still receive notable flow from the ADF site.
		Cumulative	3	4	4	1	11 - HIGH		Without mitigation construction of the ash facility is likely to only result in a slight decrease in catchment water inputs into SEW 1 due to evaporative and dispersive losses. This loss is not anticipated to be as a high as it would be under the necessary mitigation scenario where v-drains and liners are installed that completely contain and isolate water from the facility (however a lack of these structures , as flow impeding as they may be, are required to avoid other serious environmental implications e.g. water quality) .

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
		Residual	3	3	4	1	10 - HIGH		It is a necessity that clean and dirty water separation take place at the ADF and FGD. Runoff directly from these areas would be considered dirty water (the majority) and therefore need to be contained within a closed system to prevent it from entering the environment. Under Alternative 5 the ADF and associated PCDs and infrastructure would cover 584.93 (13.54%) of the Sandloop Catchment. Therefore construction of the ADF throughout the western and southern most extent of the study area would result in a loss of a large portion of the Sandloop catchment. This is likely to result in a considerable reduction in surface water (dominant source) input into the SEW 1 HGM unit.
	Direct Impact: Increased faunal mortality.	Existing	1	2	2	1	5 - MOD	The site should be searched prior to clearing by an appropriately qualified specialist and any less mobile fauna relocated. Maintain existing tortoise road signs and insert new ones where necessary. Continue to enforce speed regulation controls such as speed humps and limits.	
		Cumulative	1	2	2	1	5 - MOD		
		Residual	1	2	2	0.5	3 - MOD		

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Harvesting of hill wash material (topsoil) within the ADF footprint	Potential direct loss of depressions and semi-arid ephemeral wash wetlands and their vegetation as well as in downstream hydrological and geomorphological drivers through changes in water distribution and retention patterns and increased sedimentation respectively.	Existing	2	5	2	1	9 - MOD	Collection of hill wash material must be prohibited within at least 100 m of the delineated edge of all identified depressions and semi-arid ephemeral wash wetlands. Additionally harvesting of hillwash material should not encroach upon the delineated 1:100 year floodline boundary (which largely mirrors the 1 km buffer on the Sandloop FEPA). Ensure that harvesting of hill wash material does not take place within a 500 m radial buffer of the identified bullfrog breeding site (Depression C 20). Ensure that the responsible on site personnel have the delineated wetlands and their associated buffers on their GPSs. Make sure that these areas are clearly demarcated with high visibility fencing or markings and prohibit all activities within these areas with signage that indicates it is an environmentally sensitive area. Keep scraping neat and systematic. Stockpile topsoil in an area situated as far as possible	These somewhat cryptic wetlands were originally not idenfied by the appointed specialists during the environmental authorisation process for the ADF. An EA was granted in 2008, an inevitable consequence of this, however, was that some of the depressions and washes were lost through construction activities. Nevertheless a number of these systems still remain and with proper management have the potential to retain much of their integrity and ecological functioning.
		Cumulative	3	5	8	1	16 - HIGH		Without mitigation this impact has the potential to significantly impact water courses on a national scale and would pose legal challenges not least for encroaching on the 1:100 year floodline which supports the Sandloop FEPA but also for removing the identified wetlands.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
		Residual	2	5	4	0.5	6 - MOD	from all identified wetlands to avoid sedimentation. Ensure that measures are taken to contain topsoil during rainfall events and prevent it washing into the environment. Attempt to maintain the natural stratigraphy of the topsoil when stockpiling. Ensure that all guidelines and standards are met with regards to the stockpiling of topsoil.	Following mitigation measures and recommendations made in this report these impacts can be reduced from a High to a Medium and construction could conceivably occur without detrimentally damaging the ecological integrity and biotic functioning of these systems. The residual impact is rated as Medium as there is still the potential for a loss in water inputs (due to a collection in scraped areas) to the depressions and washes which rely so heavily on surface water inundation following rainfall events as well as the ever present potential for increased sedimentation and biotic isolation and fragmentation of these systems as connecting vegetation is cleared around them.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Earth Works: Excavations, specifically for the ADF	Indirect Positive Impact: Current artificial wetlands (excavations) and potentially additional artificial wetlands	Existing	1	3	1	0.75	4 - MOD	This is seen as positive impact for breeding habitat for in the short term for species such as African and Giant Bullfrog. These excavations fill up when it rains and allows for competition and breeding to occur	Creating artificial systems seen as a positive short term impact in an area where pans and wetlands have been destroyed
		Cumulative	1	4	1	0.5	3 - MOD		The cumulative positive impact on wetland creation is not seen to increase in significance - potentially only a few additional areas will be created and these will be temporary in nature.
		Residual	1	4	1	0.75	5 - MOD		Discussion as per the cumulative and existing impacts
Earth Works: Ground excavations, levelling, compaction, creation of berms, deposition, etc., specifically for the ADF	Direct & Indirect: Deterioration in wetland drivers.	Existing	2	4	8	1	14 - HIGH	• Minimise disturbance within 1:100 year floodline and the 1 km FEPA buffer). • Daily wetting of exposed surfaces during earth works to control dust. • Erosion Management Plan to be compiled and implemented. • Placing biodegradable sand bags around stockpiles, the construction footprint, etc. As the topography is flat, these are recommended as opposed to berms. • Ensure that the volumes of surface water floodpeaks can be accommodated in the stormwater infrastructure. • The water entering channel immediately around the ADF must	At present, the current activities in the construction of the ADF is causing an increase in bare surfaces and run-off in to the existing Storm Water Channels. During high rainfall events, these channels are not coping with the flow and breaks in the channels and overtopping is occurring.
		Cumulative	2	4	16	0.75	17 - HIGH		As above - the current impacts will be enhanced

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
		Residual	1	2	4	0.5	4 - MOD	be a closed system. The current outer channel surrounding the entire ADF needs to be reinforced with erosion protection measures such as concrete or ground reinforcing materials, particularly along the southern and western boundaries of the ADF site. The stormwater and associated infrastructure must take cognisance of the large erratic storm flows volumes. • Prevent further overflow of water from the current coal PCD. • Rehabilitation of areas disturbed both inside and outside of Site 13, these areas should be identified in the rehabilitation plan.	With mitigation (FGD) the residual impact will be moderate: *Activities will remain outside buffer of Sandloop; *Improved Storm Water Design; * Bare areas will be vegetated
Traffic, machinery & human activity	Indirect: Increased sensory disturbance to fauna	Existing	2	2	4	1	8 - MOD	Keep lighting to a minimum during construction but most significantly during operation. Lights should be angled downwards and hooded to lower light pollution. Restrict unnecessary access to the remaining patches of natural vegetation.	Currently fairly high levels of disturbance.
		Cumulative	2	3	8	0.75	10 - HIGH		Likely to increase.
		Residual	1	2	4	0.5	4 - MOD		Unlikely to decrease much below current levels.
Traffic, machinery & human activity	Direct & Indirect: Increased pollution; Increased dust & erosion and ultimately degradation of surrounding wetlands.	Existing	2	2	4	1	8 - MOD	Mitigation would require frequent maintenance of trucks, ongoing driver training, covering of vehicles. Maintenance of all machinery must be kept up to date; Regular wetting of the road network and revegetation of bare areas that are not required for lay	Current impacts on wetlands and associated biodiversity is seen in the sediment analysis and may be attributed to coal deposition along the road networks and in the storm water channels etc.

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
		Cumulative	2	3	8	0.75	10 - HIGH	down areas etc.	With continued construction of the ADF and the use of the Coal Stockpile to the west, the impact on the watercourses and wetland is considered High
		Residual	1	2	4	0.5	4 - MOD		With mitigation the impact will be reduced to a low Moderate as due to the immensity of the operations, it is not possible to completely prevent dust etc.
Clearing and resultant increase in exposed surfaces during construction of the FGD plant, ADF and associated infrastructure	Indirect: Increase in floodpeaks, sediment loads and erosion to wetlands.	Existing	2	3	4	1	9 - MOD	Implement planned stormwater management and minimise the extent of unnecessarily cleared ground. Upgrade the earthen drain around the outer boundary of the Site to prevent break through following heavy rains . This drain should be lined and reinforced (preferably concrete). Any outlet or overflow points for PCDs or drains should be done so at multiple points, each fitted with flow attenuation structures and should tie in with the natural drainage patterns and not at arbitrary points (See Figure 7 1).	Recent clearing has exposed large tracts of land within a portion of the proposed ADF. Stormwater infrastructure is rudimentary at present and there is a large potential for sediment runoff and erosion.

CONSTRUCTION PHASE									
Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
		Cumulative	2	3	4	1	9 - MOD	Regarding the FGD and associated infrastructure it would be preferable if the planned stormwater infrastructure could be constructed first. Conduct the majority of construction during winter. Continuously rehabilitate following the advancing face of the ADF.	Without mitigation (appropriate stormwater infrastructure) the current situation would be exacerbated.
		Residual	1	2	1	0.5	2 - LOW		With the installation of the proposed stormwater infrastructure the risk of sedimentation and erosion is really reduced.

Table 9-3 Impact ratings – Operation / Decommissioning Phase

OPERATIONAL PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Operation of the ADF and FGD stormwater infrastructure	Direct & Indirect: Loss of catchment area and consequent decrease in water inputs as a result of the necessary containment of dirty water runoff.	Existing	2	3	2	0.5	4 - MOD	See related impacts in construction (**Table 9.2**).	See related impacts in construction (**Table 9.2**).
		Cumulative	3	4	4	1	11 - HIGH		
		Residual	3	3	4	1	10 - HIGH		
	Direct Impact: Increased faunal mortality.	Existing	1	2	2	1	5 - MOD	See related impacts in construction (**Table 9.2**).	See related impacts in construction (**Table 9.2**).
		Cumulative	1	2	2	1	5 - MOD		
		Residual	1	2	2	0.5	3 - MOD		
Trucking waste to a registered waste disposal facility	Direct	Existing	0	0	0	0	0 - LOW	One cannot predict how many and where accidents may occur. Mitigation would require frequent maintenance of trucks, ongoing driver training, frequent stopping etc.	N/A as not yet in commencement
	Spills - Sedimentation and Surface water contamination	Cumulative	3	2	8	0.5	7 - MOD		With the trucking of the waste, there is a potential for spillages to occur along the route through accidents and uncovered trailers
		Residual	3	2	4	0.5	5 - MOD		The number of incidences are expected to reduce with proper management - vehicle maintenance, driver training

OPERATIONAL PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Storage of substrates and by-products associated with the FGD operation	Direct	Existing	3	5	4	1	12 - HIGH	Prevent contaminants from entering the receiving wetland (SEW 2). Install planned concrete slab layer beneath roads and kerb inlets to the dirty water system. Regularly clean spilt materials and inspect drain inlets and stormwater infrastructure for blockages. Install planned concrete bunding and central depression at gypsum off take area. Keep this area tidy and regularly cleaned out. Install planned bunding on oil pits and have a concrete base of 100 mm thick. Empty regularly. Establish baseline manganese levels in the stockpiles as well as the environment. Thereafter monitor levels through regular water quality testing at the pans immediately south of the FGD and compare to current baseline levels.	N/A as not yet in commencement
	Contamination of wetlands from storage facilities associated with the ADF and FGD– Consequences for bullfrogs and aquatic invertebrates.	Cumulative	3	5	8	1	16 - HIGH		With mitigation this impact could be reduced but is still regarded as a moderate impact as the risk of contamination can never be completely ruled out considering the extreme climatic events of late and the increased intensity of rainfall predicted with climate change in the near future especially considering that the infrastructure (including stormwater) is based on 1 in 50 year rainfall events and not 1 in 100 years.
		Residual	3	3	4	0.5	5 - MOD		

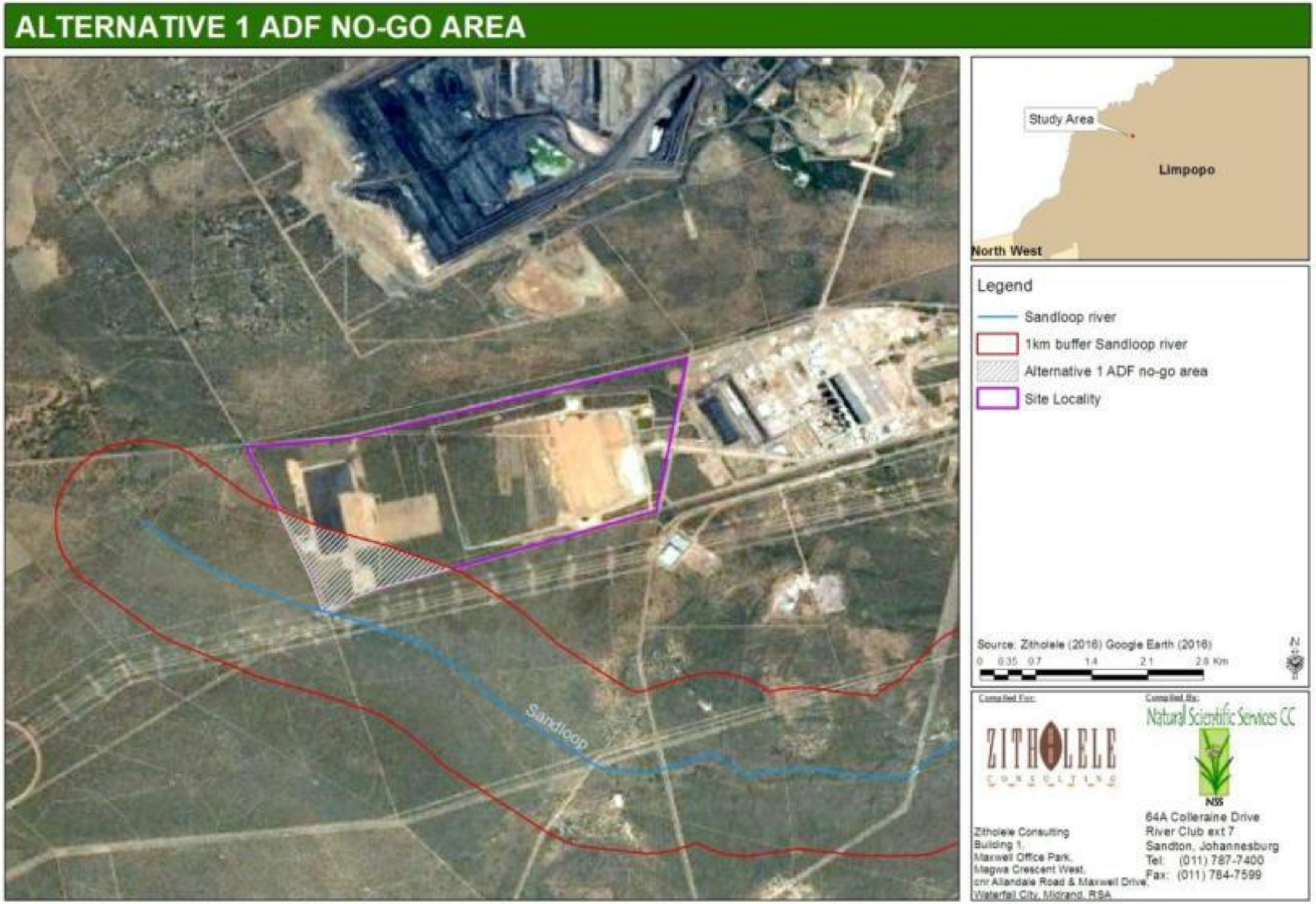


Figure 9-3 Infrastructure Alternative 1 (1 km buffer on Sandloop FEPA)

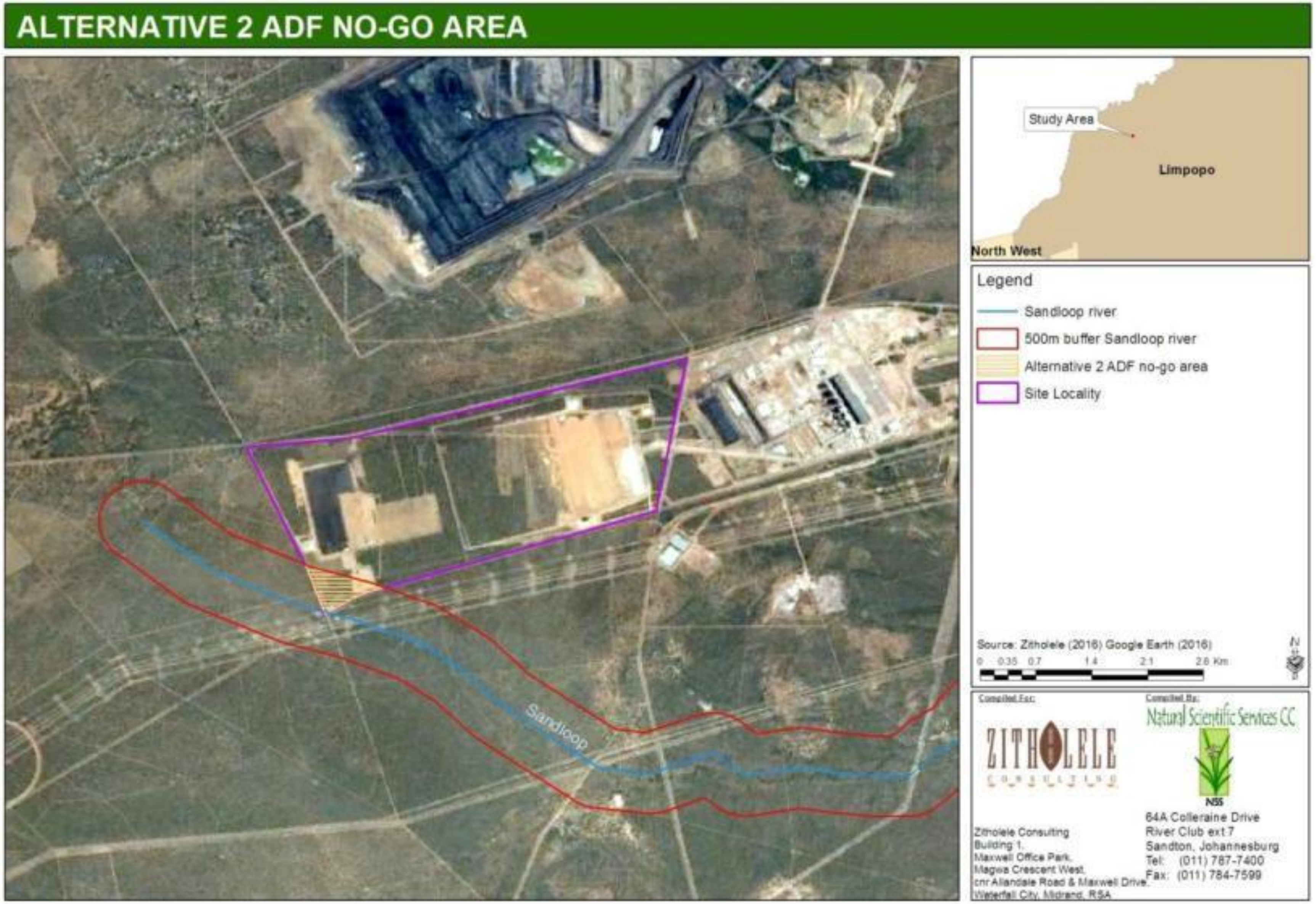


Figure 9-4 Infrastructure Alternative 2 (500 m buffer on Sandloop FEPA)

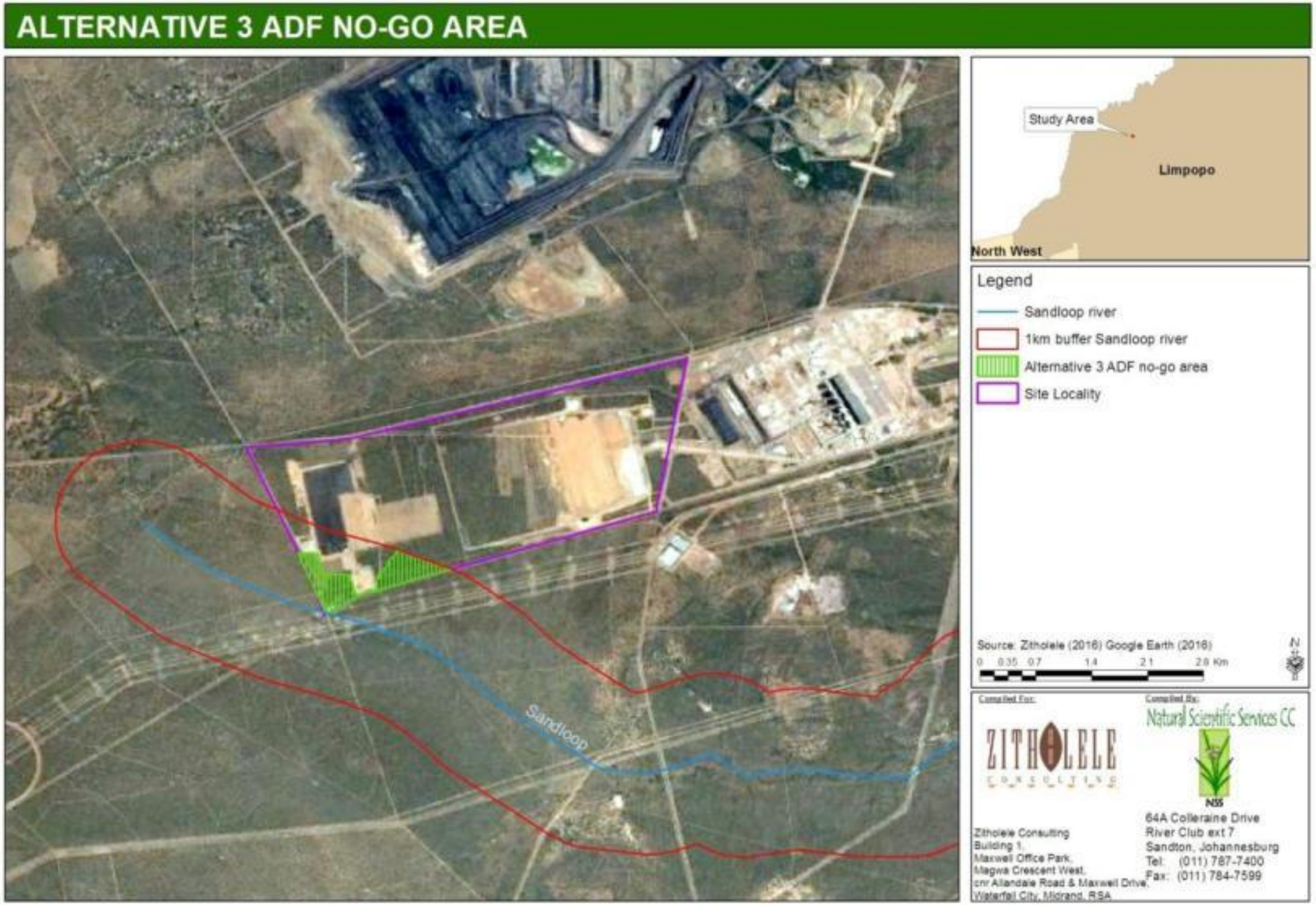


Figure 9-5 Infrastructure Alternative 3 (1 km buffer on Sandloop FEPA excluding previously disturbed areas)

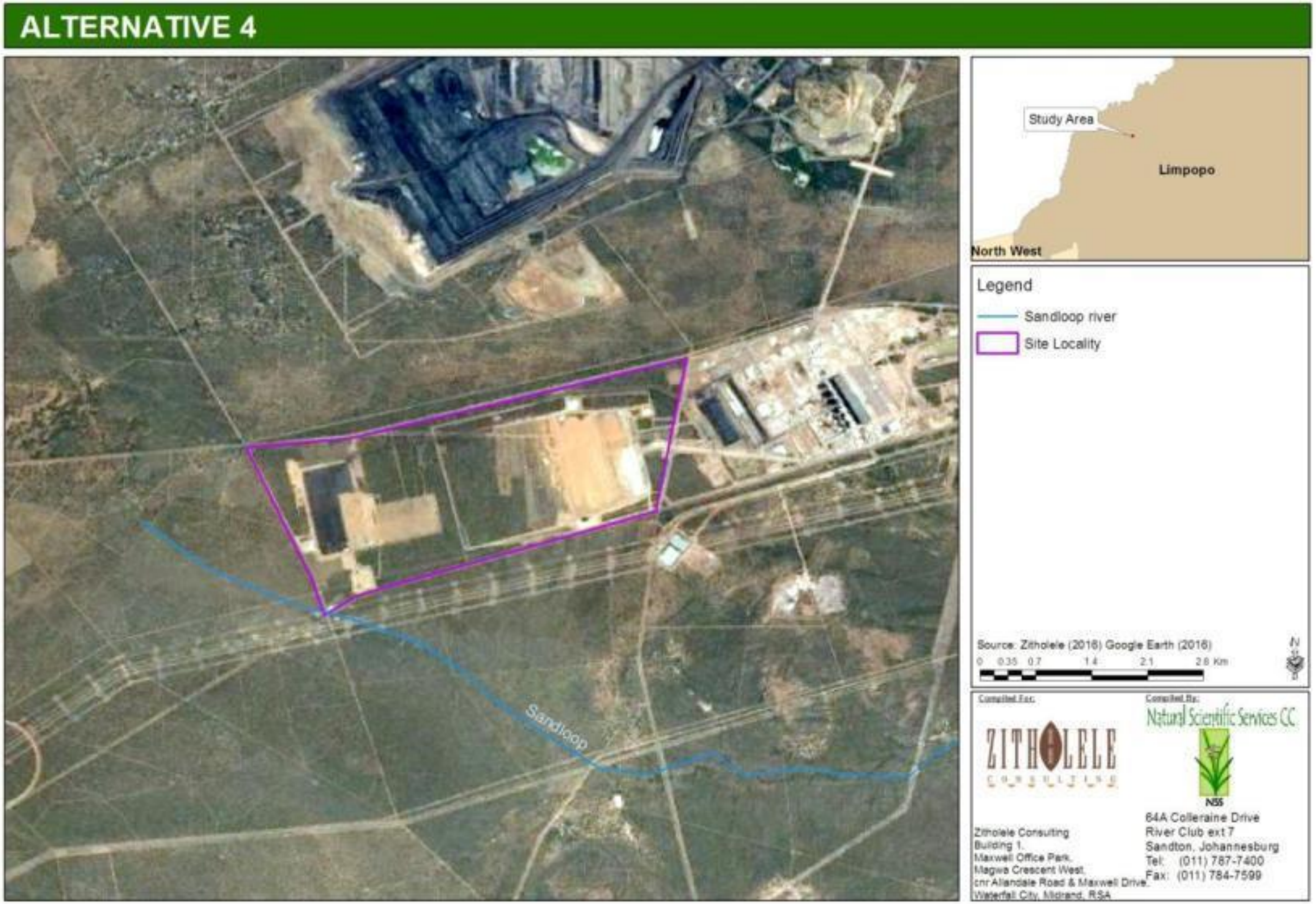


Figure 9-6 Infrastructure Alternative 4 (entire Site 13)

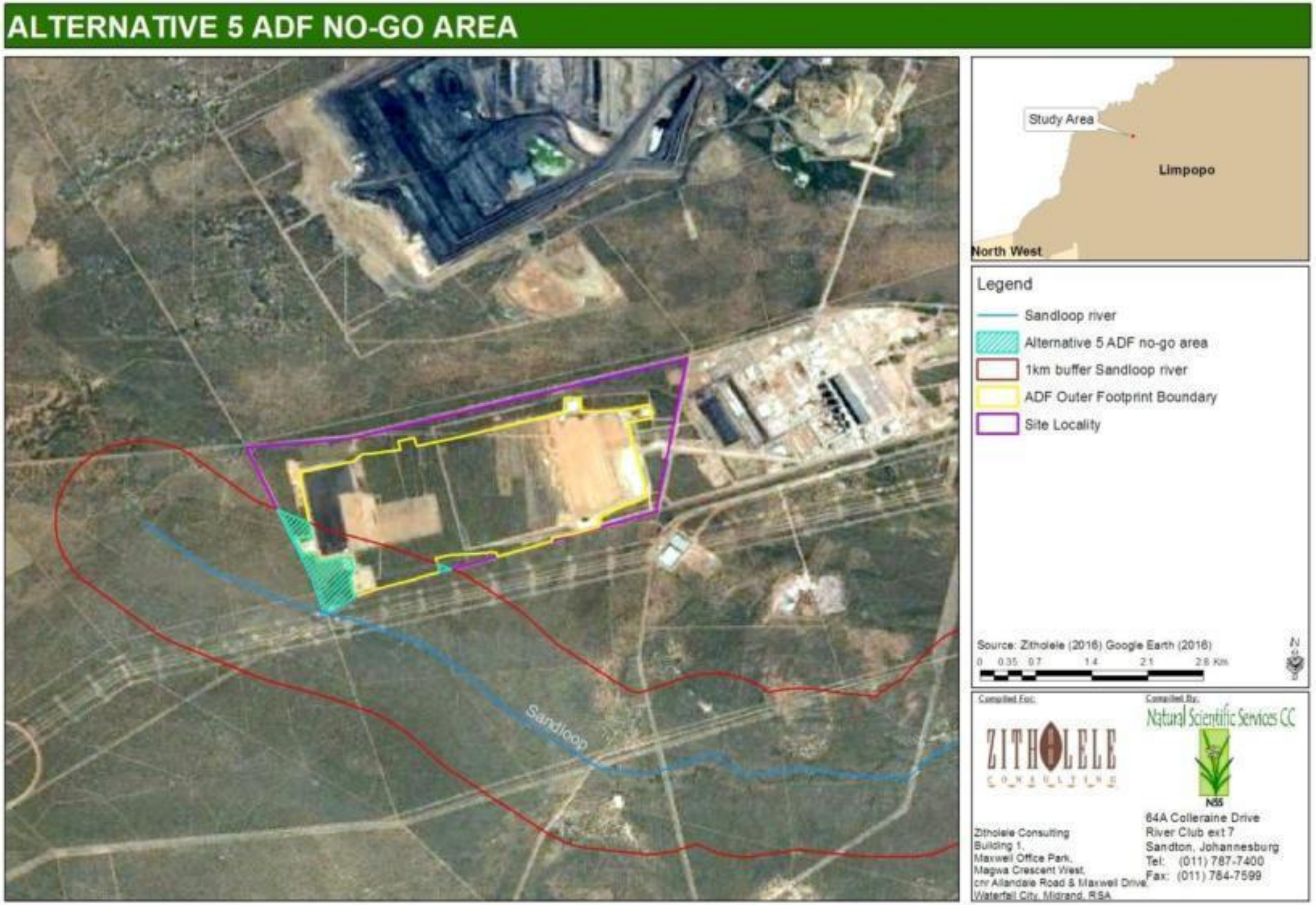


Figure 9-7 **Infrastructure Alternative 5 (current proposed footprint area supplied by Jones and Wagner)**

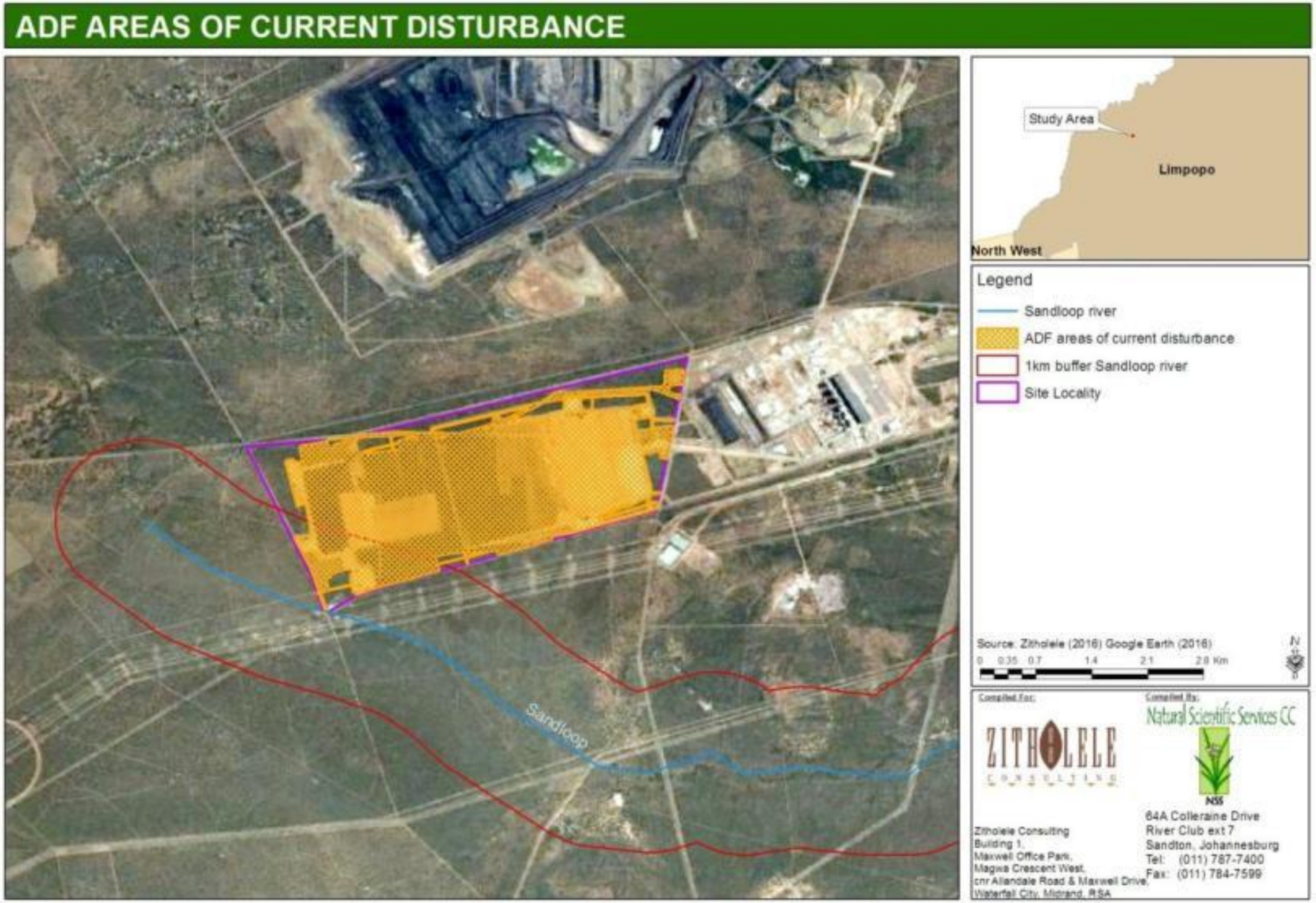


Figure 9-8 Areas of current disturbance

10. Predicted Ecological State: Targets and Strategies

Taking a proactive approach, in lieu of detailed infrastructure design alternatives (from an engineering perspective) that seek to minimise the effects of the proposed development on the Sandloop FEPA, NSS has generated five conceptual footprint area alternatives. These alternatives are illustrated in **Figure 9-3** to **Figure 9-7** and can be summarised as follows:

- **Alternative 1:** ADF and associated infrastructure is kept outside of a 1 km buffer on the Sandloop FEPA. Optimal.
- **Alternative 2:** ADF and associated Infrastructure is kept outside of the 500 m buffer on the Sandloop FEPA
- **Alternative 3:** ADF and associated Infrastructure is kept outside the 1 km buffer but only for areas not already transformed by activities as defined in **Figure 9-5**.
- **Alternative 4**: ADF and associated infrastructure fill Site 13.
- **Alternative 5**: Current footprint area for the ADF and some of the associated infrastructure as supplied by the commissioned engineers (Jones and Wagner).

10.1.1 *Predicted Health Change to SEW 1 (Upper Sandloop Tributaries).*

A comparison between the current and anticipated ecological health of the SEW 1 HGM unit (Upper Sandloop Tributaries within 500 m Site 13) in terms of hydrology, geomorphology and vegetation under the four layout alternatives for scenarios with and without mitigation is provided in **Table 10-1** below. The wetland drivers most adversely affected are likely to be hydrology and geomorphology with the most adverse effects anticipated for Alternative 4 which is considered flawed and the least for Alternative 1 which is considered optimal. Alternatives 3, 5 and 2 represent situations that are not optimal.

It is NSS' opinion that Alternative 1 should be opted for, however, it has subsequently emerged from extended correspondence with Eskom and the Engineering team that the design cannot be adjusted to fit this area. Alternatives 1 and (to a lesser extent) 3 represent the best case scenarios from an environmental perspective but are unlikely to be realised. The chosen alternative at present is Alternative 5 which represents a better case scenario than Alternative 2 but is still likely to have a significant negative effect on the health of SEW 1 and the downstream Sandloop. Under the current scenario (Alternative 5) and following mitigation health scores are anticipated to decrease (from present state) by at least one order of magnitude (post mitigation) on all wetland drivers (2.1 C to 3.5 D).

10.1.2 *Predicted Health Change to SEW 2 (System downstream of FGD plant).*

Although the ADF relates mostly to SEW 1 the FGD plant and associated storage facilities relate mostly to SEW 2. A comparison between the current and anticipated ecological health of the SEW 2 HGM unit in terms of hydrology, geomorphology and vegetation for scenarios of with and without mitigation is provided in **Table 10-2**.

Table 10-1 Predicted SEW 1 health scores for the four infrastructure alternatives with and without mitigation showing anticipated change in wetland functionality.

MITIGATION	WETLAND HEALTH SCORE				HECTARES (ha)			OPINION
						Functional Wetland		
	Hydrology	Geomorphology	Vegetation	Overall	Total Wetland Extent	Extent	Loss From Current State	
Current								
	3 (C)	1.7(B)	1 (B)	**2.1 (Lower C)**	71.5	56.8	**-**	Goal
Alternative 1								
With	4 (D)	2.1 (C)	2 (C)	**2.9 (C)**	61.4	43.8	**13.1**	Optimal
Without	4 (D)	2.7 (C)	2.4 (C)	**3.2 (C)**	61.4	42.0	**14.8**	-
Alternative 3								
With	4 (D)	2.7 (C)	2.6 (C)	**3.2 (C)**	61.4	41.6	**15.2**	Not Optimal 1
Without	4 (D)	3.3 (C)	2.8 (C)	**3.5 (C Upper)**	61.4	40.2	**16.6**	-
Alternative 5								
With	4 (D)	3.7 (C)	2.7(C)	**3.5 (C)**	55.9	36.3	**20.5**	Not Optimal 2
Without	4 (D)	4 (D)	3 (C)	**3.7 (C Upper)**	55.9	35.2	**21.6**	-
Alternative 2								
With	6.5 (E)	2.6 (C)	2.8 (C)	**4.15 (D)**	53.5	30.4	**26.5**	Not Optimal 3
Without	6.5 (E)	4.5 (D)	3.5 (C)	**5.1 (D)**	53.5	24.9	**31.9**	-
Alternative 4								
With	6.5 (E)	2.6 (C)	2.5 (C)	**4.2 (D)**	53.4	30.8	**26.1**	Flawed
Without	7 (E)	5.9 (D)	3.5 (C)	**5.7 (D Upper)**	53.4	23.0	**33.8**	-

*Red block represents the current design alternative presented by engineers.

Table 10-2 Predicted health scores for SEW 2 as a result of the FGD plant for scenarios with and without mitigation showing anticipated change in wetland functionality.

MITIGATION	WETLAND HEALTH SCORE				HECTARES (ha)		
						Functional Wetland	
	Hydrology	Geomorphology	Vegetation	Overall	Total Wetland Extent	Extent	Loss From Current State
Current State							
	3.5 (C)	3 (C)	4.2 (D)	**3.6 (C)**	38.0	24.3	**-**
Anticipated State							
With	4 (D)	3.6 (C)	5.2 (D)	**4.2 (D Lower)**	61.4	22.0	**2.3**
Without	7 (E)	4.3 (D)	5.7 (D)	**5.8 (D Upper)**	61.4	16.0	**8.3**

Currently the system is rated as a having a C (Moderately Modified) ecological health. However the construction of the FGD and associated storage facilities is anticipated to reduce the health of this system to a Upper D (Largely modified) without mitigation and a Lower D with mitigation. The drivers likely to be most adversely affected include hydrology and vegetation. In terms of hydrology, without mitigation, one would expect an increase in floodpeaks as a result of the increase in exposed, impermeable surfaces such as compacted areas, concrete, tar and other structures including the stockpiles themselves. This would likely be accompanied by a greater concentration in flow and consequently increased risk for erosion. Without appropriate mitigation the increased exposed surfaces, limestone and other stockpiles would pose a risk of considerable sedimentation of the system following rainfall events. Deposition and erosion in turn will decrease the state of the vegetation along this system. With implementation of the planned stormwater infrastructure and other suggested mitigation the it is anticipated that there will be less erosion and deposition , however there will still be a reduction in overall water inputs due to catchment loss and the presence of stormwater infrastructure channelling water into Medupi's large eastern dams. Additionally all the mitigation is designed under a 1 in 50 year flood event and considering the increasing rainfall intensity in the past few years the risk remains that mitigation may fail hence the post mitigation rating.

10.1.3 *Strategic Approach.*

In terms of biodiversity the overall goal of the project should be to minimise loss to biodiversity wherever possible. This may be achieved through commitment to the listed mitigation, effective rehabilitation of the ADF and the relocation of bullfrogs and other amphibians to newly created habitat elsewhere. The overall objective of the project as it relates to wetlands should be to ensure that there is no net loss in wetland functionality from the current state as a result of the construction of the FGD plant (and associated storage facilities / infrastructure) and the ADF. Given the relatively pristine state of the Sandloop in the vicinity of the ADF this ideal situation may be best approached by ensuring that an adequate area of the upper Sandloop is set aside for long term protection and that all remaining natural areas within the railway yard and Site 13 which have been disturbed are rehabilitated. Additionally it should be noted that the ephemeral pans within the FGD study area are important havens for wildlife not least bullfrogs which have been confirmed breeding within the study area. By the end of the said project, based on the infrastructure layout plans provided MPS would have seen the loss of 3.6 ha of this pan habitat. Although this appears to be a small size, it is significant when considering that this represents 20 possible breeding locations. As per Macfarlane *et al*. (2014) long term protection of these wetland systems entails, *inter alia*, "*the implementation of legal mechanisms (e.g. declaration of a Protected Environment or Nature Reserve under the National Environmental Management: Protected Areas Act, a legally binding conservation servitude, or a long term Biodiversity Agreement under NEMA) and putting in place appropriate management structures and actions"*.

The predicted wetland health scores for SEW 1 and 2 allows for the estimation of the extent of functional wetland that is likely to be lost from the present ecological state under each infrastructure alternative both with and without mitigation (**Table 10-1** and **Table 10-2**). It is important to note here that these values represent the basic hectare equivalents for one of three offset themes as outlined in *Wetland Offsets: A best Practice Guideline for South Africa*" Macfarlane *et al*. (2014) namely Ecosystem Services and Water Resources. Assessment of the two other themes in terms of hectare equivalents namely Ecosystem Conservation, and Species of Conservation Concern, lies beyond the scope of this report and will need to be addressed in the subsequent wetland offset plan. Additionally, given the nature of the project, presence of conservation important species (bullfrogs) and the national importance of the Sandloop FEPA, the use of modifiers to augment default offset ratios based on the three hectare equivalent theme estimations is strongly recommended. Preliminary communications with Eskom affirm their commitment to commissioning a wetland rehabilitation and stage 1 offset plan that will serve to offset functional losses to SEW 1, SEW 2 and D4 (pans), by conserving the Sandloop and associated depressions within their properties, specifically Site 12 as well as initiating the artificial recreation of pan habitat, the extent to which is to be decided in the upcoming rehabilitation and offset plan by NSS. Two pressing and urgent issues were recently identified after fieldwork on Google Earth. These are depicted in **Figure 9-8** and discussed in the bullet points below.

Figure 10-1 Areas of recent disturbance

With this in mind the following preliminary strategy is advised:

- Two urgent issues need to be addressed promptly:
    - It is evident that an overflow event from the coal stockpile PCD 4 into the watercourse on the south-western boundary of Site 13 via its spillway has occurred. Spillways are designed to protect the integrity of the structure under high capacity. The problem here is that the lined stormwater infrastructure has not been constructed and this effluent is entering the environment. This is a recent impact that needs to be dealt with swiftly to avoid further contamination of the Sandloop. Clean up the coal spillage within the watercourse and reassess the capacity of the coal PCD from an engineering perspective.
    - One of the depressions (C15) in the centre of Site 13 has been completely re-shaped into a square. Such alteration of the bed of any depression or wash cannot be allowed to happen prior to the issuing of the water use licence from DWS.
- Eskom should support the recently commissioned wetland rehabilitation and bullfrog relocation / pan restoration projects in terms of rainfall reporting, labour, machinery and engineering resources to enable the successful creation of new pan habitat within Site 12 and the successful relocation and establishment of bullfrogs therein.
- A few issues emerged during the workshop held at Zitholele with the relevant specialists and engineers that NSS feels needs addressing:
    - The precise origin and composition of the limestone to be brought in for the FGD process is yet unknown. It is advised that the source and manganese content (and any other metals) as well as the pH of the slurry formed from a combination with rain and groundwater be determined as soon as possible.
    - It was mentioned that the rehabilitation of the ADF will follow the advancing face. It was then mentioned that water coming off rehabilitated areas would be considered clean water and would enter the clean water system. A question was raised as to where this “clean water” would be stored prior to discharge into the environment. The Eskom engineers pointed out that the ADF PCDs closest to the rehabilitated side would be converted from dirty to clean water facilities to hold this water. How this transition from dirty to clean water systems is carried out is yet uncertain and may pose a significant challenge.
- Although an attempt has been made to augment the south-western corner of the ADF efforts should be taken to wherever possible minimise any further loss / encroachment into pan habitat, the upper Sandloop catchment and areas, within the 1:100 year floodline and the 1 km buffer on the Sandloop FEPA.
- Although Alternatives 1 and 3 (conservation of most of the western limb of SEW 1 within the site) were preferable correspondence with Eskom and the relevant engineers suggests an infrastructure footprint congruent with Alternative 5 will be opted for and is final. This not an optimal situation and will require stringent rehabilitation and offset measures to be implemented.

- During the development of the FGD plant, storage facilities, ash facility and associated infrastructure adhere to best practice guidelines and recommended mitigation measures as outlined in this report.
- Ensure that the stipulations within the ROD (12/12/20/695) are adhered to as well as those stipulated in the EA (Ref: 12/9/11/L50/6).
- Attempt wherever possible to avoid development within at least 100 m from any pan or semi-arid ephemeral wash outside of the footprint area as depicted in **Figure 7-12**.
- Although the loss of some wetland features on site is inevitable given the nature of this project it is imperative that every effort be taken to ensure the long term, *in situ*, conservation of the depressions C11 and where possible C20 (bullfrog breeding site) and C21 together with a minimum 100 m radial buffer around their delineated edges.
- Normally best practice guidelines on Giant Bullfrogs (Yetman and Fergusson, 2011) advocate a minimum 500 m radial buffer and idealistic 1 km buffer on breeding sites. However the froglets could not be positively distinguished as either Giant Bullfrog or African Bullfrog. The latter being of lower conservation importance. However the, bullfrog relocation project (in progress) would circumvent this situation through capture and relocation of all adults, tadpoles and froglets during the peak of the breeding season to newly created pans in Site 12. The full assistance of Eskom labour should be at the specialist's disposal for assistance in relocating the bullfrogs.
- If it has not already been removed, the possibility of adjusting the eastern boundary of the Phase 3A Temporary Storage Area to avoid the loss of depression C15 should be considered in earnest.
- Given the pristine nature of the upper Sandloop FEPA, long term protection and management is advocated as the primary offset strategy supplemented by rectification measures were deemed necessary.
- Commission a comprehensive wetland rehabilitation and offset investigation.
- The wetland delineations and preliminary ecosystem health based hectare equivalents as outlined in this report should be used to inform the wetland offset plan, and updated as deemed necessary. The two other themes in terms of hectare equivalents namely Ecosystem Conservation and Species of Conservation Concern need to be assessed in the wetland offset plan. Additionally, given the nature of the project and the national importance of the Sandloop FEPA, the use of modifiers to augment default offset ratios based on the three hectare equivalent theme estimations is strongly recommended.

11. Conclusion

In spite of the study area being situated within the otherwise flat and relatively homogenous Limpopo Sweet Bushveld (dominated by *Acacia* and *Combretum* species), fieldwork by NSS has revealed a wealth of biodiversity and uncovered the presence of a number water resources. It is the presence of these pans and semi-arid ephemeral washes wetlands, such as the Sandloop FEPA and associated tributaries that breathe life into the otherwise arid landscape. In terms of fauna the MPS and immediate surrounds was found to support a large proportion of the regions diversity of which many species are of conservation importance. Perhaps most noteworthy and directly impacted in this regard are bullfrogs. At least one breeding site was confirmed within the FGD study area with several others south and along the Sandloop System. There remains some uncertainty regarding the identification of the individuals observed on site as both bullfrog species may occur within the study area. Regardless both are large, charismatic, explosive breeding frogs that are facing high levels of habitat loss and persecution. Although limited in floral species, the pans also support an exceptional diversity of other amphibian species, reptiles, birds and mammals and the bullfrogs therefore act as good surrogates for the conservation of much wider range of species. Naturally one of the most significant impacts emanating from ADF development is the loss of the largely natural pans and water courses that support this diversity. The importance of the matter and the need to rehabilitate and offset wetland loss as well as re-create pan habitat was affirmed by DWS head office and has been duly acknowledged by Eskom with such studies set in motion. Although not particularly diverse in terms of flora, a significant amount of largely natural remaining *Acacia* veld remains which does support a number of Protected tree species and potentially one Near-Threatened herbaceous species. Vegetation units of particular significance included the *Acacia nigrescens –Combretum apiculatum* dominated woodland and the vegetation associated with the pans and ephemeral washes, which were rated Very High and Moderate -High sensitivity respectively for their natural state and importance in supporting conservation important species.

In terms of wetlands our field surveys revealed a number of small Semi-arid Ephemeral Washes and Depression wetlands within the study area (Site 13) earmarked for the construction of the ADF. These and other wetlands were originally not identified by the appointed specialists during the environmental authorisation process for the MPS and subsequently the ADF (EA granted in 2009, Ref12/9/11/L50/6). An inevitable consequence of this situation, however, is that some of the depressions and washes were lost through construction activities. Nevertheless a number of these systems still remain and have the potential to retain much of their integrity and ecological functioning. The wetlands identified on site were all rated with High conservation importance. Of greatest importance are those wetlands that are situated, and which feed into, the upper reaches of the Sandloop. Maintenance of these wetlands that fall into the 1km buffer Sandloop FEPA, as well as maintenance of the buffer itself is of utmost importance. Discovery of wetlands within the proposed infrastructure footprint at such a late stage of the project, obviously presents a number of challenges regarding the sustainable protection of these water courses. The only pragmatic solution now lies in an approach that seeks to; (i) minimise further direct losses to the wetland resources and dependant biota on site by means of strategic placement and design of infrastructure, (ii) decrease the amount of functional loss to these wetlands and the Sandloop FEPA through strict adherence to the stipulated mitigation and (iii) offset these losses by means of setting aside a portion of the upper Sandloop for long term conservation following the outcomes of a comprehensive wetland offset and monitoring plan that takes cognisance of the national conservation importance of the Sandloop FEPA.

12. References

ACOCKS, J.P.H. 1988. Veld types of South Africa 3rd Ed. Memoirs of the Botanical Survey of South Africa. No 57. National Botanical Gardens/ Botanical Research Institute. Pretoria.

AGIS, 2010. Agricultural Geo-Referenced Information System – land type data. Website: www.agis.agric.za. Accessed: 2018.

ALEXANDER G. & MARAIS J. 2008. A Guide to the Reptiles of Southern Africa. Struik Publishers, Cape Town.

ANZECC. 2000. Website: http://www.mfe.govt.nz/fresh-water/technical-guidance-and-guidelines/anzecc-2000-guidelines. Accessed in 2018.

AVENANT-OLDEWAGE & MARX, 2000. A further investigation into the bioaccumulation of lead and zinc in the organs and tissues of the African sharptooth catfish, Glorias gariepinus from two localities in the Olifants River, Kruger National Park. Koedoe 43 (2): 17-33, Pretoria

ATSDR, 2018. Website: https://www.atsdr.cdc.gov/. Accessed: 2018.

BARNES K.N. 2000. The Eskom Red Data Book of Birds of South Africa, Lesotho & Swaziland. Birdlife South Africa, Johannesburg.

BATES, M.F., BRANCH, W.R., BAUER, A.M., BURGER, M., MARAIS, J., ALEXANDER, G.J., DE VILLIERS, M.S., (eds). In press. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland (2014). Strelitzia 32. SANBI, Pretoria.

BEC, MARTIN-CREUZBERG & VON ELERT, 2006. Trophic upgrading of autotrophic picoplankton by the heterotrophic nanoflagellate Paraphysomonas sp. Limnology & Oceanography, Volume 51, Issue 4 July 2006 Pages 1699–1707

BIRDLIFE INTERNATIONAL. 2018. Website: www.birdlife.org. Accessed in 2018.

Botes & Van Staden. 2005. Investigation of trace element mobility in river sediments using ICP-OES. *Water SA* Vol. 31 (2) 2005: pp.183-192

BRANCH B. 1990. Field Guide to Snakes and Other Reptiles of Southern Africa. Struik Publishers, Cape Town.

CAMPBELL H.W. & CHRISTMAN S.P. 1982. Field Techniques for Herpetofaunal Community Analysis. In SCOTT N.J. Jr. Wildlife Research Report 13, US Dept. of the Interior and Wildlife Services.

COWLING R.M., RICHARDSON D.M. & PIERCE, S.M. 1997. Vegetation of Southern Africa. Cambridge University Press, Cambridge.

COLVIN, C., LE MAITRE, D., SAAYMAN, I. and HUGHES, S. (2007). Aquifer Dependent Ecosystems in Key Hydrogeological Typesettings in South Africa. WRC Report No TT 301/07.

Crisinel *et al*. 1994. Cyst-based ecotoxicological tests using Anostracans: Comparison of two species of Streptocephalus.

HILTON-TAYLOR C. 1996. Red Data List of southern African plants. Strelitzia 4. National Botanical Institute, Pretoria, South Africa.

DALLAS, H.F., 2005. River health programme: site characterisation field-manual and field-data sheets. Resource quality services, Department of water affairs and forestry.

DALLAS, H.F., 2007. River Health Programme: South African Scoring System (SASS) Date Interpretation Guidelines. The Freshwater Consulting Group/Freshwater Research Unit, University of Cape Town. Prepared for Institute of Natural Resources and the Department of Water Affairs and Forestry

DALLAS, H.F., DAY, D. J., 2004. The effect of water quality variables on aquatic ecosystems. Water Research Commission, Cape Town.

DAVIES, B., & J., DAY., 1998. Vanishing Waters. University of Cape Town Press

DAVIS S.D., DROOP S.J.M., GREGERSON, P., HENSON L., LEON C.J., VILA-LOBOS J.L., SYNGE H. & ZANTOVSKA J. 1986. Plants in Danger: What do we know? IUCN, Gland.

DAY, J., DAY, E., ROSS-GILLESPIE, V. & KETLEY, A. 2010. The assessment of temporary wetlands during dry conditions, March 2010. WRC Report No. TT 434/09.

DEA. (DEPARTMENT OF ENVIRONMENTAL AFFAIRS), DMR (DEPARTMENT OF MINERAL RESOURCES), CoM (CHAMBER OF MINES), SAMBF (SOUTH AFRICAN MINING & BIODIVERSITY FORUM) & SANBI (SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE). 2013. Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector. Pretoria.

DICKENS C.W.S & GRAHAM P.M., 2002: The South African Scoring System (SASS), version 5, rapid bioassessment methods for rivers, Aftrican Journal of Aquatic Science, 27, 1 – 10.

DIPPENAAR-SCHOEMAN, A. S. 2002. Baboon and Trapdoor spiders of Southern Africa: an identification manual. Plant Protection Research Institute Handbook 13, Agricultural Research Council, Pretoria. 130 pp. LINK

DRIVER A., MAZE K., LOMBARD A.T., NEL J., ROUGET M. & TURPIE J.K. 2004. South African National Spatial Biodiversity Assessment Summary Report.

DU PREEZ L. & CARRUTHERS V. 2009. A Complete Guide to the Frogs of Southern Africa. Struik Nature, Cape Town.

DWA (2013). National Water Resource Strategy. Second Edition. Department of Water Affairs. South Africa.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 1999. Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems. Version 1.0. DWAF, Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 1996. South African Water Quality Guidelines, Vol 7: Aquatic Ecosystems.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 1999. Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems. Version 1.0. DWAF, Pretoria.

DWAF. 2005. A practical field procedure for identification and delineation of wetland riparian areas. DWAF, Pretoria.

DWAF. 2011. Website: http://www.dwaf.gov.za/WAR/systems.html. Accessed in August 2011.

FERRAR, A.A., & LÖTTER, M.C., 2007. Mpumalanga Biodiversity Conservation Plan Handbook. Mpumalanga Tourism & Parks Agency, Nelspruit.

FERREIRA, J.G. 2012. Could the 'evolution' from biology to life sciences prevent 'extinction' of the subject field? South African Journal for Science and Technology 31(1):1-5

FILGUEIRAS et al. 2004. Evaluation of Distribution, Mobility and Binding Behaviour of Heavy Metals in Surficial Sediments of Louro River (Galicia, Spain) Using Chemometric Analysis: A Case Study. Science of The Total Environment. Vol 330 (1–3), Pg 115-129

FRIEDMANN Y. & DALY B. 2004. Red Data Book of the Mammals of South Africa: A Conservation Assessment. CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust, South Africa.

FROGMAP. 2018. Website: http://vmus.adu.org.za. Accessed in 2018.

GDARD (GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT). 2011. Gauteng Conservation Plan Version 3.3 (C-Plan 3.3). GDARD, Johannesburg.

GDARD (GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT). 2012. GDARD Requirements for Biodiversity Assessments Version 2. GDARD, Johannesburg.

GERMISHUIZEN G. & MEYER N.L. 2003. Plants of Southern Africa: An annotated checklist. Strelitzia 17, SANBI, Pretoria.

HAMILTON, 2004. The Demographics of Bumphead Parrotfish (Bolbometopon Muricatum) in Lightly and Heavily Fished Regions of the Western Solomon Islands: A Thesis. University of Otago

HARRISON J.A., BURGER M, MINTER L.R., DE VILLIERS A.L., BAARD E.H.W, SCOTT E., BISHOP P.J. & ELLIS S. 2001. Conservation Assessment and Management Plan for Southern Africa Frogs. Final Report. Minnesota: IUCN/SSC Conservation Breeding Specialist Group.

HASAN, M. R.; HECHT, T. ; DE SILVA, S. S. ; TACON, A. G. J., 2007. Study and analysis of feeds and fertilizers for sustainable aquaculture development. FAO Fisheries Technical Paper. No. 497. Rome, FAO. 510p.

HENNING G.A., TERBLANCHE R.F. & BALL J.B. 2009. South African Red Data Book: Butterflies. SANBI Biodiversity Series 13. South African National Biodiversity Institute, Pretoria.

HILL M.O. 1979. TWINSPAN. A Fortran Program for Arranging Multivariate Data in an Ordered Two-way Analysis. Cornell University, New York.

HILTON-TAYLOR C. 1996. Red Data List of Southern African Plants. Strelitzia 4. National Botanical Institute, Pretoria.

HURFORD & SCHNEIDER. 2007. Monitoring Nature Conservation in Cultural Habitats: A Practical Guide and Case Studies. Springer, Netherlands.

IUCN (INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES). 2012. IUCN Red List Categories and Criteria: Version 3.1. IUCN, Gland, Switzerland.

IUCN. 2013.1. The IUCN Red List of Threatened Species Version 2013.1. Website: www.iucnredlist.org. Accessed in 2013.

JOHNSON, S. & STARKE, L. (EDS). 2006. Good Practice Guidance for Mining and Biodiversity. International Council on Mining and Metals (ICMM), London, UK.

KNNCS (KWAZULU-NATAL NATURE CONSERVATION SERVICE). 1999. Nomination Proposal for the Drakensberg Park alternatively known as Ukhahlamba Park to be listed as a World Heritage Site. KwaZulu-Natal Nature Conservation Service.

KOTZE D.C., MARNEWECK G.C, BATCHELOR A.L., LINDLEY D.S. & COLLINS N.B. 2008. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/08, Water Research Commission, Pretoria.

KLEYNHANS C. J. & LOUW M. D., 2008. Module A: EcoClassification and Ecostatus determination in River EcoClassification: Manual for ecostatus determination (version 2). Pretoria, South Africa: Joint Water Research Commission and the Department of Water Affairs and Forestry.

KUNTONEN-VAN 'T RIET, J. 2007. Strategic Review of the Status of Biodiversity Management in the South African Mining Industry. Matrix+ Consulting, Johannesburg

LEDET. 2003. Limpopo Environmental Management Act, 2003 (Act 7 of 2003)

LEEMING J. 2003. Scorpions of Southern Africa. Struik Publishers, Cape Town.

LENNTECH, 2016. Website: https://www.lenntech.com/. Accessed in 2018.

LEVICK *et al*. 2008. The ecological and hydrological significance of ephemeral and intermittent streams in the arid and semi-arid American southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046, 116 pp.

LepiMap, 2018. Website: http://lepimap.adu.org.za/. Accessed in 2018.

LOW A.B. & REBELO A.G. 1996. Vegetation of South Africa, Lesotho and Swaziland. A Companion to the Vegetation Map of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MACFARLANE D.M., KOTZE D.C., ELLERY W.N., WALTERS D., KOOPMAN V., GOODMAN P., GOODMAN P. & GOGE C. 2008. Wetland Tools Assessment. WRC Report.

MACKENZIE, J., & ROUNTREE, 2007. Draft riparian delineation methods prepared for the Department of Water Affairs and Forestry, Version 1.0 (Unpublished Field Notes).

MAMMALMAP. 2018. Website: http://vmus.adu.org.za. Accessed in 2018.

MEASEY, G.J. 2011. Ensuring a Future for South Africa's Frogs: A Strategy for Conservation Research. SANBI Biodiversity Series 19. South African National Biodiversity Institute, Pretoria.

MECENERO, S., BALL J.B., EDGE D.A., HAMER M.L., HENNING G.A., KRUGER M.A., PRINGLE, E.L., TERBLANCHE R.F. & WILLIAMS M.C. Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas. Saftronics and the Animal Demography Unit, University of Cape Town.

Millennium Ecosystem Assessment, 2005. Website: https://www.millenniumassessment.org/en/index.html. Accessed in 2018.

MINTER L., BURGER M., HARRISON J.A., BRAACK H.H., BISHOP P.J. & KLOEPFER D. 2004. Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland. SI/MAB Series #9. Smithsonian Institution, Washington, DC.

MONADJEM A., TAYLOR P.J., COTTERILL F.P.D. & SCHOEMAN M.C. 2010. Bats of Southern and Central Africa – A Biogeographic and Taxonomic Synthesis. Wits University Press, Johannesburg.

MUCINA L. & RUTHERFORD M.C. 2006. The Vegetation Map of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute.

MUELLER-DOMBOIS & ELLENBERG. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

NEL, L.J. & DRIVER, A. 2012: National Biodiversity Assessment 2011: Technical Report: Volume 2: Freshwater Component. CSIR & SANBI, Pretoria.

NEL J., MAREE G., ROUX D., MOOLMAN D., KLEYNHANS N., SILBERBAUER N. & DRIVER A. 2004. South African National Spatial Biodiversity Assessment. Technical report, Volume 1. Pretoria: SANBI.

NEWMAN K. 2002. Newman's Birds of Southern Africa. Struik Publishers, Cape Town.

Nriagu & Pacyna, 1988. Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature 333, 134–139.

O'FARRELL P. 2006. Ecosystem Services and Benefits to Farmers. Conservation Farming Project.

OLLIS D.J., SNADDON C.D., JOB N.M. & MBONA, N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African National biodiversity Institute, Pretoria. RAMSAR, 1999. People and Wetlands: The Vital Link, 7th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971), San José, Costa Rica.

PELLERIN & BOOKER, 2000. Reflections on hexavalent chromium: health hazards of an industrial heavyweight. Environ Health Perspect. 2000 Sep;108(9):A402-7.

PFAB M.F. & VICTOR J.E. 2002. Threatened Plants of Gauteng, South Africa. South African Journal of Botany 68: 370-375.

PICKETT S.T.A., OSTFELD R.S., SHACHAK M. & LICKENS G.E. 1997. The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity. Chapman and Hall. New York.

POSA (PLANTS OF SOUTHERN AFRICA). 2013. Website: http://posa.sanbi.org/searchspp.php. Accessed in 2013.

REPTILEMAP. 2018. Website: http://vmus.adu.org.za. Accessed in 2018.

ROWNTREE, K.M., & WADESON, R.A., 2000. Field manual for channel classification and condition assessment. National Aquatic Ecosystem Biomonitoring Programme Report Series No. 13.Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

SABAP 1 & 2 (FIRST AND SECOND SOUTHERN AFRICAN BIRD ATLAS PROJECTS). 2018. Website: http://sabap2.adu.org.za. Accessed in 2018.

SABCA (SOUTH AFRICAN BUTTERFLY CONSERVATION ASSESSMENT). 2018. Website: http://sabca.adu.org.za. Accessed in 2018.

SAVANNAH ENVIRONMENTAL, 2013. Amendment of Environmental Management Programme Report for Sekoko Waterberg Colliery, Limpopo Province. Mining Right Ref No: LP30/5/1/2/2/184 MR

SAMWAYS, 2008. Dragonflies and Damselflies of South Africa. Pensoft Publishers. Sofia.

SAWS (SOUTH AFRICAN WEATHER SERVICE). 2018. Website: www.weathersa.co.za. Accessed in November 2017.

SCORPIONMAP. 2018. Website: http://vmus.adu.org.za. Accessed in 2018.

SCOTT E., VISSER J.D., YETMAN C.A., OLIVER L. & BROADLEY D.G. 2013. Revalidation of *Pyxicephalus angusticeps* Parry, 1982 (Anura: Natatanura: Pyxicephalidae), a Bullfrog Endemic to the Lowlands of Eastern Africa. Zootaxa 3599: 201-228.

SHEPPARD PR, RIDENOUR G, SPEAKMAN RJ, WITTEN ML. Elevated tungsten and cobalt in airborne particulates in Fallon, Nevada: possible implications for the childhood leukemia cluster. Appl Geochem. 2006;21:152–165.

STUART C. & STUART T. 2000. Field Guide to the Mammals of Southern Africa. Struik Publishers.

TAYLOR, P.J., 2000. Bats of southern Africa. University of Natal Press, Pietermaritzburg.

TAINTON N.1999. Veld Management in South Africa. University of Natal Press, Pietermaritzburg.

TICHY L. & HOLT J. 2006. JUICE Program for Management, Analysis and Classification of Ecological Data. Vegetation Science Group, Czech Republic. Upgraded December 2009 from: http://www.sci.muni.cz/botany/juice.

TOOTH, S. 2015. Wetlands in drylands: "Hotspots" of Ecosystem Services in Marginal Environments. GSDR 2015 Science Brief

VAN WYK B.E. 2002. Website: www.sawac.co.za. Accessed in 2018.

WIKUM D. & SHANHOLTZER G. 1978. Application of the Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. Environmental Management 2: 323-329.

YETMAN C.A. 2012. Conservation Biology of the Giant Bullfrog, *Pyxicephalus adspersus* (Tschudi, 1838). PhD thesis. University of Pretoria.

YETMAN, C.A. & VERBURGT, L., 2012. Geographic range extension for the Giant Bullfrog (*Pyxicephalus adspersus* Tschudi, 1838). Natural Scientific Services. African Herp News. 57: 18-20

ZITHOLELE, 2016. Website: http://www.zitholele.co.za/environmental/. Accessed in 2018.

13. Appendices

13.1. Appendix 1 Floral species recorded in the QDGS

Family	*Species*	Threat status	Growth forms
FABACEAE	*Abrus laevigatus E.Mey.*	LC	Climber
MALVACEAE	*Abutilon austro-africanum Hochr.*	LC	Dwarf shrub
MALVACEAE	*Abutilon pycnodon Hochr.*	LC	Herb, shrub
FABACEAE	*Acacia caffra (Thunb.) Willd.*	LC	Shrub, tree
FABACEAE	*Acacia fleckii Schinz*	LC	Shrub, tree
FABACEAE	*Acacia mellifera (Vahl) Benth. subsp. detinens (Burch.) Brenan*	LC	Shrub, tree
FABACEAE	*Acacia senegal (L.) Willd. var. rostrata Brenan*	LC	Shrub, tree
FABACEAE	*Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.) Brenan*	LC	Shrub, tree
EUPHORBIACEAE	*Acalypha caperonioides Baill. var. caperonioides*	DDT	Dwarf shrub, herb
EUPHORBIACEAE	*Acalypha indica L. var. indica*	LC	Dwarf shrub, herb, shrub
CUCURBITACEAE	*Acanthosicyos naudinianus (Sond.) C.Jeffrey*	LC	Herb, succulent
POACEAE	*Acroceras macrum Stapf*	LC	Graminoid
FABACEAE	*Aeschynomene indica L.*	LC	Herb, shrub
RUBIACEAE	*Agathisanthemum bojeri Klotzsch subsp. bojeri*	LC	Herb, shrub
FABACEAE	*Albizia harveyi E.Fourn.*	LC	Tree
HYACINTHACEAE	*Albuca glauca Baker*	LC	Geophyte
OROBANCHACEAE	*Alectra orobanchoides Benth.*	LC	[No lifeform defined]
FABACEAE	*Alistilus bechuanicus N.E.Br.*	LC	Herb
ASTERACEAE	*Ambrosia artemisiifolia L.*	Not Evaluated	Herb
POACEAE	*Andropogon schirensis Hochst. ex A.Rich.*	LC	Graminoid
POACEAE	*Anthephora pubescens Nees*	LC	Graminoid
APONOGETONACEAE	*Aponogeton junceus Lehm.*	LC	Geophyte, herb, hydrophyte, tenagophyte
POACEAE	*Aristida adscensionis L.*	LC	Graminoid
POACEAE	*Aristida canescens Henrard subsp. canescens*	LC	Graminoid
POACEAE	*Aristida congesta Roem. & Schult. subsp. congesta*	LC	Graminoid
POACEAE	*Aristida spectabilis Hack.*	LC	Graminoid

Family	*Species*	Threat status	Growth forms
POACEAE	*Aristida stipitata Hack. subsp. graciliflora (Pilg.) Melderis*	LC	Graminoid
POACEAE	*Aristida stipitata Hack. subsp. stipitata*	LC	Graminoid
ASPARAGACEAE	*Asparagus cooperi Baker*	LC	Dwarf shrub, shrub
ASPARAGACEAE	*Asparagus cooperi Baker*	LC	Dwarf shrub, shrub
ASPARAGACEAE	*Asparagus exuvialis Burch. forma exuvialis*	Not Evaluated	Shrub
ASPARAGACEAE	*Asparagus nelsii Schinz*	LC	Shrub
ACANTHACEAE	*Asystasia schimperi T.Anderson*	LC	Herb
ASTERACEAE	*Athrixia elata Sond.*	LC	Dwarf shrub
SCROPHULARIACEAE	*Bacopa floribunda (R.Br.) Wettst.*	LC	Herb, hydrophyte
ACANTHACEAE	*Barleria affinis C.B.Clarke*	LC	Dwarf shrub, herb, shrub
ACANTHACEAE	*Barleria galpinii C.B.Clarke*	LC	Herb, shrub
ACANTHACEAE	*Barleria lancifolia T.Anderson subsp. lancifolia*	LC	Dwarf shrub, herb, shrub
ACANTHACEAE	*Barleria mackenii Hook.f.*	LC	Herb, shrub
ACANTHACEAE	*Barleria rehmannii C.B.Clarke*	LC	Dwarf shrub, herb
FABACEAE	*Bauhinia petersiana Bolle subsp. macrantha (Oliv.) Brummitt & J.H.Ross*	LC	Climber, shrub, tree
FABACEAE	*Bauhinia petersiana Bolle subsp. macrantha (Oliv.) Brummitt & J.H.Ross*	LC	Climber, shrub, tree
ACANTHACEAE	*Blepharis breyeri Oberm.*	LC	Dwarf shrub, shrub
ACANTHACEAE	*Blepharis diversispina (Nees) C.B.Clarke*	LC	Dwarf shrub, herb, shrub
ACANTHACEAE	*Blepharis maderaspatensis (L.) Roth*	LC	Herb
CAPPARACEAE	*Boscia albitrunca (Burch.) Gilg & Gilg-Ben.*	LC	Shrub, tree
CAPPARACEAE	*Boscia foetida Schinz subsp. rehmanniana (Pestal.) Toelken*	LC	Tree
POACEAE	*Bothriochloa bladhii (Retz.) S.T.Blake*	LC	Graminoid
POACEAE	*Brachiaria nigropedata (Ficalho & Hiern) Stapf*	LC	Graminoid
BRYACEAE	*Bryum capillare Hedw.*		Bryophyte
CYPERACEAE	*Bulbostylis hispidula (Vahl) R.W.Haines subsp. pyriformis (Lye) R.W.Haines*	LC	Cyperoid, herb, mesophyte
CYPERACEAE	*Bulbostylis humilis (Kunth) C.B.Clarke*	LC	Cyperoid, herb, mesophyte
CAPPARACEAE	*Cadaba termitaria N.E.Br.*	LC	Shrub
POACEAE	*Cenchrus ciliaris L.*	LC	Graminoid
CERATOPHYLLACEAE	*Ceratophyllum demersum L. var. demersum*	LC	Hydrophyte
PEDALIACEAE	*Ceratotheca triloba (Bernh.) Hook.f.*	LC	Herb
FABACEAE	*Chamaecrista absus (L.) H.S.Irwin & Barneby*	LC	Herb
FABACEAE	*Chamaecrista biensis (Steyaert) Lock*	LC	Herb

Family	Species	Threat status	Growth forms
VERBENACEAE	*Chascanum hederaceum (Sond.) Moldenke var. hederaceum*	LC	Herb
VERBENACEAE	*Chascanum incisum (H.Pearson) Moldenke*	LC	Herb
VERBENACEAE	*Chascanum pinnatifidum (L.f.) E.Mey. var. pinnatifidum*	LC	Herb
GENTIANACEAE	*Chironia purpurascens (E.Mey.) Benth. & Hook.f. subsp. humilis (Gilg) I.Verd.*	LC	Herb
ANTHERICACEAE	*Chlorophytum recurvifolium (Baker) C.Archer & Kativu*	LC	Herb
ACANTHACEAE	*Chorisochora transvaalensis (A.Meeuse) Vollesen*	LC	Suffrutex
CAPPARACEAE	*Cleome angustifolia Forssk. subsp. petersiana (Klotzsch ex Sond.) Kers*	LC	Herb
CAPPARACEAE	*Cleome hirta (Klotzsch) Oliv.*	LC	Herb
CAPPARACEAE	*Cleome rubella Burch.*	LC	Herb
LAMIACEAE	*Clerodendrum ternatum Schinz*	LC	Dwarf shrub
EUPHORBIACEAE	*Clutia pulchella L. var. pulchella*	LC	Dwarf shrub, herb, shrub
CUCURBITACEAE	*Coccinia sessilifolia (Sond.) Cogn.*	LC	Climber, herb, succulent
COMBRETACEAE	*Combretum apiculatum Sond. subsp. apiculatum*	LC	Shrub, tree
COMMELINACEAE	*Commelina benghalensis L.*	LC	Herb
COMMELINACEAE	*Commelina erecta L.*	LC	Herb
COMMELINACEAE	*Commelina livingstonii C.B.Clarke*	LC	Herb
BURSERACEAE	*Commiphora mollis (Oliv.) Engl.*	LC	Tree
BURSERACEAE	*Commiphora neglecta I.Verd.*	LC	Succulent, tree
BURSERACEAE	*Commiphora pyracanthoides Engl.*	LC	Shrub, tree
MALVACEAE	*Corchorus asplenifolius Burch.*	LC	Herb
MALVACEAE	*Corchorus kirkii N.E.Br.*	LC	Shrub
MALVACEAE	*Corchorus psammophilus Codd*	Threatened	Herb
CARYOPHYLLACEAE	*Corrigiola litoralis L. subsp. litoralis var. litoralis*	LC	Herb
ASTERACEAE	*Cotula anthemoides L.*	LC	Herb
CRASSULACEAE	*Crassula capitella Thunb. subsp. sessilicymula (Mogg) Toelken*	LC	Herb, succulent
FABACEAE	*Crotalaria distans Benth. subsp. distans*	LC	Herb
FABACEAE	*Crotalaria orientalis Burtt Davy ex I.Verd. subsp. orientalis*	LC	Dwarf shrub, herb
FABACEAE	*Crotalaria sphaerocarpa Perr. ex DC. subsp. sphaerocarpa*	LC	Herb
APOCYNACEAE	*Cryptolepis oblongifolia (Meisn.) Schltr.*	LC	Scrambler, shrub
CUCURBITACEAE	*Cucumis africanus L.f.*	LC	Herb
CUCURBITACEAE	*Cucumis myriocarpus Naudin subsp. myriocarpus*	LC	Herb
COMMELINACEAE	*Cyanotis speciosa (L.f.) Hassk.*	LC	Herb, succulent
POACEAE	*Cymbopogon pospischilii (K.Schum.) C.E.Hubb.*	Not	Graminoid

Family	*Species*	Threat status	Growth forms
		Evaluated	
CYPERACEAE	*Cyperus chersinus (N.E.Br.) Kük.*	LC	Cyperoid, herb, mesophyte
CYPERACEAE	*Cyperus margaritaceus Vahl var. margaritaceus*	LC	Cyperoid, herb, mesophyte
POACEAE	*Dactyloctenium giganteum Fisher & Schweick.*	LC	Graminoid
EUPHORBIACEAE	*Dalechampia capensis A.Spreng.*	LC	Dwarf shrub
ASTERACEAE	*Denekia capensis Thunb.*	LC	Herb
PEDALIACEAE	*Dicerocaryum senecioides (Klotzsch) Abels*	LC	Herb
DICHAPETALACEAE	*Dichapetalum cymosum (Hook.) Engl.*	LC	Dwarf shrub
FABACEAE	*Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummitt var. africana*	LC	Shrub, tree
ACANTHACEAE	*Dicliptera minor C.B.Clarke subsp. minor*	LC	Herb
ASTERACEAE	*Dicoma tomentosa Cass.*	LC	Dwarf shrub, herb
POACEAE	*Digitaria debilis (Desf.) Willd.*	LC	Graminoid
POACEAE	*Digitaria eriantha Steud.*	LC	Graminoid
POACEAE	*Digitaria eriantha Steud.*	LC	Graminoid
EBENACEAE	*Diospyros lycioides Desf. subsp. lycioides*	LC	Shrub
EBENACEAE	*Diospyros lycioides Desf. subsp. nitens (Harv. ex Hiern) De Winter*	LC	Shrub
HYACINTHACEAE	*Dipcadi glaucum (Burch. ex Ker Gawl.) Baker*	LC	Geophyte
HYACINTHACEAE	*Dipcadi gracillimum Baker*	LC	Geophyte
HYACINTHACEAE	*Dipcadi marlothii Engl.*	LC	Geophyte
HYACINTHACEAE	*Dipcadi papillatum Oberm.*	LC	Geophyte
HYACINTHACEAE	*Dipcadi platyphyllum Baker*	LC	Geophyte
HYACINTHACEAE	*Dipcadi viride (L.) Moench*	LC	Geophyte
APOCYNACEAE	*Diplorhynchus condylocarpon (Müll.Arg.) Pichon*	LC	Shrub, tree
FABACEAE	*Dolichos junodii (Harms) Verdc.*	LC	Herb
HYACINTHACEAE	*Drimia angustifolia Baker*	LC	Geophyte
APOCYNACEAE	*Duvalia polita N.E.Br.*	LC	Succulent
ACANTHACEAE	*Dyschoriste fischeri Lindau*	LC	Dwarf shrub, shrub
ACANTHACEAE	*Dyschoriste rogersii S.Moore*	LC	Dwarf shrub, shrub
POACEAE	*Echinochloa holubii (Stapf) Stapf*	LC	Graminoid
CYPERACEAE	*Eleocharis limosa (Schrad.) Schult.*	LC	Cyperoid, emergent hydrophyte, helophyte, herb
POACEAE	*Eleusine coracana (L.) Gaertn. subsp. africana (Kenn.-O'Byrne) Hilu & de Wet*	LC	Graminoid

Family	*Species*	Threat status	Growth forms
ENTODONTACEAE	*Entodon cymbifolius Wager & Dixon*		Bryophyte, epiphyte
POACEAE	*Eragrostis aspera (Jacq.) Nees*	LC	Graminoid
POACEAE	*Eragrostis barbinodis Hack.*	LC	Graminoid
POACEAE	*Eragrostis biflora Hack. ex Schinz*	LC	Graminoid
POACEAE	*Eragrostis hierniana Rendle*	LC	Graminoid
POACEAE	*Eragrostis lehmanniana Nees var. chaunantha (Pilg.) De Winter*	LC	Graminoid
POACEAE	*Eragrostis lehmanniana Nees var. lehmanniana*	LC	Graminoid
POACEAE	*Eragrostis pallens Hack.*	LC	Graminoid
POACEAE	*Eragrostis pallens Hack.*	LC	Graminoid
POACEAE	*Eragrostis sarmentosa (Thunb.) Trin.*	LC	Graminoid
POACEAE	*Eragrostis superba Peyr.*	LC	Graminoid
ERIOCAULACEAE	*Eriocaulon abyssinicum Hochst.*	LC	Herb, hydrophyte, tenagophyte
ERIOSPERMACEAE	*Eriospermum flagelliforme (Baker) J.C.Manning*	LC	Geophyte
ERIOSPERMACEAE	*Eriospermum porphyrovalve Baker*	LC	Geophyte
BRASSICACEAE	*Erucastrum griquense (N.E.Br.) O.E.Schulz*	LC	Herb
EBENACEAE	*Euclea undulata Thunb.*	LC	Shrub, tree
POACEAE	*Eulalia aurea (Bory) Kunth*	NT*	Graminoid
EUPHORBIACEAE	*Euphorbia neopolycnemoides Pax & K.Hoffm.*	LC	Herb
EUPHORBIACEAE	*Euphorbia rhombifolia Boiss.*	LC	Shrub, succulent
EUPHORBIACEAE	*Euphorbia tirucalli L.*	LC	Shrub, succulent, tree
EUPHORBIACEAE	*Euphorbia waterbergensis R.A.Dyer*	Rare	Shrub, succulent
CONVOLVULACEAE	*Evolvulus alsinoides (L.) L.*	LC	Herb
FABRONIACEAE	*Fabronia pilifera Hornsch.*		Bryophyte, epiphyte
ASTERACEAE	*Felicia mossamedensis (Hiern) Mendonça*	LC	Herb
MORACEAE	*Ficus glumosa Delile*	LC	Succulent, tree
RUBIACEAE	*Gardenia volkensii K.Schum. subsp. spatulifolia (Stapf & Hutch.) Verdc.*	LC	Tree
ASTERACEAE	*Geigeria burkei Harv. subsp. burkei var. burkei*	LC	Herb
ASTERACEAE	*Geigeria filifolia Mattf.*	LC	Herb
GISEKIACEAE	*Gisekia pharnacioides L. var. pharnacioides*	LC	Herb
MOLLUGINACEAE	*Glinus bainesii (Oliv.) Pax*	LC	Dwarf shrub
APOCYNACEAE	*Gomphocarpus tomentosus Burch. subsp. tomentosus*	LC	Herb, shrub
MALVACEAE	*Gossypium herbaceum L. subsp. africanum (Watt) Vollesen*	LC	Shrub

Family	*Species*	Threat status	Growth forms
MALVACEAE	*Grewia avellana Hiern*	LC	Shrub
MALVACEAE	*Grewia avellana Hiern*	LC	Shrub
MALVACEAE	*Grewia flava DC.*	LC	Shrub
MALVACEAE	*Grewia flavescens Juss.*	LC	Shrub
MALVACEAE	*Grewia occidentalis L. var. occidentalis*	LC	Shrub, tree
MALVACEAE	*Grewia retinervis Burret*	LC	Shrub
MALVACEAE	*Grewia subspathulata N.E.Br.*	LC	Shrub
PEDALIACEAE	*Harpagophytum procumbens (Burch.) DC. ex Meisn. subsp. transvaalense Ihlenf. & H.E.K.Hartmann*	Not Evaluated	Herb
ASTERACEAE	*Helichrysum nudifolium (L.) Less. var. oxyphyllum (DC.) Beentje*	LC	Herb
ASTERACEAE	*Helichrysum zeyheri Less.*	LC	Dwarf shrub, shrub
BORAGINACEAE	*Heliotropium ciliatum Kaplan*	LC	Herb
BORAGINACEAE	*Heliotropium ciliatum Kaplan*	LC	Herb
BORAGINACEAE	*Heliotropium ovalifolium Forssk.*	LC	Herb
MALVACEAE	*Hermannia boraginiflora Hook.*	LC	Dwarf shrub
MALVACEAE	*Hermannia grisea Schinz*	LC	Dwarf shrub
MALVACEAE	*Hermannia modesta (Ehrenb.) Mast.*	LC	Dwarf shrub, herb
MALVACEAE	*Hermannia modesta (Ehrenb.) Mast.*	LC	Dwarf shrub, herb
MALVACEAE	*Hermannia stellulata (Harv.) K.Schum.*	LC	Herb
MALVACEAE	*Hermannia tomentosa (Turcz.) Schinz ex Engl.*	LC	Herb
AMARANTHACEAE	*Hermbstaedtia odorata (Burch.) T.Cooke var. albi-rosea Suess.*	LC	Herb
AMARANTHACEAE	*Hermbstaedtia odorata (Burch.) T.Cooke var. albi-rosea Suess.*	LC	Herb
AMARANTHACEAE	*Hermbstaedtia odorata (Burch.) T.Cooke var. aurantiaca (Suess.) C.C.Towns.*	LC	Herb
AMARANTHACEAE	*Hermbstaedtia odorata (Burch.) T.Cooke var. aurantiaca (Suess.) C.C.Towns.*	LC	Herb
AMARANTHACEAE	*Hermbstaedtia odorata (Burch.) T.Cooke var. odorata*	LC	Herb
POACEAE	*Heteropogon contortus (L.) Roem. & Schult.*	LC	Graminoid
MALVACEAE	*Hibiscus calyphyllus Cav.*	LC	Dwarf shrub, herb
MALVACEAE	*Hibiscus micranthus L.f. var. micranthus*	LC	Herb, shrub
MALVACEAE	*Hibiscus nigricaulis Baker f.*	LC	Herb
MALVACEAE	*Hibiscus physaloides Guill. & Perr.*	LC	Herb
MALVACEAE	*Hibiscus platycalyx Mast.*	LC	Shrub
MALVACEAE	*Hibiscus praeteritus R.A.Dyer*	LC	Herb
MALVACEAE	*Hibiscus pusillus Thunb.*	LC	Herb

Family	*Species*	Threat status	Growth forms
MALVACEAE	*Hibiscus schinzii Gürke*	LC	Herb
MALVACEAE	*Hibiscus sidiformis Baill.*	LC	Herb
MALVACEAE	*Hibiscus syriaca L.*	Not Evaluated	Shrub
MALVACEAE	*Hibiscus vitifolius L. subsp. vulgaris Brenan & Exell*	LC	Herb, shrub
ASTERACEAE	*Hirpicium bechuanense (S.Moore) Roessler*	LC	Dwarf shrub
APOCYNACEAE	*Huernia transvaalensis Stent*	LC	Succulent
APOCYNACEAE	*Huernia zebrina N.E.Br. subsp. magniflora (E.Phillips) L.C.Leach*	Not Evaluated	Succulent
HYPERICACEAE	*Hypericum lalandii Choisy*	LC	Herb
FABACEAE	*Indigofera bainesii Baker*	LC	Dwarf shrub, herb
FABACEAE	*Indigofera daleoides Benth. ex Harv. var. daleoides*	LC	Herb
FABACEAE	*Indigofera filipes Benth. ex Harv.*	LC	Dwarf shrub, herb, shrub
FABACEAE	*Indigofera flavicans Baker*	LC	Herb
FABACEAE	*Indigofera ingrata N.E.Br.*	LC	Herb
FABACEAE	*Indigofera nebrowniana J.B.Gillett*	LC	Dwarf shrub, herb
FABACEAE	*Indigofera sordida Benth. ex Harv.*	LC	Herb
CONVOLVULACEAE	*Ipomoea adenioides Schinz var. adenioides*	LC	Dwarf shrub, shrub
CONVOLVULACEAE	*Ipomoea coptica (L.) Roth ex Roem. & Schult.*	LC	Climber, herb
CONVOLVULACEAE	*Ipomoea crassipes Hook. var. crassipes*	LC	Herb, succulent
CONVOLVULACEAE	*Ipomoea gracilisepala Rendle*	LC	Herb
CONVOLVULACEAE	*Ipomoea hackeliana (Schinz) Hallier f.*	LC	Herb
CONVOLVULACEAE	*Ipomoea magnusiana Schinz*	LC	Herb
CONVOLVULACEAE	*Ipomoea obscura (L.) Ker Gawl. var. obscura*	LC	Herb
CONVOLVULACEAE	*Ipomoea robertsiana Rendle*	LC	Suffrutex
ACANTHACEAE	*Justicia exigua S.Moore*	LC	Herb
ACANTHACEAE	*Justicia exigua S.Moore*	LC	Herb
ACANTHACEAE	*Justicia flava (Vahl) Vahl*	LC	Dwarf shrub, herb
CUCURBITACEAE	*Kedrostis foetidissima (Jacq.) Cogn.*	LC	Climber, herb, succulent
KIRKIACEAE	*Kirkia acuminata Oliv.*	LC	Tree
KIRKIACEAE	*Kirkia wilmsii Engl.*	LC	Tree
RUBIACEAE	*Kohautia caespitosa Schnizl. subsp. brachyloba (Sond.) D.Mantell*	LC	Herb
RUBIACEAE	*Kohautia cynanchica DC.*	LC	Herb

Family	Species	Threat status	Growth forms
RUBIACEAE	*Kohautia virgata (Willd.) Bremek.*	LC	Herb
CYPERACEAE	*Kyllinga alba Nees*	LC	Cyperoid, herb, mesophyte
AMARANTHACEAE	*Kyphocarpa angustifolia (Moq.) Lopr.*	LC	Herb
FABACEAE	*Lablab purpureus (L.) Sweet subsp. uncinatus Verdc.*	LC	Climber, herb
IRIDACEAE	*Lapeirousia sandersonii Baker*	LC	Geophyte, herb
LAMIACEAE	*Leucas capensis (Benth.) Engl.*	LC	Dwarf shrub
LAMIACEAE	*Leucas sexdentata Skan*	LC	Herb
MOLLUGINACEAE	*Limeum fenestratum (Fenzl) Heimerl var. fenestratum*	LC	Herb
LESKEACEAE	*Lindbergia pseudoleskeoides Dixon*		Bryophyte, epiphyte
VERBENACEAE	*Lippia wilmsii H.Pearson*	LC	Shrub
POACEAE	*Loudetia flavida (Stapf) C.E.Hubb.*	LC	Graminoid
ONAGRACEAE	*Ludwigia adscendens (L.) Hara subsp. diffusa (Forssk.) P.H.Raven*	LC	Herb, hydrophyte
CAPPARACEAE	*Maerua angolensis DC. subsp. angolensis*	LC	Shrub, tree
APOCYNACEAE	*Marsdenia sylvestris (Retz.) P.I.Forst.*	LC	Climber
POACEAE	*Megaloprotachne albescens C.E.Hubb.*	LC	Graminoid
MALVACEAE	*Melhania acuminata Mast. var. acuminata*	LC	Dwarf shrub
MALVACEAE	*Melhania forbesii Planch. ex Mast.*	LC	Dwarf shrub, shrub
POACEAE	*Melinis repens (Willd.) Zizka subsp. grandiflora (Hochst.) Zizka*	LC	Graminoid
CONVOLVULACEAE	*Merremia verecunda Rendle*	LC	Herb
SAPOTACEAE	*Mimusops zeyheri Sond.*	LC	Shrub, tree
CUCURBITACEAE	*Momordica repens Bremek.*	LC	Herb, succulent
ACANTHACEAE	*Monechma divaricatum (Nees) C.B.Clarke*	LC	Shrub, suffrutex
GERANIACEAE	*Monsonia angustifolia E.Mey. ex A.Rich.*	LC	Herb
GERANIACEAE	*Monsonia glauca R.Knuth*	LC	Herb
FABACEAE	*Neorautanenia ficifolia (Benth. ex Harv.) C.A.Sm.*	LC	Climber, herb, succulent
FABACEAE	*Neorautanenia mitis (A.Rich.) Verdc.*	LC	Dwarf shrub, herb, succulent
AMARYLLIDACEAE	*Nerine laticoma (Ker Gawl.) T.Durand & Schinz*	LC	Geophyte
LYTHRACEAE	*Nesaea rigidula (Sond.) Koehne*	LC	Herb
ASTERACEAE	*Nidorella resedifolia DC. subsp. resedifolia*	LC	Herb
NYMPHAEACEAE	*Nymphaea nouchali Burm.f. var. caerulea (Savigny) Verdc.*	LC	Epihydate, herb, hydrophyte
HYACINTHACEAE	*Ornithogalum tenuifolium F.Delaroche subsp. tenuifolium*	Not Evaluated	Geophyte

Family	*Species*	Threat status	Growth forms
SANTALACEAE	*Osyris lanceolata Hochst. & Steud.*	LC	Shrub
FABACEAE	*Otoptera burchellii DC.*	LC	Climber, herb, shrub
POLYGONACEAE	*Oxygonum dregeanum Meisn. subsp. canescens (Sond.) Germish. var. canescens*	LC	Herb
POLYGONACEAE	*Oxygonum sinuatum (Hochst. & Steud. ex Meisn.) Dammer*		Herb
ANACARDIACEAE	*Ozoroa paniculosa (Sond.) R.& A.Fern. var. paniculosa*	LC	Shrub, tree
POACEAE	*Panicum maximum Jacq.*	LC	Graminoid
POACEAE	*Panicum maximum Jacq.*	LC	Graminoid
POACEAE	*Panicum repens L.*	LC	Graminoid
POACEAE	*Panicum schinzii Hack.*	LC	Graminoid
RUBIACEAE	*Pavetta harborii S.Moore*	LC	Shrub
MALVACEAE	*Pavonia clathrata Mast.*	LC	Herb, shrub
MALVACEAE	*Pavonia transvaalensis (Ulbr.) A.Meeuse*	LC	Dwarf shrub, herb
RUBIACEAE	*Pentanisia angustifolia (Hochst.) Hochst.*	LC	Herb
APOCYNACEAE	*Pergularia daemia (Forssk.) Chiov. subsp. daemia*	LC	Climber
POACEAE	*Perotis patens Gand.*	LC	Graminoid
POLYGONACEAE	*Persicaria attenuata (R.Br.) Soják subsp. africana K.L.Wilson*	LC	Helophyte, herb, hydrophyte
POLYGONACEAE	*Persicaria limbata (Meisn.) H.Hara*	Not Evaluated	Helophyte, herb
NYCTAGINACEAE	*Phaeoptilum spinosum Radlk.*	LC	Shrub
VERBENACEAE	*Phyla nodiflora (L.) Greene var. nodiflora*	Not Evaluated	Herb
APOCYNACEAE	*Piaranthus atrosanguineus (N.E.Br.) Bruyns*	LC	Succulent
POACEAE	*Pogonarthria squarrosa (Roem. & Schult.) Pilg.*	LC	Graminoid
POACEAE	*Pogonarthria squarrosa (Roem. & Schult.) Pilg.*	LC	Graminoid
POLYGONACEAE	*Polygonum plebeium R.Br.*	LC	Herb
FABACEAE	*Pomaria burchellii (DC.) B.B.Simpson & G.P.Lewis subsp. burchellii*	LC	Herb
URTICACEAE	*Pouzolzia mixta Solms var. mixta*	LC	Shrub, succulent, tree
VERBENACEAE	*Priva africana Moldenke*	LC	Herb
ASTERACEAE	*Pseudognaphalium luteo-album (L.) Hilliard & B.L.Burtt*		Herb
LESKEACEAE	*Pseudoleskea leskeoides (Paris) Müll.Hal.*		Bryophyte, epiphyte
PEDALIACEAE	*Pterodiscus ngamicus N.E.Br. ex Stapf*	LC	Herb, succulent
FABACEAE	*Ptycholobium contortum (N.E.Br.) Brummitt*	LC	Dwarf shrub, herb
CYPERACEAE	*Pycreus pelophilus (Ridl.) C.B.Clarke*	LC	Cyperoid, helophyte, herb,

Family	*Species*	Threat status	Growth forms
			mesophyte
CYPERACEAE	*Pycreus polystachyos (Rottb.) P.Beauv. var. polystachyos*	LC	Cyperoid, helophyte, herb, mesophyte
FABACEAE	*Requienia pseudosphaerosperma (Schinz) Brummitt*	LC	Herb, shrub
BIGNONIACEAE	*Rhigozum brevispinosum Kuntze*	LC	Shrub
FABACEAE	*Rhynchosia spectabilis Schinz*	LC	Dwarf shrub, herb, shrub
FABACEAE	*Rhynchosia totta (Thunb.) DC. var. totta*	LC	Climber, herb
RICCIACEAE	*Riccia atropurpurea Sim*		Bryophyte
RICCIACEAE	*Riccia congoana Steph.*		Bryophyte
RICCIACEAE	*Riccia okahandjana S.W.Arnell*		Bryophyte
RUBIACEAE	*Rubia horrida (Thunb.) Puff*	LC	Herb
ACANTHACEAE	*Ruellia patula Jacq.*	LC	Herb
APOCYNACEAE	*Sarcostemma viminale (L.) R.Br. subsp. viminale*	LC	Climber, succulent
EUPHORBIACEAE	*Schinziophyton rautanenii (Schinz) Radcl.-Sm.*	LC	Tree
POACEAE	*Schmidtia pappophoroides Steud.*	LC	Graminoid
POACEAE	*Schmidtia pappophoroides Steud.*	LC	Graminoid
ANACARDIACEAE	*Searsia rigida (Mill.) F.A.Barkley var. margaretae (Burtt Davy ex Moffett) Moffett*	LC	Shrub
GENTIANACEAE	*Sebaea leiostyla Gilg*	LC	Herb
APOCYNACEAE	*Secamone parvifolia (Oliv.) Bullock*	LC	Climber
SCROPHULARIACEAE	*Selago lacunosa Klotzsch*	LC	Herb
SCROPHULARIACEAE	*Selago welwitschii Rolfe var. australis Hilliard*	LC	Suffrutex
AMARANTHACEAE	*Sericorema remotiflora (Hook.f.) Lopr.*	LC	Herb
MALVACEAE	*Sida chrysantha Ulbr.*	LC	Dwarf shrub
MALVACEAE	*Sida ovata Forssk.*	LC	Dwarf shrub, herb
SOLANACEAE	*Solanum catombelense Peyr.*	LC	Dwarf shrub, shrub
SOLANACEAE	*Solanum lichtensteinii Willd.*	LC	Dwarf shrub, shrub
SOLANACEAE	*Solanum tomentosum L. var. tomentosum*	LC	Dwarf shrub, herb, shrub
MALPIGHIACEAE	*Sphedamnocarpus pruriens (A.Juss.) Szyszyl. subsp. pruriens*	LC	Climber, shrub
EUPHORBIACEAE	*Spirostachys africana Sond.*	LC	Shrub, tree
POACEAE	*Stipagrostis uniplumis (Licht.) De Winter var. uniplumis*	LC	Graminoid
OROBANCHACEAE	*Striga bilabiata (Thunb.) Kuntze subsp. bilabiata*	LC	Herb, parasite
OROBANCHACEAE	*Striga elegans Benth.*	LC	Herb, parasite
OROBANCHACEAE	*Striga gesnerioides (Willd.) Vatke*	LC	Herb, parasite

Family	*Species*	Threat status	Growth forms
ARACEAE	*Stylochaeton natalensis Schott*	LC	Herb
MYRTACEAE	*Syzygium cordatum Hochst. ex C.Krauss subsp. cordatum*	LC	Shrub, tree
PORTULACACEAE	*Talinum arnotii Hook.f.*	LC	Dwarf shrub, succulent
PORTULACACEAE	*Talinum crispatulum Dinter*	LC	Dwarf shrub, succulent
ASTERACEAE	*Tarchonanthus camphoratus L.*	LC	Shrub, tree
FABACEAE	*Tephrosia purpurea (L.) Pers. subsp. leptostachya (DC.) Brummitt var. leptostachya*	LC	Herb
FABACEAE	*Tephrosia purpurea (L.) Pers. subsp. leptostachya (DC.) Brummitt var. pubescens Baker*	LC	Herb
FABACEAE	*Tephrosia purpurea (L.) Pers. subsp. leptostachya (DC.) Brummitt var. pubescens Baker*	LC	Herb
FABACEAE	*Tephrosia zoutpansbergensis Bremek.*	LC	Dwarf shrub, shrub
COMBRETACEAE	*Terminalia sericea Burch. ex DC.*	LC	Tree
SANTALACEAE	*Thesium resedoides A.W.Hill*	LC	Herb, parasite, shrub
EUPHORBIACEAE	*Tragia dioica Sond.*	LC	Dwarf shrub, herb
POACEAE	*Tragus berteronianus Schult.*	LC	Graminoid
ZYGOPHYLLACEAE	*Tribulus terrestris L.*	LC	Herb
ZYGOPHYLLACEAE	*Tribulus zeyheri Sond. subsp. zeyheri*	LC	Dwarf shrub, herb
POACEAE	*Triraphis schinzii Hack.*	LC	Graminoid
MALVACEAE	*Triumfetta pilosa Roth var. effusa (E.Mey. ex Harv.) Wild*	LC	Shrub
CUCURBITACEAE	*Trochomeria macrocarpa (Sond.) Hook.f. subsp. macrocarpa*	LC	Climber, herb, succulent
MELIACEAE	*Turraea obtusifolia Hochst.*	LC	Climber, shrub, tree
POACEAE	*Urochloa brachyura (Hack.) Stapf*	LC	Graminoid
POACEAE	*Urochloa brachyura (Hack.) Stapf*	LC	Graminoid
VAHLIACEAE	*Vahlia capensis (L.f.) Thunb. subsp. vulgaris Bridson var. linearis E.Mey. ex Bridson*	LC	Herb
RUBIACEAE	*Vangueria infausta Burch. subsp. infausta*	LC	Tree
VERBENACEAE	*Verbena officinalis L.*	Not Evaluated	Herb
ASTERACEAE	*Verbesina encelioides (Cav.) Benth. & Hook. var. encelioides*	Not Evaluated	Herb
ASTERACEAE	*Vernonia fastigiata Oliv. & Hiern*	LC	Herb
ASTERACEAE	*Vernonia sutherlandii Harv.*	LC	Herb
FABACEAE	*Vigna frutescens A.Rich. subsp. frutescens var. frutescens*	LC	Climber, herb
FABACEAE	*Vigna unguiculata (L.) Walp. subsp. protracta (E.Mey.) B.J.Pienaar*	LC	Herb
VISCACEAE	*Viscum tuberculatum A.Rich.*	LC	Parasite, shrub, succulent

Family	Species	Threat status	Growth forms
LAMIACEAE	*Vitex rehmannii Gürke*	LC	Tree
CAMPANULACEAE	*Wahlenbergia undulata (L.f.) A.DC.*	LC	Herb
MALVACEAE	*Waltheria indica L.*	LC	Herb
FABACEAE	*Xanthocercis zambesiaca (Baker) Dumaz-le-Grand*	LC	Tree
CONVOLVULACEAE	*Xenostegia tridentata (L.) D.F.Austin & Staples subsp. angustifolia (Jacq.) Lejoly & Lisowski*	LC	Herb
OLACACEAE	*Ximenia americana L. var. microphylla Welw. ex Oliv.*	LC	Shrub, tree
XYRIDACEAE	*Xyris capensis Thunb.*	LC	Helophyte, herb, hydrophyte
RHAMNACEAE	*Ziziphus mucronata Willd. subsp. mucronata*	LC	Shrub, tree
FABACEAE	*Zornia linearis E.Mey.*	LC	Herb

13.2. Appendix 1a Additional photographic evidence of floral species on site

Clerodendrum ternatum

Alistilus bechuanicus

Evolvulus alsinoides

Kyllinga alba

Chlorophytum recurvifolium

Oxygonum dregeanum

Heliotropium species

Cyperus margaritaceus

13.3. Appendix 2 Mammal list for the study area

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
AFROSORICIDA (Golden moles)													
Neamblysomus julianae	Juliana's Golden Mole	**EN (U)**	**EN**	-	4	4							
MACROSCELIDEA (Elephant-shrews)													
Elephantulus brachyrhynchus	Short-snouted Elephant-shrew	LC (U)	LC	-	3	3							
Elephantulus intufi	Bushveld Elephant-shrew	LC (S)	LC	-	2	2			x				
Elephantulus myurus	Rock Elephant-shrew	LC (S)	LC	-	2	2							2
EULIPOTYPHLA (Hedgehogs & shrews)													
Atelerix frontalis	Southern African Hedgehog	LC (S)	**NT**	-	3	3							
Crocidura cyanea	Reddish-grey Musk Shrew	LC (S)	LC	-	2	2			x				
Crocidura fuscomurina	Tiny Musk Shrew	LC (U)	LC	-	4	4							
Crocidura hirta	Lesser Red Musk Shrew	LC (U)	LC	-	2	2							
Crocidura mariquensis	Swamp Musk Shrew	LC (U)	**NT**	-	4	4							
Myosorex cafer	Dark-footed Forest Shrew	LC (U)	LC	-	4	4							
CHIROPTERA (Bats)													
Epomophorus wahlbergi	Wahlberg's Epauletted Fruit Bat	LC (S)	LC	-	4	4							
Rousettus aegyptiacus	Egyptian Rousette	LC (S)	LC	-	4	4							
Rhinolophus smithersi	Smither's Horseshoe Bat	**NT (S)**	**NT**	-	3	3							
Rhinolophus clivosus	Geoffroy's Horseshoe Bat	LC (U)	LC	-	3	3							
Rhinolophus darlingi	Darling's Horseshoe Bat	LC (U)	LC	-	3	3							
Rhinolophus simulator	Bushveld Horseshoe Bat	LC (D)	LC	-	3	3							
Cloeotis percivali	Percival's Short-eared Trident Bat	LC (U)	**EN**	-	4	4							
Hipposideros caffer	Sundevall's Leaf-nosed bat	LC (D)	LC	-	4	4							2
Taphozous mauritianus	Mauritian Tomb Bat	LC (U)	LC	-	2	2			x				2
Tadarida aegyptiaca	Egyptian Free-tailed Bat	LC (U)	LC	-	2	2							
Mops midas	Midas Free-tailed Bat	LC (D)	LC	-	2	2					2		

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
Miniopterus natalensis	Natal Long-fingered Bat	LC (U)	LC	-	4	4							
Hypsugo anchietae	Anchieta's Pipistrelle	LC (U)	LC	-	4	4							
Pipistrellus hesperidus	Dusky Pipistrelle	LC (U)	LC	-	3	3							
Pipistrellus rusticus	Rusty Pipistrelle	LC (U)	LC	-	2	2			x				2
Neoromicia capensis	Cape Serotine	LC (S)	LC	-	1	1	x		x				2
Pipistrellus zuluensis	Zulu Serotine	LC (U)	LC	-	3	3							2
Myotis welwitschii	Welwitsch's Myotis	LC (U)	LC	-	4	4							
Myotis tricolor	Temminck's Myotis	LC (U)	LC	-	4	4							
Laephotis botswanae	Botswana Long-eared Bat	LC (S)	LC	-	3	3							
Scotophilus dinganii	Yellow-bellied House Bat	LC (U)	LC	-	2	2			x		4		3
Scotophilus viridis	Green House Bat	LC (U)	LC	-	1	1							
Nycteris thebaica	Egyptian Slit-faced Bat	LC (U)	LC	-	2	2							2
PRIMATES (Primates)													
Galago moholi	Southern Lesser Galago	LC (S)	LC	-	1	1			x				2
Papio ursinus	Chacma Baboon	LC (S)	LC	-	1	1	x	x	x				
Cercopithecus pygerythrus	Vervet Monkey	LC (S)	LC	-	1	1		x	x				
PHOLIDOTA (Pangolin)													
Manis temminckii	Pangolin	**VU (D)**	**VU**	**VU**	1	1*					2		
LAGOMORPHA (Hares & rabbits)													
Lepus saxatilis	Scrub Hare	LC (D)	LC	-	1	1	x		x	1	3		1
Pronolagus randensis	Jameson's Red Rock Rabbit	LC (U)	LC	-	3	3			*				
RODENTIA (Rodents)													
Cryptomys hottentotus	Common Mole-rat	LC (S)	LC	-	1	1	x		x				
Hystrix africaeaustralis	Porcupine	LC (S)	LC	-	1	1		x	x				2
Pedetes capensis	Springhare	LC (U)	LC	-	2	2			x				3
Xerus inauris	Cape Ground Squirrel	LC (S)	LC	-	2	2			x				
Paraxerus cepapi	Tree Squirrel	LC (S)	LC	-	1	1		x	x				
Graphiurus murinus	Woodland Dormouse	LC (S)	LC	-	2	2							

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
Acomys spinosissimus	Spiny Mouse	LC (S)	LC	-	2	2							1
Lemniscomys rosalia	Single-striped Mouse	LC (S)	LC	-	2	2							
Rhabdomys pumilio	Striped Mouse	LC (S)	LC	-	4	4							
Dasymys incomtus	Water Rat	LC (U)	**NT**	-	3	3							
Mus indutus	Desert Pygmy Mouse	LC (S)	LC	-	3	3							
Mus minutoides	Pygmy Mouse	LC (S)	LC	-	3	3			x				
Mastomys coucha	Multimammate Mouse	LC (S)	LC	-	2	2			x				
Mastomys sp.	Multimammate mice	-	-	-	-								1
Thallomys paedulcus	Tree Rat	LC (U)	LC	-	2	2							
Aethomys namaquensis	Namaqua Rock Mouse	LC (S)	LC	-	2	2							
Aethomys ineptus	Tete Veld Rat	LC (U)	LC	-	4	4							
Otomys angoniensis	Angoni Vlei Rat	LC (S)	LC	-	4	4							
Otomys irroratus	Vlei Rat	LC (S)	LC	-	3	3							
Gerbillurus paeba	Hairy-footed Gerbil	LC (S)	LC	-	3	3							
Tatera leucogaster	Bushveld Gerbil	LC (S)	LC	-	1	1	x	x	x				2
Tatera brantsii	Highveld Gerbil	LC (U)	LC	-	4	4							
Saccostomus campestris	Pouched Mouse	LC (S)	LC	-	2	2			x				
Dendromus melanotis	Grey Climbing Mouse	LC (S)	LC	-	3	3							
Dendromus mystacalis	Chestnut Climbing Mouse	LC (S)	LC	-	4	4							
Steatomys pratensis	Fat Mouse	LC (S)	LC	-	3	3							
CARNIVORA (Carnivores)													
Proteles cristatus	Aardwolf	LC (S)	LC	-	1	1			x	2			
Crocuta crocuta	Spotted Hyaena	LC (D)	**NT**	**PS**	4	4							
Hyaena brunnea	Brown hyaena	**NT (S)**	**NT**	**PS**	1	1			x	3	3		2
Acinonyx jubatus	Cheetah	**VU (D)**	**VU**	**VU**	1	1*				4		1	
Panthera pardus	Leopard	**VU (D)**	**VU**	**PS**	1	1*			x	8	8	8	23
Panthera leo	Lion	**VU (D)**	LC	**VU**	5	5							

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
Caracal caracal	Caracal	LC (U)	LC	-	1	1				4	2		
Felis silvestris	African Wild Cat	LC (D)	LC	-	1	1*			x				
Felis nigripes	Black-footed Cat	**VU (D)**	**VU**	**PS**	3	3							
Leptailurus serval	Serval	LC (S)	**NT**	**PS**	1	1							
Civettictis civetta	African Civet	LC (U)	LC	-	1	1			x				1
Genetta genetta	Small-spotted Genet	LC (S)	LC	-	2	2			x				1
Genetta tigrina	Large-spotted Genet	LC (U)	LC	-	1	1			x				1
Cynictis penicillata	Yellow Mongoose	LC (S)	LC	-	4	4							
Galerella sanguinea	Slender Mongoose	LC (S)	LC	-	1	1	x		x				
Ichneumia albicauda	White-tailed Mongoose	LC (S)	LC	-	2	2							
Atilax paludinosus	Water Mongoose	LC (D)	LC	-	1	1							1
Mungos mungo	Banded Mongoose	LC (S)	LC	-	1	1			x				2
Helogale parvula	Dwarf Mongoose	LC (S)	LC	-	2	2							
Otocyon megalotis	Bat-eared Fox	LC (U)	LC	**PS**	1	1*			x	2			
Lycaon pictus	African Wild Dog	**EN (D)**	**EN**	**EN**	1	1*							
Vulpes chama	Cape Fox	LC (S)	LC	**PS**	2	2							
Canis mesomelas	Black-backed Jackal	LC (S)	LC	-	1	1		x	x	2	1		1
Aonyx capensis	Cape Clawless Otter	**NT (D)**	**NT**	-	3	3							
Mellivora capensis	Honey Badger	LC (D)	LC	-	2	2						1	
Poecilogale albinucha	African Weasel	LC (U)	**NT**	-	2	2							
Ictonyx striatus	Striped Polecat	LC (S)	LC	-	2	2							
TUBULIDENTATA (Aardvark)													
Orycteropus afer	Aardvark	LC (U)	LC	**PS**	1	1		x	x				
PROBOSCIDEA (Elephant)													
Loxodonta africana	African Elephant	**VU (I)**	LC	**PS**	5	5							
HYRACOIDEA (Hyraxes)													
Procavia capensis	Rock Hyrax	LC (U)	LC	-	3	3			x				
Heterohyrax brucei	Yellow-spotted Rock Hyrax	LC (U)	LC	-	4	4							

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
PERISSODACTYLA (Zebras)													
Ceratotherium simum	White Rhinoceros	**NT (I)**	**NT**	**PS**	1	5		x	x				
Diceros bicornis	Black Rhinoceros	**CR (I)***	**EN**	**EN**	5	5							
Equus quagga	Plains Zebra	LC (S)	LC	**PS****	1	1			x				
SUIFORMES (Pigs & hogs)													
Potamochoerus larvatus	Bushpig	LC (S)	LC	-	4	4			x				
Phacochoerus africanus	Warthog	LC (S)	LC	-	1	1	x	x	x		1		
RUMINATA (Even-toed ungulates)													
Giraffa camelopardalis	Giraffe	LC (D)	LC	-	1	1			x		2		1
Syncerus caffer	Cape Buffalo	LC (D)	LC	-	5	5			x				
Tragelaphus strepsiceros	Kudu	LC (S)	LC	-	1	1	x	x	x				
Tragelaphus angasii	Nyala	LC (S)	LC	-	1	1			x				
Tragelaphus scriptus	Bushbuck	LC (S)	LC	-	1	1*		x	x				1
Tragelaphus oryx	Eland	LC (S)	LC	-	1	1		x	x		1		
Connochaetes gnou	Black Wildebeest	LC (I)	LC	**PS****	5	5							
Connochaetes taurinus	Blue Wildebeest	LC (S)	LC	**PS****	1	1			x				1
Alcelaphus buselaphus	Red Hartebeest	LC (D)	LC	**PS****	1	1		x	x		1		1
Damaliscus pygargus phillipsi	Blesbok	LC (S)*	LC	**PS****	1	1		x	x				
Damaliscus lunatus	Tsessebe	LC (D)	**VU**	**PS****	1	5		x	x				
Hippotragus equinus	Roan	LC (D)	**EN**	**EN**	5	5							
Hippotragus niger	Sable	LC (S)	**VU**	**VU**	1	5		x	x				
Sylvicapra grimmia	Common Duiker	LC (S)	LC	-	1	1	x		x				
Redunca arundinum	Reedbuck	LC (S)	LC	-	4	4							1
Redunca fulvorufula	Mountain Reedbuck	**EN (D)**	**EN**	-	4	4			x				
Kobus ellipsiprymnus	Waterbuck	LC (D)	LC	-	1	1			x				1
Pelea capreolus	Grey Rhebok	**NT (D)**	**NT**	-	1	1	x						
Antidorcas marsupialis	Springbok	LC (I)	LC	-	5	5							

ORDER[1] & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5,6]	FGD LoO[4,5,6]	NSS	EMPR[7]	VICINITY*	ATLAS[6]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
Ourebia ourebi	Oribi	LC (D)	EN	EN	5	5							
Raphicerus campestris	Steenbok	LC (S)	LC	-	1	1	x	x	x				
Aepyceros melampus	Impala	LC (S)	LC	-	1	1	x	x	x		1		1
Oreotragus oreotragus	Klipspringer	LC (S)	LC	-	3	3			x				2
Oryx gazelle	Gemsbok	LC (S)	LC	-	1	1							

Key

Status: CR = Critically Endangered; D = Declining; DD = Data Deficient; EN = Endangered; I = Increasing; LC = Least Concern; NT = Near Threatened; PS = Protected Species; S = Stable; U = Unknown; VU = Vulnerable

Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low; 5 = May occur as a managed population

Sources: [1]IUCN (2017.3); [2]SANBI & EWT (unpubl.); [3]ToPS List (2015); [4]Friedmann & Daly (2004); [5]Monadjem *et al.* (2010); [6]MammalMap (2018); [7]BEC (2006)

*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

**Species listed to ensure that they are managed in an ecologically sustainable manner (ToPS List, 2015)

13.4. Appendix 3 Bird list for the study area

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
2. Inland water birds											
Anhinga rufa	African Darter	LC	LC		4	4			x	x	
Ardea cinerea	Grey Heron	LC	LC		1	1	x		x	x	
Ardea goliath	Goliath Heron	LC	LC		4	4				x	
Ardea melanocephala	Black-headed Heron	LC	LC		4	4			x	x	
Ardea purpurea	Purple Heron	LC	LC		4	4				x	
Ardeola ralloides	Squacco Heron	LC	LC		1	1	x		x	x	
Bostrychia hagedash	Hadeda Ibis	LC	LC		1	1	x		x	x	
Bubulcus ibis	Western Cattle Egret	LC	LC		1	1	x		x	x	x
Butorides striata	Green-backed Heron	LC	LC		4	4				x	
Chlidonias leucopterus	White-winged Tern	LC	LC		4	4				x	
Chroicocephalus cirrocephalus	Grey-headed Gull	LC	LC		4	4				x	
Ciconia abdimii	Abdim's Stork	LC	**NT**		3	3			x	x	
Ciconia ciconia	White Stork	LC	LC		3	3				x	x
Ciconia nigra	Black Stork	LC	**VU**		4	4				x	
Egretta alba	Great Egret	LC	LC		4	4				x	
Egretta garzetta	Little Egret	LC	LC		1	1	x		x	x	
Egretta intermedia	Yellow-billed Egret	LC	LC		3	3				x	
Glareola nordmanni	Black-winged Pratincole	**NT**	**NT**		4	4				x	x
Ixobrychus minutus	Little Bittern	LC	LC		4	4					
Ixobrychus sturmii	Dwarf Bittern	LC	LC		4	4					
Leptoptilos crumeniferus	Marabou Stork	LC	**NT**		4	4				x	
Mycteria ibis	Yellow-billed Stork	LC	**EN**		4	4				x	
Nycticorax nycticorax	Black-crowned Night Heron	LC	LC		1	1	x	x	x		

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Phalacrocorax africanus	Reed Cormorant	LC	LC		1	1	x		x	x	
Phalacrocorax lucidus	White-breasted Cormorant	LC	LC		4	4			x	x	
Phoeniconaias minor	Lesser Flamingo	**NT**	**NT**		4	4				x	
Phoenicopterus roseus	Greater Flamingo	LC	**NT**		4	4				x	
Platalea alba	African Spoonbill	LC	LC		1	1	x		x	x	
Plegadis falcinellus	Glossy Ibis	LC	LC		3	3				x	
Scopus umbretta	Hamerkop	LC	LC		1	1	x		x	x	
Threskiornis aethiopicus	African Sacred Ibis	LC	LC		2	2				x	
3. Ducks & wading birds											
Actitis hypoleucos	Common Sandpiper	LC	LC		1	1	x		x	x	
Actophilornis africanus	African Jacana	LC	LC		4	4				x	
Alopochen aegyptiaca	Egyptian Goose	LC	LC		1	1	x	x	x	x	x
Amaurornis flavirostra	Black Crake	LC	LC		4	4			x	x	
Anas capensis	Cape Teal	LC	LC		4	4			x	x	
Anas erythrorhyncha	Red-billed Teal	LC	LC		1	1	x		x	x	
Anas hottentota	Hottentot Teal	LC	LC		4	4				x	
Anas smithii	Cape Shoveler	LC	LC		4	4				x	
Anas sparsa	African Black Duck	LC	LC		4	4				x	
Anas undulata	Yellow-billed Duck	LC	LC		1	1	x		x	x	
Calidris ferruginea	Curlew Sandpiper	**NT**	LC		4	4					
Calidris minuta	Little Stint	LC	LC		4	4				x	
Charadrius pecuarius	Kittlitz's Plover	LC	LC		1	1	x			x	
Charadrius tricollaris	Three-banded Plover	LC	LC		1	1	x		x	x	
Crecopsis egregia	African Crake	LC	LC		4	4					
Dendrocygna bicolor	Fulvous Whistling Duck	LC	LC		4	4				x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Dendrocygna viduata	White-faced Whistling Duck	LC	LC		1	1	x		x	x	x
Fulica cristata	Red-knobbed coot	LC	LC		1	1	x		x	x	
Gallinago nigripennis	African Snipe	LC	LC		4	4			x	x	
Gallinula chloropus	Common Moorhen	LC	LC		1	1	x		x	x	
Himantopus himantopus	Black-winged Stilt	LC	LC		1	1	x		x	x	
Netta erythrophthalma	Southern Pochard	LC	LC		4	4			x	x	
Nettapus auritus	African Pygmy Goose	LC	**VU**		4	4					
Oxyura maccoa	Maccoa Duck	**NT**	**NT**		4	4				x	
Philomachus pugnax	Ruff	LC	LC		1	1	x		x	x	
Plectropterus gambensis	Spur-winged Goose	LC	LC		1	1	x		x	x	
Rallus caerulescens	African Rail	LC	LC		4	4					
Recurvirostra avosetta	Pied Avocet	LC	LC		1	1	x			x	
Rostratula benghalensis	Greater Painted-snipe	LC	**NT**		4	4			x		
Sarkidiornis melanotos	Knob-billed Duck	LC	LC		1	1	x	x	x	x	x
Tachybaptus ruficollis	Little Grebe	LC	LC		1	1	x		x	x	
Thalassornis leuconotus	White-backed Duck	LC	LC		4	4				x	
Tringa glareola	Wood Sandpiper	LC	LC		1	1	x		x	x	x
Tringa nebularia	Common Greenshank	LC	LC		1	1	x		x	x	
Tringa stagnatilis	Marsh Sandpiper	LC	LC		4	4			x	x	
Tringa totanus	Common Redshank				4	4					
Vanellus armatus	Blacksmith Lapwing	LC	LC		1	1	x	x	x	x	x
Vanellus coronatus	Crowned Lapwing	LC	LC		1	1	x	x	x	x	x
Vanellus senegallus	African Wattled Lapwing	LC	LC		1	1	x			x	
4. Large terrestrial birds											
Afrotis afraoides	Northern Black Korhaan	LC	LC		3	3					

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Ardeotis kori	Kori Bustard	**NT**	**NT**	**PS**	4	4			x	x	x
Burhinus capensis	Spotted Thick-knee	LC	LC		2	2			x	x	x
Burhinus vermiculatus	Water Thick-knee	LC	LC		4	4			x	x	
Coturnix coturnix	Common Quail	LC	LC		1	1	x		x	x	
Coturnix delegorguei	Harlequin Quail	LC	LC		3	3				x	
Cursorius temminckii	Temminck's Courser	LC	LC		3	3			x	x	
Dendroperdix sephaena	Crested Francolin	LC	LC		1	1	x	x		x	x
Lophotis ruficrista	Red-crested Korhaan	LC	LC		1	1	x	x		x	x
Numida meleagris	Helmeted Guineafowl	LC	LC		1	1	x		x	x	x
Peliperdix coqui	Coqui Francolin	LC	LC		2	2				x	x
Pternistis natalensis	Natal Spurfowl	LC	LC		1	1	x	x		x	
Pternistis swainsonii	Swainson’s Spurfowl	LC	LC		1	1	x	x		x	x
Rhinoptilus chalcopterus	Bronze-winged Courser	LC	LC		3	3			x	x	x
Sagittarius serpentarius	Secretarybird	**VU**	**VU**		3	3				x	x
Struthio camelus	Common Ostrich	LC	LC		1	1	x		x	x	x
Turnix sylvaticus	Common (Kurrichane) Buttonquail	LC	LC		3	3			x		
5. Raptors											
Accipiter badius	Shikra	LC	LC		1	1	x				x
Accipiter melanoleucus	Black Sparrowhawk	LC	LC		4	4					
Accipiter minullus	Little Sparrowhawk	LC	LC		2	2			x	x	x
Accipiter ovampensis	Ovambo Sparrowhawk	LC	LC		2	2				x	
Aquila nipalensis	Steppe Eagle	**EN**	LC		3	3					x
Aquila rapax	Tawny Eagle	LC	**EN**	**EN**	1	1	x		x	x	x
Aquila spilogaster	African Hawk Eagle	LC	LC		1	1	x			x	
Aquila verreauxii	Verreauxs' Eagle	LC	**VU**		2	2				x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Buteo buteo	Common (Steppe) Buzzard	LC	LC		1	1	x			x	x
Buteo rufofuscus	Jackal Buzzard	LC	LC		1	2		x	x		
Circaetus cinereus	Brown Snake Eagle	LC	LC		1	1	x		x	x	x
Circaetus pectoralis	Black-chested Snake Eagle	LC	LC		1	1	x		x	x	x
Circus pygargus	Montagu's Harrier	LC	LC		4	4				x	
Clanga pomarina	Lesser Spotted Eagle	LC	LC		4	4					
Elanus caeruleus	Black-shouldered Kite	LC	LC		1	1	x		x	x	x
Falco amurensis	Amur Falcon	LC	LC		2	2				x	x
Falco biarmicus	Lanner Falcon	LC	VU		3	3					
Falco rupicolus	Rock Kestrel	LC	LC		4	4				x	x
Gyps africanus	White-backed Vulture	CR	CR	EN	1	1	x		x	x	x
Gyps coprotheres	Cape Vulture	EN	EN	EN	1	1	x		x		x
Haliaeetus vocifer	African Fish Eagle	LC	LC		3	3			x	x	
Hieraaetus pennatus	Booted Eagle	LC	LC		2	2					x
Hieraaetus wahlbergi	Wahlberg's Eagle	LC	LC		1	1	x		x	x	x
Kaupifalco monogrammicus	Lizard Buzzard	LC	LC		2	2			x	x	
Melierax canorus	Pale Chanting Goshawk	LC	LC		1	1	x		x	x	x
Melierax gabar	Gabar Goshawk	LC	LC		1	1	x		x	x	x
Milvus aegyptius	Yellow-billed Kite	LC	LC		2	2				x	
Milvus migrans	Black Kite	LC	LC		2	2			x	x	
Pandion haliaetus	Western Osprey	LC	LC		4	4					
Polemaetus bellicosus	Martial Eagle	VU	EN	EN	2	2				x	
Polyboroides typus	African Harrier-Hawk	LC	LC		1	1	x		x	x	
Terathopius ecaudatus	Bateleur	NT	EN	EN	4	4				x	x
Torgos tracheliotos	Lappet-faced Vulture	EN	EN	EN	2	2			x		x

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
6. Owls & nightjars											
Bubo africanus	Spotted Eagle-Owl	LC	LC		1	1	x		x	x	x
Bubo lacteus	Verreaux's Eagle-Owl	LC	LC		1	1	x				
Caprimulgus pectoralis	Fiery-necked Nightjar	LC	LC		2	2			x	x	
Caprimulgus rufigena	Rufous-cheeked Nightjar	LC	LC		1	1	x		x		x
Caprimulgus tristigma	Freckled Nightjar	LC	LC		1	1	x		x	x	
Glaucidium perlatum	Pearl-spotted Owlet	LC	LC		1	1	x	x	x	x	x
Otus senegalensis	African Scops Owl	LC	LC		1	1	x			x	
Ptilopsis granti	Southern White-faced Owl	LC	LC		1	1	x				x
Tyto alba	Western Barn Owl	LC	LC		2	2			x	x	
7. Sandgrouse, doves etc											
Centropus burchellii	Burchell's Coucal	LC	LC		1	1	x		x	x	
Chrysococcyx caprius	Diederik Cuckoo	LC	LC		1	1	x	x	x	x	x
Chrysococcyx klaas	Klaas's Cuckoo	LC	LC		1	1	x	x	x	x	x
Clamator glandarius	Great Spotted Cuckoo	LC	LC		2	2			x	x	
Clamator jacobinus	Jacobin Cuckoo	LC	LC		1	1	x	x	x	x	x
Clamator levaillantii	Levaillant's Cuckoo	LC	LC		2	2			x	x	x
Columba guinea	Speckled Pigeon	LC	LC		1	1	x		x	x	x
Columba livia	Rock Dove	LC	LC		2	2				x	
Corythaixoides concolor	Grey Go-away-bird	LC	LC		1	1	x	x	x	x	x
Cuculus clamosus	Black Cuckoo	LC	LC		1	1	x	x	x	x	x
Cuculus gularis	African Cuckoo	LC	LC		2	2				x	x
Cuculus solitarius	Red-chested Cuckoo	LC	LC		1	1	x			x	x
Oena capensis	Namaqua Dove	LC	LC		1	1	x	x	x	x	x
Poicephalus meyeri	Meyer's Parrot	LC	LC		2	2				x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Pterocles bicinctus	Double-banded Sandgrouse	LC	LC		2	2			x	x	
Pterocles burchelli	Burchell's Sandgrouse	LC	LC		3	3			x	x	x
Streptopelia capicola	Cape Turtle Dove	LC	LC		1	1	x	x	x	x	x
Streptopelia semitorquata	Red-eyed Dove	LC	LC		1	1	x	x	x	x	x
Streptopelia senegalensis	Laughing Dove	LC	LC		1	1	x	x	x	x	x
Treron calvus	African Green Pigeon	LC	LC		3	3				x	
Turtur chalcospilos	Emerald-spotted Wood Dove	LC	LC		1	1	x	x	x	x	x
8. Aerial feeders, etc											
Alcedo cristata	Malachite Kingfisher	LC	LC		4	4				x	
Apus affinis	Little Swift	LC	LC		1	1	x	x	x	x	x
Apus apus	Common Swift	LC	LC		1	1	x	x	x	x	x
Apus barbatus	African Black Swift	LC	LC		2	2			x	x	
Apus caffer	White-rumped Swift	LC	LC		1	1	x		x	x	
Apus horus	Horus Swift	LC	LC		3	3					
Campethera abingoni	Golden-tailed Woodpecker	LC	LC		1	1	x	x	x	x	x
Campethera bennettii	Bennett's Woodpecker	LC	LC		2	2				x	
Cecropis abyssinica	Lesser Striped Swallow	LC	LC		1	1	x	x	x	x	
Cecropis cucullata	Greater Striped Swallow	LC	LC		1	2		x	x	x	
Cecropis semirufa	Red-breasted Swallow	LC	LC		1	1	x	x	x	x	x
Ceryle rudis	Pied Kingfisher	LC	LC		1	1	x		x	x	
Colius colius	White-backed Mousebird	LC	LC		1	1	x		x		
Colius striatus	Speckled Mousebird	LC	LC		2	2			x	x	x
Coracias caudatus	Lilac-breasted Roller	LC	LC		1	1	x		x	x	x
Coracias garrulus	European Roller	LC	**NT**		2	2			x	x	x
Coracias naevius	Purple Roller	LC	LC		1	1	x	x		x	x

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Cypsiurus parvus	African Palm Swift	LC	LC		3	3				x	
Delichon urbicum	Common House Martin	LC	LC		2	2			x	x	
Dendropicos fuscescens	Cardinal Woodpecker	LC	LC		1	1	x		x	x	x
Dendropicos namaquus	Bearded Woodpecker	LC	LC		1	1	x	x	x	x	x
Halcyon albiventris	Brown-hooded Kingfisher	LC	LC		1	1	x	x	x	x	x
Halcyon chelicuti	Striped Kingfisher	LC	LC		3	3					
Halcyon leucocephala	Grey-headed Kingfisher	LC	LC		3	3					
Halcyon senegalensis	Woodland Kingfisher	LC	LC		1	1	x		x	x	
Hirundo albigularis	White-throated Swallow	LC	LC		2	2			x	x	
Hirundo dimidiata	Pearl-breasted Swallow	LC	LC		1	1	x		x	x	
Hirundo fuligula	Rock Martin	LC	LC		3	3			x	x	
Hirundo rustica	Barn Swallow	LC	LC		1	1	x	x	x	x	x
Indicator indicator	Greater Honeyguide	LC	LC		1	1	x		x	x	x
Indicator minor	Lesser Honeyguide	LC	LC		1	1	x			x	
Ispidina picta	African Pygmy Kingfisher	LC	LC		4	4				x	
Lybius torquatus	Black-collared Barbet	LC	LC		2	2				x	x
Megaceryle maxima	Giant Kingfisher	LC	LC		3	3				x	
Merops apiaster	European Bee-eater	LC	LC		1	1	x		x	x	x
Merops bullockoides	White-fronted Bee-eater	LC	LC		2	2			x	x	x
Merops hirundineus	Swallow-tailed Bee-eater	LC	LC		1	1	x		x	x	x
Merops nubicoides	Southern Carmine Bee-eater	LC	LC		2	2			x	x	x
Merops persicus	Blue-cheeked Bee-eater	LC	LC		1	2		x		x	
Merops pusillus	Little Bee-eater	LC	LC		1	1	x	x	x	x	x
Phoeniculus purpureus	Green Wood-hoopoe	LC	LC		1	1	x	x	x	x	x
Pogoniulus chrysoconus	Yellow-fronted Tinkerbird	LC	LC		1	1	x			x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Prodotiscus regulus	Brown-backed Honeybird	LC	LC		4	4			x		
Rhinopomastus cyanomelas	Common Scimitarbill	LC	LC		1	2		x	x	x	x
Riparia cincta	Banded Martin	LC	LC		4	4					
Riparia paludicola	Brown-throated Martin	LC	LC		1	1	x			x	
Riparia riparia	Sand Martin	LC	LC		4	4				x	
Tachymarptis melba	Alpine Swift	LC	LC		2	2				x	
Tockus leucomelas	Southern Yellow-billed Hornbill	LC	LC		1	1	x	x	x	x	x
Tockus nasutus	African Grey Hornbill	LC	LC		1	1	x	x	x	x	x
Tockus rufirostris	Southern Red-billed Hornbill	LC	LC		1	1	x	x	x	x	x
Trachyphonus vaillantii	Crested Barbet	LC	LC		1	1	x	x	x	x	x
Tricholaema leucomelas	Acacia Pied Barbet	LC	LC		2	2			x	x	x
Upupa africana	African Hoopoe	LC	LC		1	2		x	x	x	x
Urocolius indicus	Red-faced Mousebird	LC	LC		1	1	x	x	x	x	x
9. Cryptic & elusive insect-eaters											
Acrocephalus arundinaceus	Great Reed Warbler	LC	LC		3	3					
Acrocephalus baeticatus	African Reed Warbler	LC	LC		4	4				x	
Acrocephalus gracilirostris	Lesser Swamp Warbler	LC	LC		4	4				x	
Acrocephalus palustris	Marsh Warbler	LC	LC		4	4					
Anthus caffer	Bushveld Pipit	LC	LC		2	2				x	
Anthus cinnamomeus	African Pipit	LC	LC		2	2			x	x	x
Anthus leucophrys	Plain-backed Pipit	LC	LC		2	2					x
Anthus lineiventris	Striped Pipit	LC	LC		3	3					
Anthus similis	Long-billed Pipit	LC	LC		3	3				x	
Anthus vaalensis	Buffy Pipit	LC	LC		2	2					
Apalis thoracica	Bar-throated Apalis	LC	LC		2	2				x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Bradypterus baboecala	Little Rush Warbler	LC	LC		4	4				x	
Calamonastes fasciolatus	Barred Wren-Warbler	LC	LC		1	1	x	x	x	x	x
Calandrella cinerea	Red-capped Lark	LC	LC		3	3			x	x	x
Calendulauda africanoides	Fawn-coloured Lark	LC	LC		2	2				x	x
Calendulauda sabota	Sabota Lark	LC	LC		1	1	x			x	x
Camaroptera brachyura	Green-backed Camaroptera	LC	LC		4	4				x	x
Camaroptera brevicaudata	Grey-backed Camaroptera	LC	LC		1	1	x	x	x	x	x
Certhilauda chuana	Short-clawed Lark	LC	NT		4	4			x		
Chlorocichla flaviventris	Yellow-bellied Greenbul	LC	LC		3	3					
Cisticola aberrans	Lazy Cisticola	LC	LC		3	3					
Cisticola aridulus	Desert Cisticola	LC	LC		1	1	x		x	x	x
Cisticola chiniana	Rattling Cisticola	LC	LC		1	1	x	x	x	x	x
Cisticola fulvicapilla	Neddicky	LC	LC		1	1	x		x	x	x
Cisticola juncidis	Zitting Cisticola	LC	LC		2	2			x	x	x
Cisticola rufilatus	Tinkling Cisticola	LC	LC		3	3			x		x
Cisticola tinniens	Levaillant's Cisticola	LC	LC		2	2				x	
Eremomela icteropygialis	Yellow-bellied Eremomela	LC	LC		2	2				x	x
Eremomela usticollis	Burnt-necked Eremomela	LC	LC		1	1	x		x	x	x
Eremopterix leucotis	Chestnut-backed Sparrow-lark	LC	LC		3	3				x	x
Eremopterix verticalis	Grey-backed Sparrow-lark	LC	LC		2	2				x	
Hippolais icterina	Icterine Warbler	LC	LC		3	3			x		
Hippolais olivetorum	Olive-tree Warbler	LC	LC		3	3			x		
Macronyx capensis	Cape Longclaw	LC	LC		2	2					
Mirafra africana	Rufous-naped Lark	LC	LC		2	2			x	x	x
Mirafra passerina	Monotonous Lark	LC	LC		1	1	x		x	x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Mirafra rufocinnamomea	Flappet Lark	LC	LC		3	3			x		
Motacilla aguimp	African Pied Wagtail	LC	LC		4	4			x	x	
Motacilla capensis	Cape Wagtail	LC	LC		1	1	x		x	x	
Phylloscopus trochilus	Willow Warbler	LC	LC		1	2		x	x	x	x
Pinarocorys nigricans	Dusky Lark	LC	LC		4	4			x		x
Prinia flavicans	Black-chested Prinia	LC	LC		2	2			x	x	x
Prinia subflava	Tawny-flanked Prinia	LC	LC		1	1	x		x	x	x
Pycnonotus nigricans	African Red-eyed Bulbul	LC	LC		2	2			x	x	x
Pycnonotus tricolor	Dark-capped Bulbul	LC	LC		1	1	x		x	x	x
Sylvietta rufescens	Long-billed crombec	LC	LC		1	1	x	x	x	x	x
10. Regular insect-eaters											
Acridotheres tristis	Common Myna				1	1	x		x		
Anthoscopus caroli	Grey Penduline-Tit	LC	LC		2	2					
Anthoscopus minutus	Cape Penduline-Tit	LC	LC		1	1	x			x	x
Batis molitor	Chinspot Batis	LC	LC		1	1	x	x	x	x	x
Bradornis mariquensis	Marico flycatcher	LC	LC		1	1	x		x	x	x
Bradornis pallidus	Pale flycatcher	LC	LC		3	3			x		
Campephaga flava	Black Cuckooshrike	LC	LC		1	1	x				
Cercomela familiaris	Familiar Chat	LC	LC		1	1	x		x	x	
Chlorophoneus sulfureopectus	Orange-breasted Bush-Shrike	LC	LC		1	1	x		x		
Cinnyricinclus leucogaster	Violet-backed Starling	LC	LC		2	2			x	x	x
Corvinella melanoleuca	Magpie Shrike	LC	LC		1	1	x	x	x	x	x
Corvus albus	Pied Crow	LC	LC		1	1	x		x	x	
Cossypha caffra	Cape Robin-Chat	LC	LC		1	1	x			x	
Cossypha humeralis	White-throated Robin-Chat	LC	LC		2	2			x	x	

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Creatophora cinerea	Wattled Starling	LC	LC		1	1	x		x	x	x
Dicrurus adsimilis	Fork-tailed Drongo	LC	LC		1	1	x	x	x	x	x
Dryoscopus cubla	Black-backed Puffback	LC	LC		1	1	x	x	x	x	
Erythropygia leucophrys	White-browed Scrub Robin	LC	LC		1	1	x			x	x
Erythropygia paena	Kalahari Scrub Robin	LC	LC		1	1	x			x	x
Eurocephalus anguitimens	Southern White-crowned Shrike	LC	LC		1	1	x		x	x	x
Lamprotornis australis	Burchell's Starling	LC	LC		1	1	x	x		x	x
Lamprotornis chalybaeus	Greater Blue-eared Starling	LC	LC		2	2			x	x	x
Lamprotornis nitens	Cape Glossy Starling	LC	LC		1	1	x		x	x	x
Laniarius atrococcineus	Crimson-breasted Shrike	LC	LC		1	1	x	x	x	x	x
Laniarius ferrugineus	Southern Boubou	LC	LC		2	2					
Lanius collaris	Southern (Common) Fiscal	LC	LC		2	2			x	x	x
Lanius collurio	Red-backed Shrike	LC	LC		1	1	x	x	x	x	x
Lanius minor	Lesser Grey Shrike	LC	LC		1	1	x		x	x	x
Malaconotus blanchoti	Grey-headed Bush-Shrike	LC	LC		1	1	x	x		x	x
Melaenornis pammelaina	Southern Black flycatcher	LC	LC		2	2				x	
Muscicapa caerulescens	Ashy Flycatcher	LC	LC		4	4					
Muscicapa striata	Spotted flycatcher	LC	LC		1	1	x		x	x	x
Myioparus plumbeus	Grey Tit-flycatcher	LC	LC		2	2				x	
Myrmecocichla formicivora	Ant-eating Chat	LC	LC		2	2			x	x	x
Nilaus afer	Brubru	LC	LC		1	1	x	x	x	x	x
Oenanthe pileata	Capped Wheatear	LC	LC		2	2			x	x	x
Onychognathus morio	Red-winged Starling	LC	LC		1	1	x		x	x	
Oriolus larvatus	Black-headed Oriole	LC	LC		1	1	x	x	x	x	x
Oriolus oriolus	Eurasian Golden Oriole	LC	LC		3	3				x	x

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Parus cinerascens	Ashy Tit	LC	LC		1	1	x		x		x
Parus niger	Southern Black Tit	LC	LC		1	1	x	x	x	x	x
Prionops plumatus	White-crested Helmet-Shrike	LC	LC		1	1	x			x	x
Saxicola torquatus	African StoneChat	LC	LC		2	2				x	
Sigelus silens	Fiscal Flycatcher	LC	LC		1	1	x			x	
Sylvia communis	Common Whitethroat	LC	LC		4	4					
Sylvia subcaerulea	Chestnut-vented Tit-Babbler	LC	LC		2	2			x	x	x
Tchagra australis	Brown-crowned Tchagra	LC	LC		1	1	x		x	x	x
Tchagra senegalus	Black-crowned Tchagra	LC	LC		1	1	x	x	x	x	x
Terpsiphone viridis	African Paradise Flycatcher	LC	LC		1	1	x	x		x	x
Thamnolaea cinnamomeiventris	Mocking Cliff Chat	LC	LC		3	3			x	x	
Turdoides bicolor	Southern Pied Babbler	LC	LC		1	1	x	x	x	x	x
Turdoides jardineii	Arrow-marked Babbler	LC	LC		1	1	x		x	x	x
Turdus libonyanus	Kurrichane Thrush	LC	LC		1	1	x		x	x	
Turdus litsitsirupa	Groundscraper Thrush	LC	LC		1	1	x		x	x	x
Turdus smithi	Karoo Thrush	LC	LC		2	2					
11. Oxpeckers & nectar feeders											
Buphagus erythrorynchus	Red-billed Oxpecker	LC	LC		1	1	x		x	x	
Chalcomitra amethystina	Amethyst Sunbird	LC	LC		1	1	x			x	
Cinnyris mariquensis	Marico Sunbird	LC	LC		1	1	x			x	x
Cinnyris talatala	White-bellied Sunbird	LC	LC		1	1	x	x		x	x
Zosterops pallidus	Orange River White-eye	LC	LC		3	3				x	
Zosterops virens	Cape White-eye	LC	LC		1	1	x		x	x	
12. Seedeaters											
Amadina erythrocephala	Red-headed Finch	LC	LC		2	2				x	x

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Amadina fasciata	Cut-throat Finch	LC	LC		2	2			x	x	x
Amandava subflava	Orange-breasted Waxbill	LC	LC		2	2				x	
Anaplectes rubriceps	Red-headed Weaver	LC	LC		1	1	x				
Anomalospiza imberbis	Cuckoo Finch	LC	LC		3	3				x	
Bubalornis niger	Red-billed Buffalo Weaver	LC	LC		1	1	x	x	x	x	x
Crithagra atrogularis	Black-throated Canary	LC	LC		2	2			x	x	x
Crithagra flaviventris	Yellow Canary	LC	LC		2	2			x	x	x
Crithagra mozambica	Yellow-fronted Canary	LC	LC		2	2			x	x	
Emberiza capensis	Cape Bunting	LC	LC		4	4					
Emberiza flaviventris	Golden-breasted Bunting	LC	LC		1	1	x		x	x	x
Emberiza impetuani	Lark-like Bunting	LC	LC		3	3				x	
Emberiza tahapisi	Cinnamon-breasted Bunting	LC	LC		3	3			x	x	x
Estrilda astrild	Common Waxbill	LC	LC		1	1	x			x	
Estrilda erythronotos	Black-faced Waxbill	LC	LC		1	1	x		x	x	x
Euplectes afer	Yellow-crowned Bishop	LC	LC		1	1	x		x		x
Euplectes albonotatus	White-winged Widowbird	LC	LC		2	2			x	x	
Euplectes ardens	Red-collared Widowbird	LC	LC		3	3				x	
Euplectes orix	Southern Red Bishop	LC	LC		2	2			x	x	
Gymnoris superciliaris	Yellow-throated Petronia	LC	LC		3	3			x	x	x
Lagonosticta rhodopareia	Jameson's Firefinch	LC	LC		1	1	x		x	x	x
Lagonosticta senegala	Red-billed Firefinch	LC	LC		1	1	x		x	x	x
Lonchura cucullata	Bronze Mannikin	LC	LC		2	2				x	
Ortygospiza fuscocrissa	African Quail-finch	LC	LC		1	1	x			x	x
Passer diffusus	Southern Grey-headed Sparrow	LC	LC		1	1	x		x	x	x
Passer domesticus	House Sparrow				2	2			x	x	x

CATEGORY & SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*	SABAP2	
		GLOBAL RED LIST[1]	S.A. RED LIST[1]	S.A. ToPS LIST[2]						2340_2730	2340_2725
Passer melanurus	Cape Sparrow	LC	LC		1	2		x		x	x
Passer motitensis	Great Sparrow	LC	LC		2	2				x	x
Plocepasser mahali	White-browed Sparrow-Weaver	LC	LC		1	1	x		x	x	x
Ploceus capensis	Cape Weaver	LC	LC		3	3					
Ploceus cucullatus	Village Weaver	LC	LC		1	1	x	x		x	x
Ploceus intermedius	Lesser Masked Weaver	LC	LC		2	2				x	
Ploceus ocularis	Spectacled Weaver	LC	LC		4	4					
Ploceus velatus	Southern Masked Weaver	LC	LC		1	1	x	x	x	x	x
Pytilia melba	Green-winged Pytilia	LC	LC		1	1	x		x	x	x
Quelea quelea	Red-billed Quelea	LC	LC		1	1	x		x	x	x
Sporopipes squamifrons	Scaly-feathered Finch	LC	LC		2	2			x	x	x
Uraeginthus angolensis	Blue Waxbill	LC	LC		1	1	x	x	x	x	x
Uraeginthus granatinus	Violet-eared Waxbill	LC	LC		1	1	x		x	x	x
Vidua chalybeata	Village Indigobird	LC	LC		1	1	x		x	x	x
Vidua funerea	Dusky Indigobird	LC	LC		3	3					
Vidua macroura	Pin-tailed Whydah	LC	LC		2	2			x	x	
Vidua paradisaea	Long-tailed Paradise Whydah	LC	LC		1	1	x		x	x	x
Vidua purpurascens	Purple Indigobird	LC	LC		4	4					
Vidua regia	Shaft-tailed Whydah	LC	LC		1	1	x	x	x	x	x

Key

Status: CR = Critically Endangered; EN = Endangered; LC = Least Concern; NT = Near Threatened; PS = Protected Species; VU = Vulnerable

Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low

Sources: [1]Taylor *et al.* (2015); [2]ToPS List (2015); [3]SABAP2 (2018); [4]BEC (2006)

*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

13.5. Appendix 4 Reptile list for the study area

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		MEDUPI LoO[1,3]	FGD LoO[1,3]	NSS	EMPR[5]	VICINITY*	ATLAS[3]			
		RED LIST[1]	S.A. ToPS LIST[2]						2327CB	2327DA	2327CD	2327DC
PELOMEDUSIDAE (Terrapins)												
Pelomedusa subrufa	Marsh Terrapin	2LC	-	1	1		x	x		1		
Pelusios sinuatus	Serrated Hinged Terrapin	2LC	-	2	2							
TESTUDINIDAE (Tortoises)												
Kinixys lobatsiana	Lobatse Hinged Tortoise	1LC	-	3	3							
Kinixys spekii	Speke's Hinged-back Tortoise	2LC	-	1	1							
Psammobates oculifer	Serrated Tent Tortoise	1LC	-	2	3			x	2	1		
Stigmochelys pardalis	Leopard Tortoise	1LC	-	1	1		x	x	1	6		1
CROCODYLIDAE (Crocodiles)												
Crocodylus niloticus	Nile crocodile	**2VU**	**EN**	5	5			x				
GEKKONIDAE (Geckos)												
Afroedura nov sp. 10 [waterbergensis]	Flat Gecko		-	4	4							7
Chondrodactylus turneri	Turner's Gecko	1LC	-	2	2			x	1			
Hemidactylus mabouia	Common Tropical House Gecko	2LC	-	1	1			x	1	1		2
Homopholis wahlbergii	Wahlberg's Velvet Gecko	1LC	-	1	1			x				1
Lygodactylus capensis capensis	Common Dwarf Gecko	1LC	-	1	1			x	1	1		1
Lygodactylus ocellatus ocellatus	Spotted Dwarf Gecko	1LC (End)	-	2	2							
Pachydactylus affinis	Transvaal Gecko	1LC (End)	-	2	2							2
Pachydactylus capensis	Cape Gecko	2LC	-	2	2			x		1		2
Pachydactylus punctatus	Speckled Gecko	2LC	-	4	4							
Ptenopus garrulus garrulus	Common Barking Gecko	1LC	-	2	3			x	1			
AMPHISBAENIDAE (Worm Lizards)												
Monopeltis capensis	Cape Worm Lizard	1LC	-	3	3							
Zygaspis quadrifrons	Kalahari Dwarf Worm Lizard	2LC	-	2	2			x	1	4		
LACERTIDAE (Lacertid lizards)												
Heliobolus lugubris	Bushveld Lizard	2LC	-	2	2			x		2		
Ichnotropis capensis	Ornate Rough-scaled Lizard	1LC	-	2	2			x	1	3		

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		MEDUPI LoO[1,3]	FGD LoO[1,3]	NSS	EMPR[5]	VICINITY*	ATLAS[3]			
		RED LIST[1]	S.A. ToPS LIST[2]						2327CB	2327DA	2327CD	2327DC
Meroles squamulosus	Savanna Lizard	1LC	-	1	1			x				1
Nucras holubi	Holub's Sandveld Lizard	2LC	-	2	3			x				
Nucras intertexta	Spotted Sandveld Lizard	2LC	-	2	3		x					
Nucras ornata	Ornate Sandveld Lizard	2LC	-	3	3							
Pedioplanis lineoocellata lineoocellata	Spotted Sand Lizard	2LC	-	1	1	x			1			
Pedioplanis lineoocellata pulchella	Spotted Sand lizard	1LC	-	3	3							1
CORDYLIDAE (Girdled lizards)												
Cordylus jonesii	Jones' Girdled Lizard	1LC	-	3	3			x		2		2
Cordylus vittifer	Common Girdled Lizard	1LC	-	3	3							
Smaug breyeri	Waterberg Dragon Lizard	1LC (End)	-	2	3			x				2
Smaug vandami	Van Dam's Dragon Lizard	1LC (End)	-	3	4							
Platysaurus minor	Waterberg Flat Lizard	1LC (End)	-	3	4							
GERRHOSAURIDAE (Plated lizards)												
Broadleysaurus major	Rough-scaled Pated Lizard	2LC	-	2	3			x				
Gerrhosaurus flavigularis	Yellow-throated Plated Lizard	2LC	-	2	2			x				1
Metabosaurus validus	Common Giant Plated Lizard	1LC	-	4	4			x				
Gerrhosaurus auritus	Kalahari Plated Lizard	NE	-	2	3				1	1		
SCINCIDAE (Skinks)												
Acontias occidentalis	Savanna Legless Skink	LC	-	3	3					1		
Afroablepharus maculicollis	Spotted-neck Snake-eyed Skink	2LC	-	3	3							
Afroablepharus wahlbergii	Wahlberg's Snake-eyed Skink	2LC	-	2	3			x		1		
Mochlus sundevallii	Sundevall's Writhing Skink	2LC	-	2	2			x	1	1		1
Trachylepis capensis	Cape Skink	2LC	-	2	2			x				
Trachylepis margaritifer	Rainbow Skink	2LC	-	3	4							
Trachylepis punctatissima	Speckled Rock Skink	2LC	-	3	3			x		1		1
Trachylepis punctulata	Speckled Sand Skink	2LC	-	2	3							
Trachylepis striata	Striped Skink	2LC	-	1	1			x				1
Trachylepis varia	Variable Skink	2LC	-	1	1	x		x		1		9
Trachylepis variegata	Variegated Skink	2LC	-	2	3			x				

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		MEDUPI LoO[1,3]	FGD LoO[1,3]	NSS	EMPR[5]	VICINITY*	ATLAS[3]			
		RED LIST[1]	S.A. ToPS LIST[2]						2327CB	2327DA	2327CD	2327DC
Scelotes limpopoensis limpopoensis	Limpopo Dwarf Burrowing Skink	1LC	-	3	3							
VARANIDAE (Monitor lizards)												
Varanus albigularis albigularis	Southern Rock Monitor	2LC	-	1	1		x	x		2		
Varanus niloticus	Nile Monitor	2LC	-	3	3							
CHAMAELEONIDAE (Chamaeleons)												
Chamaeleo dilepis	Common Flap-neck Chameleon	2LC	-	1	1*			x		3		
AGAMIDAE (Agamas)												
Agama aculeata distanti	Eastern Ground Agama	1LC (End)	-	2	2			x		1		
Agama armata	Northern Ground Agama	2LC	-	2	2			x				
Agama atra	Southern Rock Agama	1LC	-	3	3							
Acanthocercus atricollis atricollis	Southern Tree Agama	1LC	-	1	1	x	x	x		1		1
TYPHLOPIDAE (Blind snakes)												
Afrotyphlops bibronii	Bibron's Blind Snake	1LC	-	4	4							
Rhinotyphlops lalandei	Delalande's Beaked Blind Snake	2LC	-	3	3							
LEPTOTYPHLOPIDAE (Worm & thread snakes)												
Leptotyphlops distanti	Distant's Thread Snake	1LC	-	3	3							
Leptotyphlops incognitus	Incognito Thread Snake	1LC	-	3	3							
Leptotyphlops scutifrons	Peters' Thread Snake	1LC	-	2	2			x				
PYTHONIDAE (Pythons)												
Python natalensis	Southern African Python	2LC	**PS**	1	1*			x		1		
VIPERIDAE (Adders & vipers)												
Bitis arietans arietans	Puff Adder	2LC	-	1	1			x		1		1
Causus defilippii	Snouted Night Adder	2LC	-	2	3							
Causus rhombeatus	Rhombic Night Adder	2LC	-	2	2							
LAMPROPHIIDAE (Slug-eaters, house snakes, wolf snakes, grass snakes, sand snakes & mole snakes)												
Amblyodipsas polylepis polylepis	Common Purple-glossed Snake	1LC	-	3	3							
Amblyodipsasventrimaculata	Kalahari Purple-glossed Snake	1LC	-	3	3				1	1		
Aparallactus capensis	Black-headed Centipede-eater	2LC	-	2	3							

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		MEDUPI LoO[1,3]	FGD LoO[1,3]	NSS	EMPR[5]	VICINITY*	ATLAS[3]			
		RED LIST[1]	S.A. ToPS LIST[2]						2327CB	2327DA	2327CD	2327DC
Atractaspis bibronii	Bibron's Stiletto Snake	2LC	-	2	2					1		1
Xenocalamus bicolor bicolor	Bicoloured Quill-snouted Snake	1LC	-	2	2			x				
Boaedon capensis	Common House Snake	2LC	-	2	2			x		1		
Gonionotophis nyassae	Black File Snake	2LC	-	4	4							
Lycodonomorphus inornatus	Olive Ground Snake	1LC (End)	-	2	2					1		
Lycodonomorphus rufulus	Brown Water Snake	1LC	-	3	3							
Lycophidion capense capense	Cape Wolf Snake	2LC	-	2	2					1		
Lycophidion variegatum	Variegated Wolf Snake	2LC	-	4	4							
Hemirhagerrhis nototaenia	Eastern Bark Snake	2LC	-	3	3							
Psammophis angolensis	Dwarf Sand Snake	2LC	-	4	4							
Psammophis brevirostris	Short-snouted Grass Snake	1LC	-	2	2							
Psammophis jallae	Jalla's Sand Snake	2LC	-	2	2							
Psammophis subtaeniatus	Western yellow-bellied Sand Snake	2LC	-	1	1		x	x		1		1
Psammophylax tritaeniatus	Striped Grass Snake	2LC	-	2	2			x				
Prosymna stuhlmannii	East African Shovel-snout	2LC	-	4	4							
Prosymna bivittata	Two-striped Shovel-snout	LC	-	3	3					2		
Pseudaspis cana	Mole Snake	2LC	-	2	2			x		1		
ELAPIDAE (Cobras, mambas & relatives)												
Aspidelaps scutatus scutatus	Common Shield Cobra	1LC	-	2	2							
Dendroaspis polylepis	Black Mamba	2LC	-	1	1			x			1	1
Elapsoidea sundevallii	Sundevall's Garter Snake	1LC	-	2	2			x	1	1		
Naja annulifera	Snouted Cobra	2LC	-	2	2					1		1
Naja mossambica	Mozambique Spitting Cobra	2LC	-	1	1*		x			1		
COLUBRIDAE (Herald snakes, egg-eaters, boomslang, green snakes)												
Crotaphopeltis hotamboeia	Red-lipped Snake	2LC	-	3	3							
Dasypeltis scabra	Rhombic Egg-eater	2LC	-	2	2			x		1		
Dispholidus typus	Boomslang	2LC	-	1	1			x		3		2
Philothamnus hoplogaster	South-eastern Green Snake	2LC	-	4	4							
Philothamnus natalensis occidentalis	Western Natal Green Snake	1LC (End)	-	3	3							
Philothamnus semivariegatus	Spotted Bush Snake	2LC	-	2	2			x				

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		MEDUPI LoO[1,3]	FGD LoO[1,3]	NSS	EMPR[5]	VICINITY*	ATLAS[3]			
		RED LIST[1]	S.A. ToPS LIST[2]						2327CB	2327DA	2327CD	2327DC
Telescopus semiannulatus semiannulatus	Eastern Tiger Snake	2LC	-	2	2			x				
Thelotornis capensis capensis	Southern Twig Snake	1LC	-	2	2							
Key												
Status: D = Declining; End = Endemic; LC = Least Concern; NT = Near Threatened; PS = Protected Species; U = Unknown; VU = Vulnerable												
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low; 5 = May occur as a managed population												
Sources: [1]Bates *et al*. (2014); [2]ToPS List (2015); [3]IUCN (2013.1); [4]ReptileMap (2014); [5]BEC (2006)												
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station												

13.6. Appendix 5 Frog list for the study area

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5]	FGD LoO[4,5]	NSS	EMPR[6]	VICINITY*	ATLAS[5]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
BREVICIPITIDAE													
Breviceps adspersus adspersus	Bushveld Rain Frog	LC (U)*	LC	-	1	1	x		x	1	2	1	
BUFONIDAE (Toads)													
Sclerophrys garmani	Olive Toad	LC (U)	LC	-	1	1	x		x	1	2	1	2
Sclerophrys gutturalis	Guttural Toad	LC (I)	LC	-	1	1	x		x		1		1
Sclerophrys pusilla	Flat-backed Toad	LC (S)	LC	-	3	3					1		4
Sclerophrys capensis	Raucous Toad	LC (D)	LC	-	3	3					1		
Poyntonophrynus fenoulheti	Northern Pygmy Toad	LC (U)	LC	-	2	2			x				3
Schismaderma carens	Red Toad	LC (U)	LC	-	1	1	x		x				
HEMISOTIDAE (Shovel-nosed Frogs)													
Hemisus marmoratus	Mottled Shovel-nosed Frog	LC (U)	LC	-	1	1	x						1
HYPEROLIIDAE (Kassinas, Rattling frogs & Reed frogs)													
Kassina senegalensis	Bubbling Kassina	LC (U)	LC	-	1	1	x	x	x	1	4	1	5
MICROHYLIDAE (Rubberfrogs)													
Phrynomantis bifasciatus	Banded Rubber Frog	LC (U)	LC	-	1	1	x	x	x	1	2	1	2
PHRYNOBATRACHIDAE (Puddle Frogs)													
Phrynobatrachus natalensis	Snoring Puddle Frog	LC (S)	LC	-	1	1	x		x		1		3
PIPIDAE (Platannas)													
Xenopus laevis	Common Platanna	LC (I)	LC	-	1	1	x	x			1		2
Xenopus muelleri	Muller's Platanna	LC (U)	LC	-	4	4							5
PTYCHADENIDAE (Grass & Ornate Frogs)													
Hildebrandtia ornata	Ornate Frog	LC (U)	LC	-	1	1	x		x	1	1	1	
Ptychadena anchietae	Plain Grass Frog	LC (U)	LC	-	1	1	x		x	1	2	1	2
Ptychadena mossambica	Broad-banded Grass Frog	LC (U)	LC	-	1	2		x				1	1
Ptychadena porosissima	Striped Grass Frog	LC (U)	LC	-	1	3		x					
PYXICEPHALIDAE (African Common Frogs)													
Amietia delalandii	Delalande's River Frog	LC (S)	LC	-	3	3							1

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS			MEDUPI LoO[4,5]	FGD LoO[4,5]	NSS	EMPR[6]	VICINITY*	ATLAS[5]			
		GLOBAL RED LIST[1]	S.A. RED LIST[2]	S.A. ToPS LIST[3]						2327CB	2327DA	2327CD	2327DC
Cacosternum boettgeri	Boettger's Caco	LC (U)	LC	-	1	1	x	x	x			1	
Pyxicephalus adspersus	Giant Bullfrog	LC (D)	**NT**	**PS**	3	1**	x			1	2		
Pyxicephalus edulis	African Bullfrog	LC (U)	LC	**PS**	1	1	x		x	1	2	1	1
Tomopterna cryptotis	Tremolo Sand Frog	LC (S)	LC	-	1	1	x		x	1	2	1	1
Tomopterna krugerensis	Knocking Sand Frog	LC (U)	LC	-	1	1		x	x	1		1	
Tomopterna marmorata	Russet-backed Sand Frog	LC (U)	LC	-	3	3							
Tomopterna natalensis	Natal Sand Frog	LC (U)	LC	-	4	4							
RHACOPHORIDAE (Foam Nest Frogs)													
Chiromantis xerampelina	Southern Foam Nest Frog	LC (U)	LC	-	1	1	x	x			2	1	2
Key													
Status: LC = Least Concern; I = Increasing; NT = Near Threatened; PS = Protected Species; S = Stable; U = Unknown													
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low													
Sources: [1]IUCN (2017.3); [2]Minter *et al*. (2004); [3]ToPS List (2007); [4]Du Preez & Carruthers (2009); [5]FrogMap (2018); [6]BEC (2006)													
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station													
**Tentative identification													

13.7. Appendix 6 Butterfly list for the study area

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS 2327CB	ATLAS 2327DA	ATLAS 2327CD	ATLAS 2327DC
HESPERIIDAE (Sandmen, skippers, policemen & sylphs)											
Abantis tettensis	Spotted Paradise Skipper	1LC	2	2							
Abantis venosa	Veined Paradise Skipper	1LC	3	3							
Afrogegenes hottentota	Marsh Hottentot Skipper	1LC	3	3							1
Caprona pillaana	Ragged Skipper	1LC	1	1	x						
Coeliades forestan forestan	Striped Policeman	1LC	3	3							
Coeliades pisistratus	Two-pip Policeman	1LC	2	2							1
Gegenes hottentota	Marsh Hottentot Skipper	1LC	3	3							1
Gegenes niso niso	Common Hottentot Skipper	1LC	3	3							1
Gegenes pumilio gambica	Dark Hottentot	1LC	3	3							2
Gomalia elma elma	Green-marbled Skipper	1LC	2	2							1
Kedestes callicles	Pale Ranger	LC	1	1	x		x		1		
Leucochitonea levubu	White-cloaked Skipper	1LC	4	4							
Metisella willemi	Netted Sylph	1LC	4	4							
Parosmodes morantii morantii	Morant's Orange	1LC	3	3							
Pelopidas mathias	Black-banded Swift	1LC	3	3							
Pelopidas thrax	White-banded Swift	1LC	3	3							1
Platylesches neba	Flower-girl Hopper	1LC	3	3							1
Sarangesa motozi	Forest Elfin	1LC	2	2						1	
Sarangesa phidyle	Small Elfin	1LC	2	2							1
Spialia asterodia	Star Sandman	1LC	4	4							
Spialia colotes transvaaliae	Bushveld Sandman	1LC	2	2							1
Spialia delagoae	Delagoa Sandman	1LC	2	2							
Spialia depauperata australis	Wandering sandman	1LC	3	3							
Spialia diomus ferax	Common Sandman	1LC	1	1	x						1
Spialia dromus	Forest Sandman	1LC	2	2							
Spialia mafa mafa	Mafa sandman	1LC	2	2							1
Spialia spio	Mountain sandman	1LC	3	3					1		

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Tsitana tsita	Dismal Sylph	1LC	3	3							
PAPILIONIDAE (Swallowtails, swordtails & handkerchiefs)											
Graphium antheus	Large Striped Swordtail	1LC	1	1							
Graphium morania	White lady	1LC	3	3							
Papilio dardanus cenea	Flying handkerchief	1LC	4	4					1		
Papilio demodocus demodocus	Citrus swallowtail	1LC	2	2						1	2
Papilio nireus lyaeus	Green-banded swallowtail	1LC	2	2					2		1
PIERIDAE (Whites, tips & travellers)											
Belenois aurota	Brown-veined white	1LC	1	1	x	x	x		8	1	4
Belenois creona severina	African common white	1LC	1	1	x			1	1		3
Belenois gidica abyssinica	African veined white	1LC	2	2							1
Belenois zochalia zochalia	Forest White	1LC	4	4							
Catopsilia florella	African migrant	1LC	2	2					1		2
Colias electo electo	African clouded yellow	1LC	2	2							
Colotis annae annae	Scarlet tip	1LC	1	2	x				2	1	4
Colotis antevippe gavisa	Red tip	1LC	1	1	x						3
Colotis auxo auxo	Sulphur orange tip	1LC	2	2							2
Colotis celimene amina	Lilac tip	1LC RLD	3	3							
Colotis euippe omphale	Smoky orange tip	1LC	2	2						1	4
Colotis evagore antigone	Small orange tip	1LC	2	2					2	1	5
Colotis evenina evenina	Orange tip	1LC	2	2					5	1	2
Colotis ione	Bushveld purple tip	1LC	2	2							1
Colotis pallene	Bushveld orange tip	1LC	2	2			x			1	2
Colotis regina	Queen purple tip	1LC	2	2					1	1	1
Colotis vesta argillaceus	Veined Arab	1LC	1	1	x				2	1	5
Eurema brigitta brigitta	Broad-bordered grass yellow	1LC	1	1	x		x		3	1	3
Eurema hecabe solifera	Common Grass Yellow	1LC	2	2							
Mylothris agathina agathina	Common dotted border	1LC	2	2					3		2
Mylothris rueppellii haemus	Twin dotted border	1LC	2	2							1

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Pinacopteryx eriphia eriphia	Zebra white	1LC	1	1	x		x		2	1	2
Pontia helice helice	Common meadow white	1LC	2	2							
Teracolus agoye agoye	Speckled sulphur tip	1LC	2	2					2		
Teracolus eris eris	Banded gold tip	1LC	1	1	x				1	1	3
Teracolus subfasciatus	Lemon traveller	1LC	2	2						1	3
NYMPHALIDAE (Acraeas, monarchs, pansies, browns, ringlets & charaxes)											
Acraea acara acara	Acara acraea	1LC	2	2							
Acraea aglaonice	Window Acraea	1LC	3	3							
Acraea anemosa	Broad-bordered acraea	1LC	1	1	x		x				
Acraea axina	Little acraea	1LC	2	2					1		2
Acraea barberi	Barber's acraea	1LC	2	2							
Acraea caldarena caldarena	Black-tipped acraea	1LC	2	2							1
Acraea horta	Garden acraea	1LC	4	4							
Acraea lygus	Lygus acraea	1LC	3	3							
Acraea natalica	Natal acraea	1LC	2	2					1		1
Acraea neobule neobule	Wandering donkey acraea	1LC	2	2			x		2		1
Acraea oncaea	Rooibok Acraea	1LC	3	3					4		1
Acraea stenobea	Suffused acraea	1LC	2	2							1
Brakefieldia perspicua perspicua	Eyed Bush Brown	1LC	2	2							4
Byblia anvatara acheloia	Joker	1LC	1	1						1	1
Byblia ilithyia	Spotted joker	1LC	2	2			x		4	2	3
Catacroptera cloanthe cloanthe	Pirate	1LC	3	3							
Charaxes achaemenes achaemenes	Bushveld charaxes	1LC	2	2					1	1	3
Charaxes brutus natalensis	White-barred charaxes	1LC	3	3					2		
Charaxes candiope	Green-veined charaxes	1LC	2	2							1
Charaxes jahlusa rex	Pearl-spotted charaxes	1LC	2	2							
Charaxes phaeus	Demon charaxes	1LC	2	2					1		1
Charaxes saturnus saturnus	Foxy charaxes	1LC	2	2					1	1	3
Charaxes vansoni	Van Son's charaxes	1LC	3	3							2
Charaxes varanes varanes	Pearl charaxes	1LC	3	3					1		

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Charaxes zoolina	Club-tailed charaxes	1LC	4	4							
Coenyropsis natalii natalii	Natal brown	1LC	1	1							
Danaus chrysippus orientis	African monarch	1LC	1	1	x	x	x		4	1	2
Hamanumida daedalus	Guinea-fowl butterfly	1LC	1	1	x		x		3	1	4
Heteropsis perspicua perspicua	Eyed bush brown	1LC	2	2							4
Hypolimnas misippus	Common diadem	1LC	1	1			x		2		2
Junonia hierta cebrene	Yellow pansy	1LC	2	2			x		4	1	4
Junonia oenone oenone	Blue pansy	1LC	2	2			x		1		2
Junonia orithya madagascariensis	Eyed pansy	1LC	2	2			x				1
Melanitis leda	Twilight brown	1LC	3	3							2
Neptis saclava marpessa	Spotted sailer	1LC	4	4							1
Phalanta phalantha aethiopica	African Leopard	1LC	2	2							
Physcaeneura panda	Dark-webbed ringlet	1LC	1	1							
Precis antilope	Darker commodore	1LC	3	3							
Precis archesia archesia	Garden commodore	1LC	2	2							
Precis ceryne ceryne	Marsh commodore	1LC	3	3							
Precis octavia sesamus	Gaudy Commodore	1LC	3	3							
Protogoniomorpha anacardii nebulosa	Clouded Mother-of-pearl	1LC	3	3							1
Stygionympha wichgrafi wichgrafi	Wichgraf's hillside brown	1LC	3	3							
Telchinia encedon encedon	White-barred acraea	1LC	3	3							
Telchinia rahira rahira	Marsh acraea	1LC	2	2							
Telchinia serena	Dancing acraea	1LC	1	1	x				2		4
Vanessa cardui	Painted lady	1LC	1	2		x	x	1			2
Ypthima asterope hereroica	African ringlet	1LC	2	2							
Ypthima impura paupera	Impure ringlet	1LC	3	3							
LYCAENIDAE (Coppers, blues & relatives)											
Actizera lucida	Rayed blue	1LC	3	3							
Alaena amazoula amazoula	Yellow zulu	1LC	4	4							
Aloeides aranda	Aranda copper	1LC	3	3							
Aloeides damarensis damarensis	Damara copper	1LC	3	3					1		

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Aloeides damarensis mashona	Damara copper	1LC	2	2							
Aloeides taikosama	Dusky copper	1LC	1	1	x						
Anthene amarah amarah	Black striped hairtail	1LC	2	2							
Anthene definita definita	Common hairtail	1LC	2	2							
Anthene dulcis dulcis	Mashuna hairtail	1LC	3	3							
Anthene livida livida	Pale hairtail	1LC	2	2							
Anthene millari	Millar's hairtail	1LC	3	3							
Anthene otacilia otacilia	Trimen’s hairtail	1LC	3	3							
Axiocerses amanga amanga	Bush scarlet	1LC	2	2					1		1
Axiocerses coalescens	Black-tipped scarlet	1LC	4	4							
Axiocerses tjoane tjoane	Eastern scarlet	1LC	2	2							
Azanus jesous	Topaz babul blue	1LC	1	1	x				1		2
Azanus mirza	Mirza babul blue	1LC	4	4							
Azanus moriqua	Thorn-tree babul blue	1LC	1	1	x						
Azanus ubaldus	Velvet-spotted babul blue	1LC	3	3							3
Cacyreus lingeus	Bush bronze	1LC	4	4							
Cacyreus marshalli	Common geranium bronze	1LC	3	3					1		
Cacyreus virilis	Mocker bronze	1LC	3	3							
Chilades trochylus	Grass jewel	1LC	2	2				1	1		1
Cigaritis ella	Ella's bar	1LC	4	4							
Cigaritis mozambica	Mozambique bar	1LC	3	3							
Cigaritis natalensis	Natal bar	1LC	2	2							
Cigaritis phanes	Silvery bar	1LC	4	4					1		
Cnodontes penningtoni	Pennington's buff	1LC	3	3							2
Crudaria leroma	Silver spotted grey	1LC	2	2							
Cupidopsis cissus cissus	Common meadow blue	1LC	3	3							
Cupidopsis jobates jobates	Tailed meadow blue	1LC	2	2							
Eicochrysops messapus mahallakoaena	Cupreous blue	1LC	3	3							
Eicochrysops messapus messapus	Cupreous blue	1LC	3	3							
Euchrysops dolorosa	Sabie smoky blue	1LC	2	2							

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Euchrysops malathana	Common smoky blue	1LC	3	3						1	1
Euchrysops osiris	Osiris smoky blue	1LC	4	4					1		
Euchrysops subpallida	Ashen smoky blue	1LC	4	4							
Hypolycaena philippus philippus	Purplebrown hairstreak	1LC	2	2					1		
Iolaus alienus alienus	Brown-line sapphire	1LC	3	3					1		
Iolaus pallene	Saffron sapphire	1LC	3	3					1		
Iolaus silarus silarus	Straight-line sapphire	1LC	2	2							1
Iolaus silas	Southern sapphire	1LC	4	4							
Iolaus trimeni	Trimen's sapphire	1LC	3	3							
Lachnocnema durbani	D'Urban's woolly legs	1LC	3	3							
Lampides boeticus	Pea blue	1LC	2	2					4		1
Lepidochrysops glauca	Silvery blue	1LC	2	2							
Lepidochrysops patricia	Patricia blue	1LC	3	3							
Lepidochrysops plebeia plebeia	Twin-spot blue	1LC	4	4							
Leptomyrina gorgias gorgias	Common black-eye	1LC	3	3							
Leptomyrina henningi henningi	Henning's black-eye	1LC	1	1	x						1
Leptomyrina sp.	-	-	-	-					1		
Leptotes babaulti	Babault's zebra blue	1LC	1	1	x						
Leptotes pirithous pirithous	Common zebra blue	1LC	2	2							2
Pseudonacaduba sichela sichela	Dusky blue	1LC	2	2							1
Stugeta bowkeri bowkeri	Bowker's marbled sapphire	1LC	3	3							
Stugeta bowkeri tearei	Bowker's marbled sapphire	1LC	2	2							
Tarucus sybaris sybaris	Dotted blue	1LC	2	2					2		1
Tuxentius calice	White pie	1LC	2	2							1
Tuxentius melaena melaena	Black pie	1LC	2	2							
Uranothauma nubifer nubifer	Black heart	1LC	2	2							
Virachola antalus	Brown playboy	1LC	2	2					1		1
Virachola dinochares	Apricot playboy	1LC	3	3							1
Zintha hintza hintza	Hintza pierrot	1LC	2	2							
Zizeeria knysna knysna	Sooty blue	1LC	2	2							1

FAMILY & SPECIES	COMMON NAME	STATUS[1]	MEDUPI LoO[1,2]	FGD LoO[1,2]	NSS	EMPR[2]	VICINITY*	ATLAS			
								2327CB	2327DA	2327CD	2327DC
Zizula hylax	Gaika blue	1LC	2	2							1

Key
Status: LC = Least Concern; RLD = Rare Low Density; 1 = Global
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low
Sources: [1]Mecenero *et al*. (2013); [2]LepiMap (2018); [3]BEC (2006);
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station

13.8. Appendix 7 Present and potentially occurring dragonfly and damselfly species within the study area

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		DBI[1]	MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*
		GLOBAL RED LIST[1]	S.A. RED LIST[2]						
CALOPTERYGIDAE (Demoiselles)									
Phaon iridipennis	Glistening Demoiselle	-	-	2	2	2			
CHLOROCYPHIDAE (Jewels)									
Platycypha caligata	Dancing Jewel	-	-	2	4	4			
SYNLESTIDAE (Malachites)									
Chlorolestes fasciatus	Mountain Malachite	-	-	4	4	4			
Chlorolestes tessellatus	Forest Malachite	-	-	4	4	4			
LESTIDAE (Spreadwings)									
Lestes pallidus	Pale Spreadwing	-	-	2	2	2			
Lestes plagiatus	Highland Spreadwing	-	-	2	3	3			
Lestes tridens	Spotted Spreadwing	-	-	3	2	2			
PLATYCNEMIDIDAE (Featherlegs)									
Mesocnemis singularis	Riverjack	-	-	3	4	4			
Elattoneura glauca	Common Threadtail	-	-	1	3	3			
COENAGRIONIDAE (Pond Damsels)									
Ceriagrion glabrum	Common Citril	-	-	0	2	2			
Pseudagrion hamoni	Drab Sprite	-	-	2	3	3			
Pseudagrion kersteni	Kersten's Sprite	-	-	1	4	4			
Pseudagrion makabusiense	Makabusi Sprite	LC	**VU**	4	4	4			
Pseudagrion massaicum	Masai Sprite	-	-	1	4	4			
Pseudagrion salisburyense	Slate Sprite	-	-	1	2	2			
Pseudagrion sublacteum	Cherry-eye Sprite	-	-	2	3	3			
Pseudagrion sudanicum	Sudan Sprite	LC	LC	4	3	3			
Ischnura senegalensis	Marsh Bluetail	-	-	0	2	2			
Africallagma glaucum	Swamp Bluet	-	-	1	2	2			
Azuragrion nigridorsum	Sailing Bluet	-	-	3	2	2			
Agriocnemis exilis	Little Wisp	-	-	4	3	3			
Agriocnemis pinheyi	Pinhey's Wisp	-	-	2	3	3			
AESHNIDAE (Hawkers)									
Anax ephippiger	Vagrant Emperor	-	-	2	2	2			
Anax imperator	Blue Emperor	-	-	1	2	2			
Anax speratus	Orange Emperor	-	-	1	2	2			
Anax tristis	Black Emperor	-	-	4	3	3			
GOMPHIDAE (Clubtails)									
Ictinogomphus ferox	Common Tigertail	-	-	2	3	3			
Lestinogomphus angustus	Spined Fairytail	LC	**NT**	4	4	4			
Ceratogomphus pictus	Common Thorntail	-	-	2	2	2			
Paragomphus cognatus	Boulder Hooktail	-	-	1	3	3			
Paragomphus genei	Green Hooktail	-	-	3	1	1	x		
CORDULIIDAE (Emeralds)									
Phyllomacromia contumax	Two-banded Cruiser	-	-	3	2	2			

FAMILY & SPECIES	COMMON NAME	CONSERVATION STATUS		DBI[1]	MEDUPI LoO[3]	FGD LoO[3]	NSS	EMPR[4]	VICINITY*
		GLOBAL RED LIST[1]	S.A. RED LIST[2]						
LIBELLULIDAE (Skimmers & relatives)									
Orthetrum abbotti	Little Skimmer	-	-	2	3	3			
Orthetrum chrysostigma	Epaulet Skimmer	-	-	2	3	3			
Orthetrum hintzi	Hintz's Skimmer	-	-	3	3	3			
Orthetrum icteromelas	Spectacled Skimmer	-	-	2	3	3			
Orthetrum julia	Julia Skimmer	-	-	1	4	4			
Orthetrum machadoi	Machado's Skimmer	-	-	3	2	2			
Orthetrum stemmale	Strong Skimmer	-	-	4	3	3			
Orthetrum trinacria	Long Skimmer	-	-	1	2	2			
Nesciothemis farinosa	Black-tailed Skimmer	-	-	1	4	4			
Palpopleura jucunda	Yellow-veined Widow	-	-	2	2	2			
Palpopleura lucia	Lucia Widow	-	-	2	3	3			
Palpopleura portia	Portia Widow	-	-	2	3	3			
Acisoma panorpoides	Grizzled Pintail	-	-	2	4	4			
Diplacodes lefebvrii	Black Percher	-	-	3	4	4			
Diplacodes luminans	Barbet Percher	-	-	3	1	1	x		
Crocothemis erythraea	Broad Scarlet	-	-	0	2	2			
Crocothemis sanguinolenta	Little Scarlet	-	-	3	2	2			
Brachythemis leucosticta	Banded Groundling	-	-	2	1	1			x
Sympetrum fonscolombii	Nomad	-	-	0	2	2			
Trithemis annulata	Violet Dropwing	-	-	1	4	4			
Trithemis arteriosa	Red-veined Dropwing	-	-	0	3	3			
Trithemis donaldsoni	Denim Dropwing	-	-	4	4	4			
Trithemis furva	Navy Dropwing	-	-	0	4	4			
Trithemis hecate	Silhouette Dropwing	-	-	4	3	3			
Trithemis kirbyi	Kirby's Dropwing	-	-	0	1	1	x		
Trithemis pluvialis	Riffle-and-Reed Dropwing	-	-	2	4	4			
Trithemis stictica	Jaunty Dropwing	-	-	1	4	4			
Zygonyx torridus	Ringed Cascader	-	-	2	4	4			
Rhyothemis semihyalina	Phantom Flutterer	-	-	1	3	3			
Tholymis tillarga	Twister	-	-	3	3	3			
Pantala flavescens	Pantala	-	-	0	2	2			
Tramea basilaris	Keyhole Glider	-	-	0	2	2			
Urothemis assignata	Red Basker	-	-	3	3	3			
Urothemis edwardsii	Blue Basker	-	-	2	3	3			

Key

Status: LC = Least Concern; NT = Near Threatened; VU = Vulnerable;

Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low

Dragonfly Biotic Index (DBI): An index developed by Samways (2008) based on three criteria: geographical distribution, conservation status and sensitivity to change in habitat and ranges from a minimum of 0 (very common, widespread species which is highly tolerant of human disturbance) to 9 (range-restricted, threatened and sensitive endemic).

Sources: [1]IUCN (2017.3); [2]Samways (2006); [3]Samways (2008); [4]BEC (2006)

13.9. Appendix 8 Present and potentially occurring scorpion species within the study area

FAMILY & SPECIES	COMMON NAME	MEDUPI LoO[1]	FGD LoO[1]	NSS	EMPR[2]	VICINITY*
Parabuthus mossambicensis	Thick-tailed scorpions	2	2			x
Parabuthus granulatus	Thick-tailed scorpions	3	3			
Parabuthus transvaalicus	Thick-tailed scorpions	3	3			
Uroplectes planimanus	Stinger scorpions	2	2			
Uroplectes carinatus	Stinger scorpions	1	2	x		
Uroplectes vittatus	Stinger scorpions	2	2			x
Opistacanthus asper	Creeping scorpions	1	1	x		
Hadogenes troglodytes	Rock scorpions	3	3			
Opistophthalmus glabifrons	Burrowing scorpions	3	3			
Opistophthalmus carinatus	Burrowing scorpions	3	3			
Opistophthalmus wahlbergii	Burrowing scorpions	3	3			x
Key						
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate						
Sources: [1]Leeming (2003); [2]BEC (2006)						
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station						

13.10. Appendix 9 Present and potentially occurring baboon spider species within the study area

SPECIES	COMMON NAME	MEDUPI LoO[1]	FGD LoO[1]	NSS	EMPR[2]	VICINITY*
Ceratogyrus bechuanicus	Starbust Horned Baboon Spider	2	2			
Ceratogyrus brachycephalus	Rhino Horned Baboon Spider	2	2			
Ceratogyrus sp.	-	3	3			x
Pterinochilus junodi	Soutpansberg Starburst Baboon Spider	4	4			
Pterinochilus pluridentatus	-	4	4			
Harpactira sp.	-	3	3			x
Key						
Likelihood of Occurrence (LoO): 1 = Present; 2 = High; 3 = Moderate; 4 = Low						
Sources: [1]Dippenaar-Schoeman (2002); [2]BEC (2006)						
*Combined records from NSS studies at Grootegeluk and Limpopo West Mines, Mafutha Project and Matimba Power Station						

AIRSHED
PLANNING PROFESSIONALS

Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project

Project done on behalf of **Zitholele Consulting**

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Report No: 14ZIT10 | **Date:** February 2018

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Report Details

Report No.	14ZIT10
Status	Rev 1
Report Title	Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project
Date	December 2016
Client	Zitholele Consulting
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Revision Record

Revision Number	Date	Reason for Revision
Draft	27 February 2015	Client review
Draft	2 March 2015	Minor grammatical changes
Rev 0.2	27 March 2015	Inclusion of additional information
Rev 0.3	16 April 2015	Incorporation of comments received by the client
Rev 0.4	7 May 2015	Incorporation of second round of comments received by the client
Rev 0.5	11 May 2015	Incorporation of third round of comments received by the client
Rev 0.6	11 May 2015	Incorporation of minor comments received by the client
Rev 0.7	24 November 2016	Inclusion of additional information regarding the waste disposal of the gypsum, salts and sludge
Rev 0.8	5 December 2016	Minor grammatical changes
Rev 0.9	18 January 2018	Incorporation of changes to authorisation and licencing approach in 2017
Rev 1.0	7 February 2018	Incorporation of comments received by the client

List of Abbreviations

AQA	Air quality act
APCS	Air pollution control systems
ARM	Ambient Ratio Method
As	Arsenic
Cd	Cadmium
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
DEA	Department of Environmental Affairs
ESP	Electro static precipitator
g	Gram
g/s	Gram per second
HCl	Hydrogen chloride
Hg	Mercury
HNO_3	Nitric acid
HF	Hydrogen fluoride
LMo	Monin-Obukhov length
m	Meter
m^2	Meter squared
m^3	Meter cubed
m/s	Meters per second
Mn	Manganese
NAAQS	National ambient air quality standards
NH_3	Ammonia
Ni	Nickel
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
OLM	Ozone Limiting Method
PBL	Planetary boundary layer
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate matter with diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with diameter of less than 2.5 µm
Sb	Antimony
ppb	Parts per billion
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide
Tl	Thalium
US EPA	United States Environmental Protection Agency

V	Vanadium
VOC	Volatile organic concentrations
µ	micro
°C	Degrees Celsius

Glossary

Airshed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Assessment of environmental effects	A piece of expert advice submitted to regulators to support a claim that adverse effects will or will not occur as a result of an action, and usually developed in accordance with section 88 of the Resource Management Act 1991
Atmospheric chemistry	The chemical changes that gases and particulates undergo after they are discharged from a source
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Complex terrain	Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows
Configuring a model	Setting the parameters within a model to perform the desired task
Convection	Vertical movement of air generated by surface heating
Convective boundary layer	The layer of the atmosphere containing convective air movements
Diffusion	Clean air mixing with contaminated air through the process of molecular motion. Diffusion is a very slow process compared to turbulent mixing.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Dispersion coefficients	Variables that describe the lateral and vertical spread of a plume or a puff

Executive Summary

Airshed Planning Professionals (Pty) Limited was appointed by Zitholele Consulting to undertake an air quality impact assessment for a proposed Medupi Flue Gas Desulphurisation (FGD) retrofit project (hereafter referred to as the Project). The FGD retrofit project will reduce the sulphur dioxide (SO_2) emissions from the power station by 84% on average, to ensure compliance with an SO_2 emission limit of 500 mg/Nm^3 (at 10% O_2).

The aim of the investigation is to quantify the possible impacts resulting from the proposed activities on the surrounding environment and human health. To achieve this, a good understanding of the local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality.

Scope of Work

Confirmed scope of work includes assessment of the following activities and infrastructure:

1. Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
2. Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
3. The construction and operation of the wet FGD system that will reduce the SO_2 content in the flue gas emitted;
4. Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of storm water infrastructure and conservancy tanks for sewage;
5. The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant.
6. Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the waste water treatment plant (WWTP) that will be located close to the FGD infrastructure within the Medupi Power Station;
7. Construction and operation of the WWTP;
8. Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility.
9. The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system.
10. Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report as prescribed in the Environmental Impact Assessment (EIA) Regulations (Government Notice R.543 in Government Gazette 33306 of 18 June 2010).

Potential Air Emissions from the Proposed Project

For the Air Quality Assessment initiated in 2014 the approach focussed on the impacts from the operation of the FGD ("the Project"). The main pollutant that will be affected through the operations of the Project is SO2, as the FGD control aims at the reduction of this pollutant. The emission concentrations of nitrogen dioxide (NO2) and particulate matter from the stack releases was provided by Eskom personnel to remain the same with and without the control of FGD but the buoyancy of the plume and its ability to disperse from the point of release will be altered due to changes in exit temperatures effecting the ambient concentrations of the pollutant at ground level. The gypsum by-product will alter the potential wind-blown dust from the ash storage facility (assuming the disposal of ash and gypsum together in an appropriate Class C facility) or may generate additional dust from an independent disposal facility. For the current assessment, the assumption was made that the ash and gypsum would be disposed of in a single facility.

Towards the middle of 2017 changes to the authorisation and licencing approach for the Medupi FGD Retrofit Project applications were proposed in order to streamline the application processes to ensure compliance with the NEMAQA compliance requirements by the year 2021. The changes that influence potential air emissions include the application for activities associated with the construction and operation of the FGD system within the Medupi PS footprint and the railway yard and siding, including limestone and gypsum handling facilities and diesel storage facilities new access roads. The impacts from the construction activities were not assessed further as their impacts would be localised and of a temporary nature. The impacts from the railway siding and handling operations as well as vehicle entrainment from the new access road would contribute to the particulate matter. The diesel storage facility would contribute to volatile organic compounds. Impacts from these activities, however, will be localised and will not exceed National Ambient Air Quality Standards offsite. These changes were therefore not deemed significant and were thus not assessed further.

Baseline Assessment

The baseline study encompassed the analysis of meteorological data. Local meteorological data (including wind speed, wind direction and temperature) was obtained from MM5[1] data for the period 2011 to 2013. The identification of sources of emissions in the study area also formed part of the baseline assessment.

Two scenarios were assessed which consisted of (i) 2014 baseline (including operations of the Matimba Power Station) and (ii) 2020 baseline (including the operations of the Matimba Power Station and the Medupi Power Station with all six units excluding FGD).

Emissions Inventory

Emissions inventories provide the source input required for the simulation of ambient air concentrations. Windblown fugitive source emissions from the ash disposal facilities were quantified. Point source emissions and parameters for the proposed operations were provided by Eskom personnel.

[1] The MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) is a regional mesoscale model used for creating weather forecasts and climate projections. It is a community model maintained by Penn State University and the National Centre for Atmospheric Research.

Impact Prediction Study

SO_2, NO_2 and particulate concentrations due to the baseline and proposed operations were simulated using the CALMET/CALPUFF dispersion modelling suite. Ambient concentrations were simulated to ascertain highest hourly, daily and annual averaging levels occurring as a result of the baseline and proposed Project operations.

Three scenarios were assessed: (i) 2014 baseline: the potential impacts due to the Matimba Power Station operations, (ii) 2020 baseline: the potential impacts due to the Matimba Power Station operations and the Medupi Power Station operations including all six units without FGD, and (iii) proposed Project operations: the potential impacts due to the Matimba Power Station operations and the Medupi Power Station operations including all six units with FGD. The fugitive emissions due to windblown dust from the disposal of ash and gypsum at the ash disposal facility was also quantified at the existing Ash Disposal Facility (ADF) as an unmitigated operation (no controls in place) and as a mitigated operation (80% control efficiency in place through active re-vegetation and wetting). Stack emissions and parameters were provided by Eskom personnel for the study.

Assessment Criteria

For the current study, the impacts were assessed against published National Ambient Air Quality Standards (NAAQS).

Assumptions, Exclusions and Limitations

- Emissions emanating from all existing sources in the area were not quantified nor were resultant ambient air pollutant concentrations due to such sources simulated, with the exception of the existing Matimba Power Station and its associated ashing operations. Given that Matimba Power Station is the most significant source of ambient SO_2 concentrations in the region, this study limitation is not significant for assessing compliance and health risk potentials due to SO_2. Matimba Power Station is, however, not the major contributor to ambient fine particulate concentrations. In order to project cumulative particulate concentrations other significant sources, particularly local mining operation emissions, would need to be quantified.

- Routine emissions from power station operations were estimated and modelled. Atmospheric releases occurring as a result of accidents were not accounted for.

- For the current assessment, the assumption was made that the ash and gypsum would be disposed together in the same facility, until there is an opportunity in the market for alternative use of gypsum. The gypsum material on the disposal facility is expected to provide a crust when mixed with water. To what extent this material will crust will depend on how the material is disposed (i.e. mixed with the ash or deposited as layers of gypsum material in between the ash material) and how much water is added to the disposal facility. The crust may also be disturbed from time to time with activity on the disposal facility. For the current assessment, the effectiveness of this crust in lowering windblown emissions could not be quantified.

- MM5 was used as the "initial guess" field for the CALMET model. Although two monitoring stations are located within the study area, MM5 could not be used together with the surface measurements as the Eskom-operated Marapong station is sited incorrectly providing questionable wind direction and, with one representative station (South African Weather Service Station located at Lephalale), CALMET requires 100% data availability which was not present.

The most important *assumptions* made during the air quality impact assessment are as follows:

- Source parameters and emission rates for these emission scenarios required for input to the dispersion modelling study were provided by Eskom personnel. The assumption was made that this information was accurate and correct.

- A constant NH_3 background concentration of 20 ppb was used in Calpuff (Scorgie et al, 2006). Measured ozone data from the Marapong station was included for the background data required for the chemical transformation module in Calpuff.

Main Findings

The main findings from the baseline air quality characterisation study (prior to the operation of the Medupi Power Station), which was based on information from both monitoring and modelling studies, are as follows:

- SO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits at the monitoring stations located at Marapong and Lephalale. Modelled SO_2 concentrations also indicate infrequent short-term exceedances of the NAAQ limits at these sensitive receptors. There is however compliance with the NAAQS.

- Currently, the Matimba Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. Other sources which may contribute significantly due to their low release level include: spontaneous combustion of coal discards associated with mining operations, clamp firing emissions during brickmaking at Hanglip and potentially household fuel burning within Marapong. The highest ground level SO_2 concentrations due to the Matimba Power Station stack emissions are expected to occur during unstable conditions, usually occurring during the day, when the plume is brought to ground in relatively close proximity to the power station.

- NO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits (but are in compliance with NAAQS) at the monitoring stations located at Marapong and Lephalale, which is reiterated in the modelled results. Low level sources of NO_x in the region include combustion within coal discard dumps, brick firing operations and possibly also household fuel burning and infrequent veld burning.

- Measured PM_{10} concentrations exceed the daily NAAQS at Marapong for the period 2014 but are lower at Lephalale (where levels comply with daily NAAQS). The measured $PM_{2.5}$ concentrations are within the daily NAAQS applicable till 2030 at Marapong and Lephalale, but exceed the more stringent daily NAAQS applicable in 2030. The annual average PM_{10} and $PM_{2.5}$ concentrations measured at Lephalale are within NAAQS. Measured annual PM_{10} concentrations at Marapong during the period 2013 exceed annual NAAQS.

- 2014 Baseline simulations:
  - The contribution of Matimba Power Station to primary and secondary particulates was simulated, with no exceedances of the SO_2, NO_2, PM_{10} and $PM_{2.5}$ NAAQS at Marapong and Lephalale. Secondary particulates form in the atmosphere through the conversion of SO_x and NO_x emissions to sulfate and nitrate.

- 2020 Baseline simulations:
  - The area of non-compliance with the hourly and daily SO_2 NAAQS extended ~30km southwest of the Medupi Power Station due to the cumulative operations of Matimba Power Station and Medupi Power

Station without FGD control. Non-compliance with the hourly and daily SO_2 NAAQS was simulated at the residential settlement to the northwest of the Matimba Power Station under these conditions.

- Various local (informed through observation from site visits) and far-field (informed by literature) sources are expected to contribute to the suspended fine particulate concentrations in the region. Local dust sources include wind erosion from exposed areas, fugitive dust from mining and brickmaking operations, vehicle entrainment from roadways and veld burning. Household fuel burning may also constitute a local source of low-level emissions. Long-range transport of particulates emitted from remote tall stacks and from biomass burning in countries to the north of Republic of South Africa (RSA) and the accumulation and recirculation of such regional air masses over the interior is well documented (Andreae et al., 1996; Garstang et al., 1996; Piketh, 1996) (detail pertaining to the recirculation of air masses is provided in Section 3.3.1.9).

The main findings of the impact assessment for the proposed Project are provided as follows:

- The area of exceedance of the hourly and daily SO_2 NAAQS was significantly reduced when FGD controls on the Medupi Power Station are considered, bringing the simulated ground level concentrations within compliance of the hourly and daily SO_2 NAAQS at all sensitive receptors in the study area.

- Simulated impacts from the Matimba Power Station and the Medupi Power Station without FGD (2020 baseline) was in non-compliance with SO_2 NAAQS on a regional scale resulting in a MODERATE significance. The area of non-compliance of SO_2 concentrations reduces significantly for proposed Project operations (i.e. Matimba Power Station operations and Medupi Power Station operations <u>with</u> FGD) and reduces the significance to LOW as no exceedances of the NAAQS are simulated at the closest sensitive receptors in the study area. No exceedances of the NAAQS for NO_2, PM_{10} and $PM_{2.5}$ were simulated at sensitive receptors due to proposed Project operations resulting in LOW significance. The available monitoring data shows that the PM_{10} concentrations are in non-compliance with the daily NAAQS at Marapong. Simulated impacts due to proposed Project operations, however, do not contribute significantly to current ambient particulate concentrations.

<u>Recommendation</u>

As the proposed Project operations will significantly reduce SO_2 impacts from the Medupi Power Station, it is recommended that the FGD Retrofit Project (including the increase in height of 12 m at the ADF) be implemented.

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Air Quality Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project

1 Introduction

Airshed Planning Professionals (Pty) Limited was appointed by Zitholele Consulting to undertake an air quality impact assessment for a proposed Medupi Flue Gas Desulphurisation (FGD) retrofit project (hereafter referred to as the Project). The FGD retrofit project will reduce the sulphur dioxide (SO_2) emissions from the power station by 84%.

The aim of the investigation is to quantify the possible impacts resulting from the proposed activities on the surrounding environment and human health. To achieve this, a good understanding of the regional climate and local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality is required.

Typical of specialist investigations conducted, the air quality investigation comprises both a baseline study and an impact assessment. The baseline study includes the review of site-specific atmospheric dispersion potentials, and existing ambient air quality in the region, in addition to the identification of potentially sensitive receptors. The ambient air quality impact assessment comprised the establishment of an emissions inventory for the proposed activities, the simulation of ambient air pollutant concentrations occurring due to Project operations, and the evaluation of the resultant potential for impacts and non-compliance.

1.1 Description of Project Activities from an Air Quality Perspective

Confirmed scope of work includes assessment of the following activities and infrastructure:

11. Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
12. Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
13. The construction and operation of the wet FGD system that will reduce the SO_2 content in the flue gas emitted;
14. Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of storm water infrastructure and conservancy tanks for sewage;
15. The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant.
16. Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the waste water treatment plant (WWTP) that will be located close to the FGD infrastructure within the Medupi Power Station;
17. Construction and operation of the WWTP;
18. Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility.
19. The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system.
20. Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

1.2 Approach and Methodology

The methodology followed in the assessment to quantify the air quality impacts associated with the proposed Project is discussed below. The general tasks included:

- The establishment of the baseline air quality (based on available information);
- Quantification of air emissions from the proposed Project;
- Discussion of meteorological parameters required to establish the atmospheric dispersion potential;
- Calculation of the air concentrations from the proposed Project using a suitable atmospheric dispersion model;
- Assessment of the significance of the impact through the comparison of simulated air concentrations with local National Ambient Air Quality Standards (for compliance).

1.2.1 Potential Air Emissions from the Proposed Project

For the Air Quality Assessment initiated in 2014 the approach focussed on the impacts from the operation of the FGD ("the Project"). The main pollutant that will be affected through the operations of the Project is SO_2, as the FGD control aims at the reduction of this pollutant. The emission concentrations of nitrogen dioxide (NO_2) and particulate matter from the stack releases was provided by Eskom personnel to remain the same with and without the control of FGD but the buoyancy of the plume and its ability to disperse from the point of release will be altered due to changes in exit temperatures effecting the ambient concentrations of the pollutant at ground level. The gypsum by-product will alter the potential wind-blown dust from the ash storage facility (assuming the disposal of ash and gypsum together in an appropriate Class C facility) or may generate additional dust from an independent disposal facility. For the current assessment, the assumption was made that the ash and gypsum would be disposed of in a single facility.

Towards the middle of 2017 changes to the authorisation and licencing approach for the Medupi FGD Retrofit Project applications were proposed in order to streamline the application processes to ensure compliance with the NEMAQA compliance requirements by the year 2021. The changes that influence potential air emissions include the application for activities associated with the construction and operation of the FGD system within the Medupi PS footprint and the railway yard and siding, including limestone and gypsum handling facilities and diesel storage facilities new access roads. The impacts from the construction activities were not assessed further as their impacts would be localised and of a temporary nature. The impacts from the railway siding and handling operations as well as vehicle entrainment from the new access road would contribute to the particulate matter. The diesel storage facility would contribute to volatile organic compounds. Impacts from these activities, however, will be localised and will not exceed National Ambient Air Quality Standards offsite. These changes were therefore not deemed significant and were thus not assessed further.

1.2.2 Regulatory Requirements and Assessment Criteria

In the evaluation of air emissions and ambient air quality impacts reference is made to National Ambient Air Quality Standards (NAAQS) for compliance. These standards generally apply only to a number of common air pollutants, collectively known as criteria pollutants. Criteria pollutants typically include SO_2, NO_2, carbon monoxide (CO), inhalable particulate matter (including thoracic particulate matter with an aerodynamic diameter of equal to or less than 10 µm or PM_{10} and Inhalable particulate matter with an aerodynamic diameter equal to or less than 2.5 µm or $PM_{2.5}$), benzene, ozone and lead. For the proposed Project, pollutants of concern included SO_2, NO_2, PM_{10} and $PM_{2.5}$ (screened against NAAQS) and metals within the ash deposition facility (screened against international health effect screening levels).

1.2.3 Description of the Baseline Environment

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. For this assessment use was made of a numerical weather prediction model (Mesoscale Model version 5 (MM5[2])).

1.2.4 Existing Ambient Air Quality

The Department of Environmental Affairs (DEA) has an ambient air quality monitoring network for the Waterberg-Bojanala Priority area consisting of stations located at Lephalale, Mokopane and Thabazimbi. The closest DEA managed monitoring station to the proposed Project is in Lephalale (~12 km east). Eskom also operates an ambient monitoring station located in Marapong (~8 km northeast of the Project). The monitored information from these two stations was used in the current assessment.

1.2.5 Emissions Inventory

The establishment of a comprehensive emissions inventory formed the basis for the assessment of the air quality impacts from proposed operations. Proposed Project operations will result in point and fugitive gaseous and particulate emissions.

Point sources are well defined with set parameters and emission concentrations. The information on the point sources was provided by Eskom for use in the current assessment.

Fugitive emissions refer to emissions that are spatially distributed over a wide area. In the quantification of fugitive dust, use was made of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. (Emission factors used are discussed in more detail in Section 3.3.3).

1.2.6 Atmospheric Dispersion Modelling

1.2.6.1 Dispersion Model Selection

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on ground level air pollution concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and determining emission control requirements. Care was therefore taken in the selection of a suitable dispersion model for the task at hand. For the current study, it was decided to use the US Environmental Protection Agency's CALMET meteorological model and the CALPUFF dispersion model in combination.

Most regulatory dispersion models, such as the widely used AERMOD model, are based on the steady-state plume assumption, with meteorological inputs for these models assuming a horizontally uniform flow field. Usually the winds are derived from a single point measurement, which is often made at a nearby non-complex terrain site. The meteorological processors for the regulatory models do not adjust the winds to reflect terrain effects. The steady-state flow fields either do not or only partially reproduce the terrain-induced spatial variability in the wind field. In addition to which, the straight-line trajectory assumption of the plume models cannot easily handle curved trajectories associated with terrain-induced deflection

[2] The MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) is a regional mesoscale model used for creating weather forecasts and climate projections. It is a community model maintained by Penn State University and the National Centre for Atmospheric Research.

or channelling. These limitations of plume models can significantly affect the models ability to correctly represent the spatial area of impact from sources in complex terrain, in addition to the magnitude of the peak values in certain instances.

CALPUFF is a regional Lagrangian Puff model intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA 1998). A number of dispersion coefficients options are accommodated, including

- stability-based empirical relationships such as the Pasquill-Gifford or McElroy-Pooler dispersion coefficients;
- turbulence-based dispersion coefficients (based on measured standard deviations of the vertical and crosswind horizontal components of the wind); and
- similarity theory to estimate the turbulent quantities using the micrometeorological variables calculated by CALMET.

The most desirable approach is to use turbulence-based dispersion coefficients using measured turbulent velocity variances or intensity components, if such data are readily available and they are of good quality. However, since reliable turbulent measurements are generally not available, use can be made of the similarity approach.

CALPUFF also has the capability to model the effects of vertical wind shear by explicitly allowing different puffs to be independently advected by their local average wind speed and direction, as well as by optionally allowing well-mixed puffs to split into two or more puffs when across-puff shear becomes important. Another option is to use a probability density function (pdf) model to simulate vertical dispersion during convective conditions.

CALPUFF includes parameterized chemistry modules for the formation of secondary sulfate and nitrate from the oxidation of the emitted primary pollutants, SO_2 and NO_x. The conversion processes are assumed to be linearly dependent (first-order) on the relevant primary species concentrations. Two options are included, namely the MESOPUFF II and RIVAD/ARM3 chemistry options. In both options, a fairly simple stoichiometric thermodynamic model is used to estimate the partitioning of total inorganic nitrate between gas-phase nitric acid and particle-phase ammonium nitrate. Ammonia and ozone concentrations are required as background values to the model.

CALPUFF uses dry deposition velocities to calculate the dry deposition of gaseous and particulate pollutants to the surface. These dry deposition velocities can either be user-specified or calculated internally in CALPUFF. A resistance-based model is used for the latter option. For gaseous pollutants, the resistances that are considered are the atmospheric resistance, the deposition layer resistance, and the canopy resistance. For particles, a gravitational settling term is included and the canopy resistance is assumed to be negligible. CALPUFF uses the scavenging coefficient approach to parameterize wet deposition of gases and particles. The scavenging coefficient depends on pollutant characteristics (e.g., solubility and reactivity), as well as the precipitation rate and type of precipitation. The model provides default values for the scavenging coefficient for various species and two types of precipitation (liquid and frozen). These values may be overridden by the user.

The CALPUFF modelling system consists of a number of components, as summarised in Table 1-1. However only CALMET and CALPUFF contain the simulation engines to calculate the three-dimensional atmospheric boundary layer conditions and the dispersion and removal mechanisms of pollutants released into this boundary layer. The other codes are mainly used to assist with the preparation of input and output data. Table 1-1 also includes the development versions of each of the codes used in the investigation.

Table 1-1: Summary description of CALPUFF/CALMET model suite with versions used in the investigation

Module	Version	Description
CALMET	v6.334	Three-dimensional, diagnostic meteorological model
CALPUFF	v6.42	Non-steady-state Gaussian puff dispersion model with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation and other effects.
CALPOST	V6.292	A post-processing program for the output fields of meteorological data, concentrations and deposition fluxes.
CALSUM	v1.4 (1)	Sums and scales concentrations or wet/dry fluxes from two or more source groups from different CALPUFF runs
PRTMET	v 4.495(1)	Lists selected meteorological data from CALMET and creates plot files
POSTUTIL	v1.641(1)	Processes CALPUFF concentration and wet/dry flux files. Creates new species as weighted combinations of modelled species; merges species from different runs into a single output file; sums and scales results from different runs; repartitions nitric acid/nitrate based on total available sulfate and ammonia.
TERREL	v3.69(1)	Combines dna grids terrain data
CTGPROC	v3.5(1)	processes and grids land use data
MAKEGEO	v3.2(1)	merges land use and terrain data to produce the geophysical data file for CALMET

Note (1): These modules indicate version number as listed on http://www.src.com/calpuff/download/mod6_codes.htm (for CALPro Plus v6) [version number not given in GUI interface or 'About' information].

1.2.6.2 Atmospheric Dispersion Processes

CALPUFF initiates the simulation of point source plumes with a calculation of buoyant plume rise. Transport winds are extracted from the meteorological data file at the location of the stack and at the effective plume height (stack height plus plume rise). For near-field effects, the height of the plume in transition to the final plume height is taken into account. The puff release rate is calculated internally, based on the transport speed and the distance to the closest receptor.

As the puff is transported downwind, it grows due to dispersion and wind shear, and the trajectory is determined by advection winds at the puff location and height at each time step. The pollutant mass within each puff is initially a function of the emission rate from the original source. The pollutant mass is also subject to chemical transformation, washout by rain and dry deposition, when these options are selected, as is the case in this application. Chemical transformation and removal are calculated based on a one-hour time step.

Both wet and dry deposition fluxes are calculated by CALPUFF, based on a full resistance model for dry deposition and the use of precipitation rate-dependent scavenging coefficients for wet deposition. Pollutant mass is removed from the puff due to deposition at each time step. For the present modelling analyses, most options were set at "default" values, including the MESOPUFF II transformation scheme and the treatment of terrain.

Nitrogen Dioxide Formation

Of the several species of nitrogen oxides, only NO_2 is specified in the NAAQS. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be selected.

Estimation of this conversion normally follows a tiered approach, as discussed in the Regulations Regarding Air Dispersion Modelling (Gazette No 37804 published 11 July 2014), which presents a scheme for annual averages:

- Tier 1: Total Conversion Method

Use any of the appropriate models recommended to estimate the maximum annual average NO_2 concentrations by assuming a total conversion of NO to NO_2. If the maximum NO_x concentrations are less than the NAAQS for NO_2, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO_2, or if a more "realistic" estimate of NO_2 is desired, proceed to the second tier level.

- Tier 2: Ambient Ratio Method (ARM) - Multiply NO_x by a national ratio of NO_2/NO. = 0.80

Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of NO_2/NO_x = 0.80. The ratio is recommended for South Africa as the conservative ratio based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO_2 monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition[3] where further significant changes of the NO/NO_2 ratio is not expected, then the NO/NO_2 ratio based on the monitoring data can be applied to derive NO_2 as an alternative to the national ratio of 0.80 (as stipulated in the Regulations (Gazette No 37804 published 11 July 2014)).

In the Total Conversion Method, the emission rate of all NO_x species is used in the dispersion model to predict ground-level concentrations of total NO_x. These levels of NO_x are assumed to exist as 100% NO_2, and are directly compared to the NAAQS for NO_2. If the NAAQS are met, the Tier 2 methods are not necessary.

Although not provided in the Regulations (Gazette No 37804 published 11 July 2014), the conversion of NO to NO_2 may also be based on the amount of ozone available within the volume of the plume. The NO_2/NO_x conversion ratio is therefore coupled with the dispersion of the plume. This is known as the Ozone Limiting Method (OLM). Use of onsite ozone data is always preferred for the OLM method.

The MESOPUFF II chemical transformation scheme, used in the current assessment, included in the CALPUFF model accommodates NO_x reactions, these are only considering the formation of nitrates and not the NO/NO_2 reactions.

Given all of the above limitations, it was decided to employ the Ambient Ratio Method (ARM), i.e. the second version of the DEA Tier 2 option. The ARM ambient ratio method is based upon the premise that the NO_2/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source (Scire and Borissova, 2011). In their study, Scire and Borissova analysed hourly monitored NO_2 and NO_x data for 2006 at 325 monitoring sites throughout USA, which amounted to approximately 2.8 million data points for each species. These observations were grouped into a number of concentration ranges (bins), and the binned data were used to compute bin maximums and bin average curves. Short-term (1-hr) NO_2/NO_x ratios were subsequently developed based on bin-maximum data. Similarly, long-term (annual average) NO_2/NO_x ratios were based on bin-averaged data. The method was tested using the NO_2/NO_x ratios applied to the observed NO_x at selected stations to predict NO_2, and then compared to observed NO_2 concentrations at that station. The comparison of NO_2 derived from observed NO_x using these empirical curves was shown to be a conservative estimate of observed NO_2 (as obtained from measurements at Marapong), whilst at the same time arriving at a more realistic approximation than if simply assuming a 100% conversion rate. More details of the adopted conversion factors are given in Appendix A.

[3] A process is called a quasi-equilibrium process if the intermediate steps in the process are all close to equilibrium.

Particulate Formation

CALPUFF includes two chemical transformation schemes for the calculation of sulfate and nitrate formation from SO_2 and NO_x emissions. These are the MESOPUFF II and the RIVAD / ARM3 chemical formulations. The chemical transformation scheme chosen for this analysis was the MESOPUFF II scheme (as recommended via personal communication with Joe Scire[4]). As described in the CALPUFF User Guide it is a "pseudo first-order chemical reaction mechanism" and involves five pollutant species namely SO_2, sulphates (SO_4), NO_x, nitric acid (HNO_3) and particulate nitrate. CALPUFF calculates the rate of transformation of SO_2 to SO_4, and the rate of transformation of NO_x to NO_3, based on environmental conditions including the ozone concentration, atmospheric stability, solar radiation, relative humidity, and the plume NO_x concentration. The daytime reaction formulation depends on solar radiation and the transformation increases non-linearly with the solar radiation (see the SO_2 to SO_4 transformation rate equation (equation 2-253 in the CALPUFF User Guide). At night, the transformation rate defaults to a constant value of 0.2% per hour. Calculations based on these formulas show that the transformation rate can reach about 3 per cent per hour at noon on a cloudless day with 100 ppb of ozone.

With the MESOPUFF-II mechanism, NO_x transformation rates depend on the concentration levels of NO_x and O_3 (equations 2-254 and 2-255 in the CALPUFF User Guide) and both organic nitrates (RNO_3) and HNO_3 are formed. According to the scheme, the formation of RNO_3 is irreversible and is not subject to wet or dry deposition. The formation of HNO_3, however, is reversible and is a function of temperature and relative humidity. The formation of particulate nitrate is further determined through the reaction of HNO_3 and NH_3. Background NH_3 concentrations[5] are therefore required as input to calculate the equilibrium between HNO_3 and particulate nitrate. At night, the NO_x transformation rate defaults to a constant value of 2.0% per hour. Hourly average ozone and ammonia concentrations were included as input in the CALPUFF model to facilitate these sulfate and nitrate formation calculations.

The limitation of the CALPUFF model is that each puff is treated in isolation, i.e. any interaction between puffs from the same or different points of emission is not accounted for in these transformation schemes. CALPUFF first assumes that ammonia reacts preferentially with sulfate, and that there is always sufficient ammonia to react with the entire sulfate present within a single puff. The CALPUFF model performs a calculation to determine how much NH_3 remains after the particulate ammonium sulfate has been formed and the balance would then be available for reaction with NO_3 within the puff to form ammonium nitrate. The formation of particulate nitrate is subsequently limited by the amount of available NH_3. Although this may be regarded as a limitation, in this application the particulate formation is considered as a group and not necessarily per species.

Ozone Formation

Similar to sulphate, nitrate and nitrogen dioxide, ozone (O_3) is also formed through chemical reactions between pollutants released into the atmosphere. As a secondary pollutant, O_3 is formed in the lower part of the atmosphere, from complex photochemical reactions following emissions of precursor gases such as NO_x and VOCs (Seinfeld and Pandis, 1998). O_3 is produced during the oxidation of CO and hydrocarbons by hydroxyls (OH) in the presence of NO_x and sunlight (Seinfeld and Pandis, 1998). The rate of ozone production can therefore be limited by CO, VOCs or NO_x. In densely populated regions with high emissions of NO_x and hydrocarbons, rapid O_3 production can take place and result in a surface air pollution problem. In these urban areas O_3 formation is often VOC-limited. O_3 is generally NO_x-limited in rural areas and downwind suburban areas (Seinfeld and Pandis, 1998).

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[4] Joe Scire is the primary developer of the CALMET/CALPUFF modelling suite.

[5] Background NH_3 information was obtained from the previous impacts assessment undertaken for the Medupi Power Station (Scorgie et al., 2006).

O_3 concentration levels have the potential to become particularly high in areas where considerable O_3 precursor emissions combine with stagnant wind conditions during the summer, when high insolation and temperatures occur (Seinfeld and Pandis, 1998). The effects of sunlight on O_3 formation depend on its intensity and its spectral distribution.

In general, the main sectors that emit ozone precursors are road transport, power and heat generation plants, household (heating), industry, and petrol storage and distribution. In many urban areas, O_3 nonattainment is not caused by emissions from the local area alone (Seinfeld and Pandis, 1998). Due to atmospheric transport, contributions of precursors from the surrounding region can also be important. The transport of O_3 is determined by meteorological and chemical processes which typically extend over spatial scales of several hundred kilometres. Thus, in an attempt to study O_3 concentrations in a local area, it is necessary to include regional emissions and transport. This requires a significantly larger study domain with the inclusion of a significantly more comprehensive emissions inventory of NO_x and VOCs sources (e.g. vehicle emissions). Such a study was not within the scope of this report.

For the current assessment, onsite O_3 data from the Marapong monitoring station was used.

1.2.6.3 Model Input

Modelling Domain

A modelling domain of 50 km (east-west) x 50 km (north-south) with a regular Cartesian receptor grid resolution of 200 m by 200 m was selected for the current assessment. The meteorology (based on MM5 data at 4 km resolution) was modelled for the entire area covering 50 km (east-west) x 50 km (north-south) with a resolution of 1000 m by 1000 m.

Meteorological inputs

CALMET was used to simulate the meteorological field within the study area, including the spatial variations – both in the horizontal and in the vertical - and temporal variations in the wind field and atmospheric stability. The initial guess field required by CALMET was informed by MM5-prognostic model data for surface and upper air profiles for the period 2011-2013.

Source Data Requirements

A three dimensional meteorological data set for the region was output by the CALMET model for application in the CALPUFF model. This data set provides spatial (horizontal and vertical) and temporal variations in the parameters required for modelling the dispersion and removal of pollutants, including: vertical wind speed, wind direction, temperature, mixing depths, atmospheric stability, (etc.). Meteorological parameters were projected at various heights above the ground, viz.: 20 m, 40 m, 80 m, 160 m, 300 m, 600 m, 1000 m, 1500 m, 2200 m and 3000 m. In projecting vertical changes in the wind field, temperature, etc. it was possible to accurately parameterize the atmospheric conditions characteristic of within valley layers, transitional layers and atmospheric layers located above the terrain.

1.3 Assumptions, Exclusions and Limitations

In interpreting the study findings it is important to note the limitations and assumptions on which the assessment was based. The most important *limitations* of the air quality impact assessment are as follows:

- Emissions emanating from all existing sources in the area were not quantified nor were resultant ambient air pollutant concentrations due to such sources simulated, with the exception of the existing Matimba Power Station and its associated ashing operations. Given that Matimba Power Station is currently the most significant source of ambient SO_2 concentrations in the region, this study limitation is not significant for assessing compliance and health risk potentials due to SO_2. Matimba Power Station is, however, not the major contributor to ambient fine particulate concentrations (Scorgie et al, 2006). In order to project cumulative particulate concentrations other significant sources, particularly local mining operation emissions, would need to be quantified.

- Routine emissions from power station operations were estimated and modelled. Atmospheric releases occurring as a result of incidences that would result in shutdown, maintenance or change in routine emissions from the power station was not accounted for.

- For the current assessment, the assumption was made that the ash and gypsum would be disposed together in the same facility, until there is an opportunity in the market for alternative use of gypsum. The gypsum material mixed with the ash for disposal at the existing facility is expected to provide a crust when mixed with water. To what extent this material will crust will depend on how the material is disposed (i.e. mixed with the ash or deposited as layers of gypsum material in between the ash material) and how much water is added to the disposal facility. The crust may also be disturbed from time to time with activity on the disposal facility. For the current assessment, the effectiveness of this crust in lowering windblown emissions could not be quantified.

- MM5 was used as the “initial guess” field for the CALMET model. Although two monitoring stations are located within the study area, MM5 could not be used together with the surface measurements as the Eskom-operated Marapong station is sited incorrectly providing questionable wind direction and, with one representative station (South African Weather Service Station located at Lephalale), CALMET requires 100% data availability which was not present.

- The modelling guidelines stipulate that three years of off-site meteorological data should be used from a period no older than five years to the year of assessment. As the onset of the Air Quality Assessment was in 2014, meteorological data for the period 2011 – 2013 was used. Presently two of the three years falls outside of the last five-year period. This limitation is not found to be significant, however, as the meteorological conditions within the study area have not shown any significant historical changes.

The most important *assumptions* made during the air quality impact assessment are as follows:

- Source parameters and emission rates for these emission scenarios required for input to the dispersion modelling study were provided by Eskom personnel. The assumption was made that this information was accurate and correct.

- A constant NH_3 background concentration of 20 ppb was used in Calpuff (Scorgie et al, 2006). Measured ozone data from the Marapong station was included for the background data required for the chemical transformation module in Calpuff[6].

1.4 Outline of Report

Minimum Emission Standards and National Ambient Air Quality Standards applicable to power station operations and their ancillary infrastructure are presented in Section 2. The synoptic climatology and atmospheric dispersion potential of the area as well as information on existing sources and baseline air quality are discussed in Section 3. Section 4 presents the impact assessment of the proposed Project. Conclusions are presented in Section 5.

[6] Measured NH_3 concentrations within the study area are only available from the Marapong monitoring station.

2 Regulatory Requirements and Assessment Criteria

2.1 Minimum Emission Standards

Activities associated with the proposed Project will trigger the Listed Activity - Category 1: Combustion Installations, under the NEM Air Quality Act of 2004 (AQA) (Government Gazette No. 37054 published on 22 November 2013).

Table 2-1 provides the requirements as set out in the published Listed Activities and Associated Minimum Emission Standards for Subcategory 1.1: Solid fuel combustion installation. Note that "New plant" relates per definition to all installations applying for authorisation in terms of the National Environmental Management Act 1998, (Act No.107 of 1998), made on or after 1 April 2010. "Existing plant" includes operations legally authorised to commence before 1 April 2010 or any plant where an application for authorisation in terms of the National Environmental Management Act, 1998 (Act No.107 of 1998), was made before 01 April 2010. It is therefore understood that the Medupi Power Station would have to comply with "existing plant" standards until 1 April 2020, where the more stringent "new plant" standards would be applicable.

The minimum emission standards apply to normal operating conditions. Should normal start-up, maintenance, upset and shut-down conditions exceed a period of 48 hours, Section 30 of NEMA (as amended) shall apply unless otherwise stipulated by the Licensing Authority.

Section 30 of NEMA states that; the cause and effect of the incident needs to be reported, within 14 days, to the Director-General, provincial head of department and municipality. Reasonable measures to contain, minimise and remedy the effects of the incident are required and an assessment of the immediate and long-term effects undertaken as soon as reasonably practical.

Table 2-1: Subcategory 1.1: Solid fuel combustion installations

Description:	Solid fuels (excluding biomass) combustion installations used primarily for steam raising or electricity generation.		
Application:	All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.		
Substance or mixture of substances		Plant status	mg/Nm³ under normal conditions of 10% O_2, 273 K and 101.3 kPa
Common name	Chemical symbol		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO_2	New	500
		Existing	3500
Oxides of nitrogen	NO_x expressed as NO_2	New	750
		Existing	1100

(a) The following special arrangements shall apply –
   (i) Continuous emission monitoring of PM, SO_2 and NO_x is required.

Additional Listed Activities that will be undertaken at the Medupi Power Station include Subcategory 2.4: Storage and Handling of Petroleum Products and Subcategory 5.1: Storage and Handling of Coal and Ore.

2.2 National Ambient Air Quality Standards for Criteria Pollutants

The air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards are intended to provide safe hourly, daily and annual exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime.

The South African Bureau of Standards (SABS) was engaged to assist the Department of Environmental Affairs (DEA) in the facilitation of the development of ambient air quality standards. This included the establishment of a technical committee to oversee the development of standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for $PM_{2.5}$, PM_{10}, SO_2, NO_2, carbon monoxide (CO), ozone (O_3), lead (Pb) and benzene (C_6H_6) (Table 2-2).

Table 2-2: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	5	0	1 January 2015
Carbon Monoxide (CO)	1 hour	30000	88	Immediate
	8 hour[(a)]	10000	11	Immediate
Lead (Pb)	1 year	0.5	0	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	88	Immediate
	1 year	40	0	Immediate
Ozone (O_3)	8 hour[(b)]	120	11	Immediate
$PM_{2.5}$	24 hour	65	4	Immediate till 31 December 2015
	24 hour	40	4	1 January 2016 till 31 December 2029
	24 hour	25	4	1 January 2030
	1 year	25	0	Immediate till 31 December 2015
	1 year	20	0	1 January 2016 till 31 December 2029
	1 year	15	0	1 January 2030
PM_{10}	24 hour	75	4	1 January 2015
	1 year	40	0	1 January 2015
Sulfur Dioxide (SO_2)	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hour	125	4	Immediate
	1 year	50	0	Immediate

Notes:
(a) Calculated on 1 hour averages.
(b) Running average.

2.3 Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa, 2014

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations Regarding Air Dispersion Modelling was published in Government Gazette No. 37804 (11 July 2014), and recommends a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. This code of practice was followed in the current assessment.

2.4 Waterberg-Bojanala Priority Area

The Medupi Power Station falls within the Waterberg-Bojanala Priority Area (Figure 2-1). Under the National Environmental Management: Air Quality Act (Act No. 39 of 2004), airshed priority areas can be declared where there is concern of elevated atmospheric pollutant concentrations within the area. The DEA identified the potential of an airshed priority area in the vicinity of the Waterberg District Municipality (Government Gazette, Number 33600; 8 October 2010). This was later expanded to include the Bojanala Platinum District Municipality, North-West Province (Government Gazette, Number 34631; 30 September 2011) and the Waterberg-Bojanala Priority Area (WBPA) was officially declared on 15th June 2012 (Government Gazette, Number 35435).

Figure 2-1: Location of the Medupi Power Station within the Waterberg-Bojanala Priority Area (Scott, 2012)

The Waterberg-Bojanala Priority Area Air Quality Management Plan: Baseline Characterisation was released for public comment on the 7th August 2014 (SAAQIS, 2014, access date: 2014-08-21). The Baseline Characterisation of the WBPA reported that power generation activities contribute 95% of SO_2, 93% of NO_2 and 68% of the particulate emissions across the Waterberg District Municipality.

3 Description of the Receiving/Baseline Environment

3.1 Air Quality Sensitive Receptors

Given that the Project will be associated with low level emissions (e.g. from ashing operations) and elevated emissions (power station stacks), the proposed Project has the potential of impacting on receptors in the near and medium fields[7].

Residential areas in the vicinity of the proposed operations include Marapong northeast of the existing Matimba Power Station, a residential settlement to the northwest of Matimba Power Station and Lephalale situated to the southeast and east of the existing power station respectively. Farm households are scattered through the area, with livestock farming (primarily cattle and game) representing the main agricultural land-use in the area. The closest schools, hospitals and clinics included in the study area are indicated in Figure 3-1.

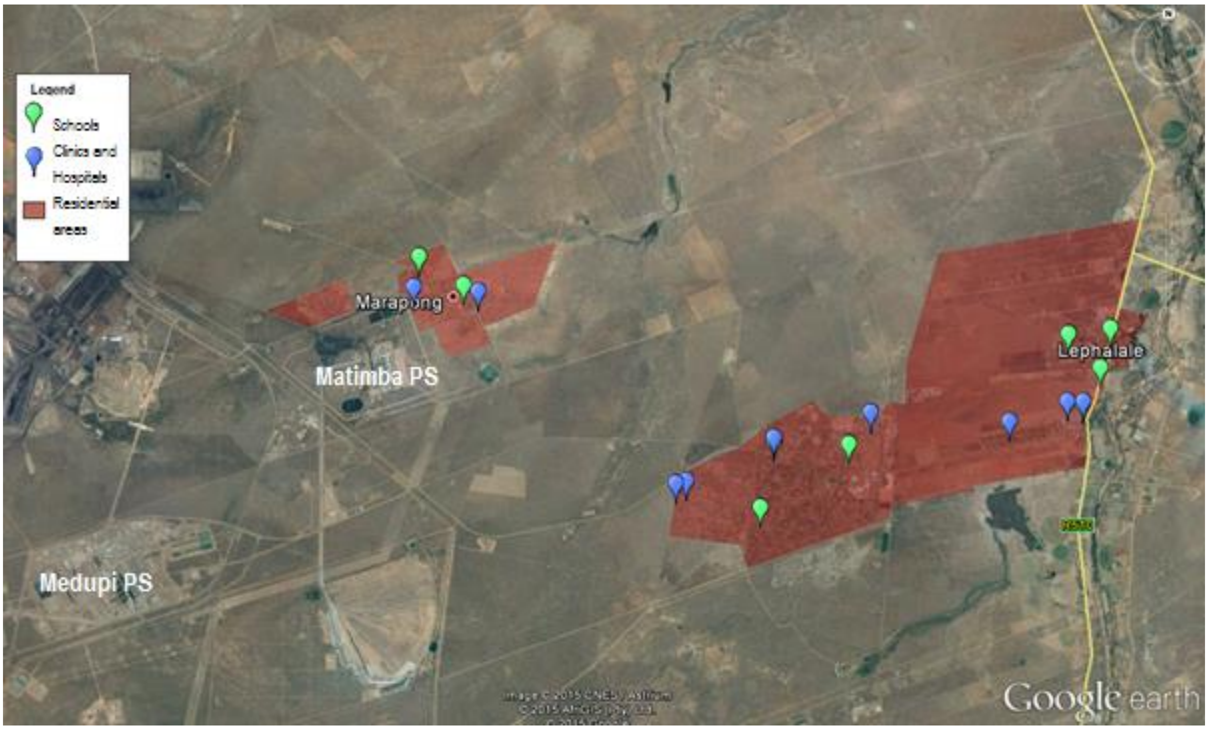

Figure 3-1: Location of sensitive receptors in the vicinity of the Medupi Power Station

3.2 Atmospheric Dispersion Potential

In the assessment of the possible impacts from air pollutants on the surrounding environment and human health, a good understanding of the regional climate and local air dispersion potential of a site is essential. Meteorological characteristics of a site govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer as well as advection.

Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a

[7] Near field would constitute as a distance of 0 km to 1 km from the operations and medium field as 1 km to 20 km from operations.

result of plume ‘stretching’. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness.

The wind direction and its variability, determine the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentration levels fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales need therefore be taken into account in order to understand the atmospheric dispersion potential of a particular area.

3.2.1 Surface Wind Field

In characterising the dispersion potential of the site, reference was made to calculated MM5 meteorological data (extracted at the Medupi Power Station site) for the period 2011-2013.

Period, day- and night-time wind roses for the study area are illustrated in Figure 3-2.

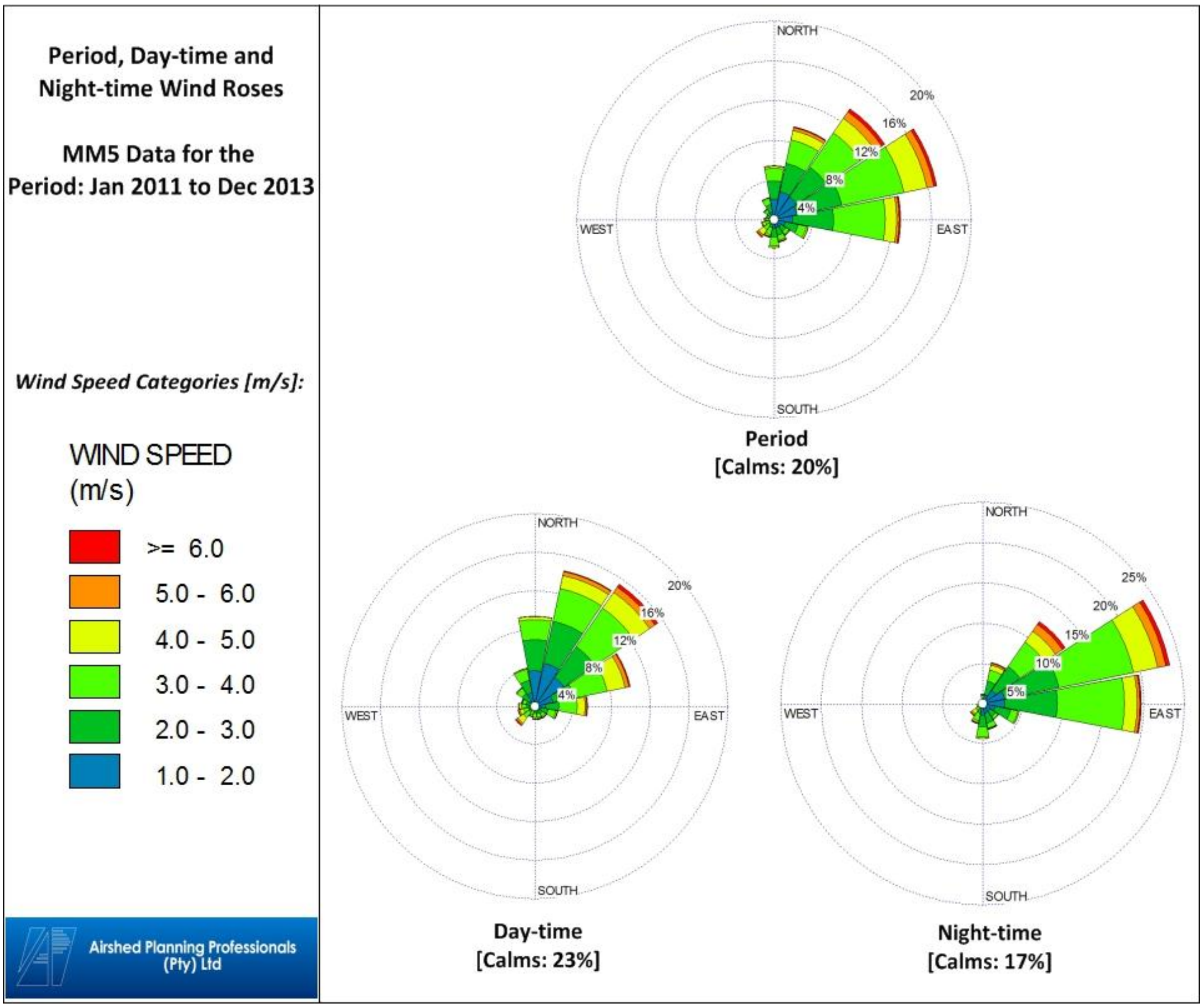

Figure 3-2: Period, day- and night-time wind roses for the period 2011-2013

Wind roses represent wind frequencies for the 16 cardinal wind directions. Wind frequencies are indicated by the length of the shaft when compared to the circles drawn to represent frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies of high and low wind for each wind vector. The frequency of calm periods, defined as periods for which wind speeds are below 1 m/s, are indicated below the wind rose.

The flow field is dominated by north-easterly winds. Winds are infrequently experienced from the westerly and southerly sectors. The wind speeds are generally low (1-3 m/s) to moderate (3-5 m/s) throughout the period.

3.2.2 Temperature

A summary of the monthly diurnal temperature averages of the Medupi Power Station site (as extracted from MM5 data) is provided in Figure 3-3.

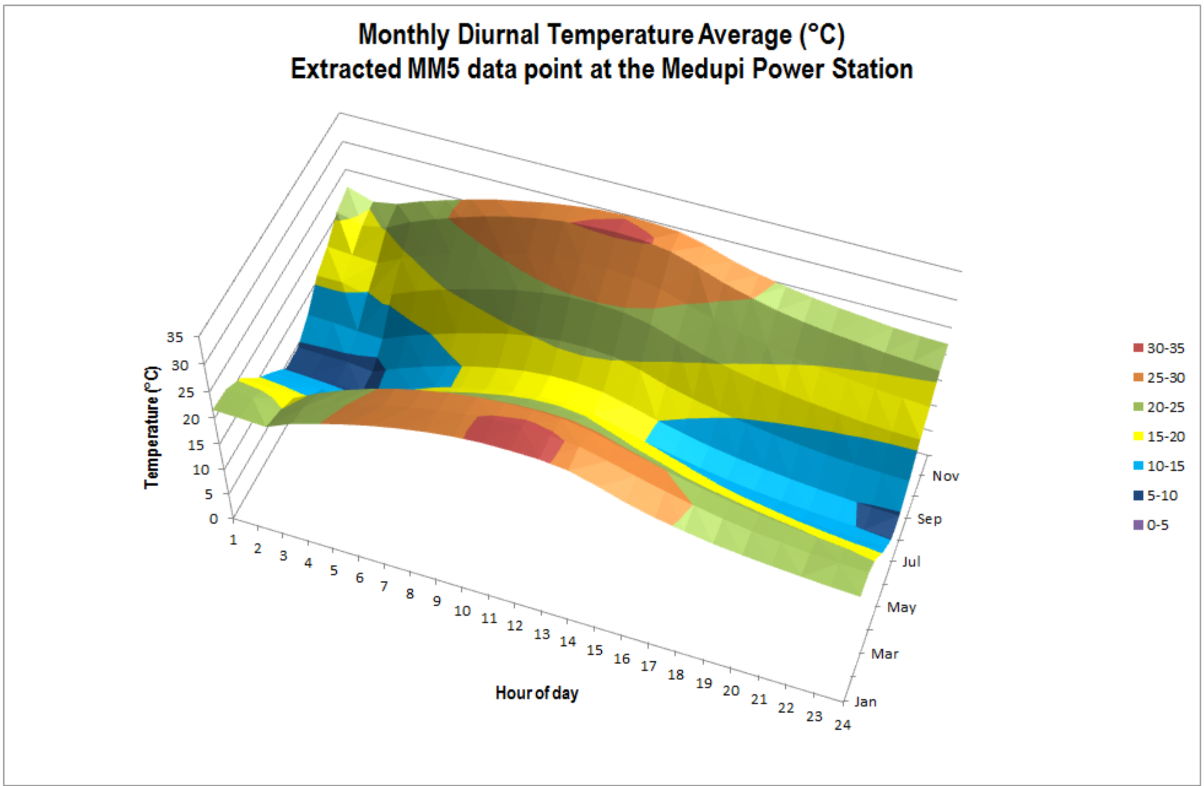

Figure 3-3: Monthly diurnal temperature averages for the Medupi Power Station Site (as extracted from MM5 data)

3.2.3 Atmospheric Stability

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured, and must therefore often be estimated using prognostic models that derive the depth from some of the other parameters that are routinely measured, e.g. solar radiation and temperature. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 3-1.

Table 3-1: Atmospheric Stability Classes

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

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

3.3 Status Quo Ambient Air Quality

3.3.1 Atmospheric Emissions

Source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants that may be of importance in terms of cumulative impact potentials.

Existing sources of atmospheric emissions which occur in the vicinity of the proposed development sites include:

- Matimba Power Station and its associated ash dump;
- Coal mining operations;
- Brickworks operating at Hanglip;
- Household fuel combustion;
- Potential veld fires (infrequent);
- Sewage works (Farm Nelsonskop);
- Windblown dust from open areas and agricultural activities;
- Vehicle exhaust releases and road dust entrainment along paved and unpaved roads in the area.

Emissions from the Matimba Power Station are simulated together with the Medupi Power Station in order to determine resultant cumulative concentrations of key pollutants such as SO_2 and NO_2.

3.3.1.1 Matimba Power Station

The existing Matimba Power Station is a dry-cooled, coal-fired pulverised fuel power station comprising six 665 MW units, representing a total nominal capacity of 3990 MW and a total net maximum capacity of 3690 MW.

Air pollutants released by coal-fired power stations primarily include particulates, SO_2, NO_x, carbon monoxide, carbon dioxide (CO_2), nitrous oxide (N_2O), and trace amounts of mercury. CO_2 and N_2O represent greenhouse gases (i.e. gases associated with global warming) and are therefore of concern despite not resulting in direct health effects. Air pollutants associated with health effects include SO_2, NO_x (primarily as NO_2) and particulates. South African coals have relatively high ash contents and therefore hold the potential for releasing significant particulate emissions. Eskom however currently implements highly effective particulate abatement technology which reduces its particulate emission concentrations substantially. No SO_2 or NO_2 abatement measures are currently in place at the existing Matimba Power Station.

3.3.1.2 Coal Mining Operations

Open-cast coal mining operations, such as that undertaken at Grootgeluk, are frequently significant sources of fugitive dust emissions, particularly if poorly controlled. Sources of fugitive dust include operations such as drilling, blasting, dragline and/or truck and shovel activities, in addition to vehicle entrainment and materials handling operations. Depending on the type of explosives used, blasting operations are also associated with gaseous emissions, e.g. nitrogen oxides, carbon monoxide and smaller quantities of sulphur dioxide. Gaseous and particulate emissions may also occur as a result of spontaneous combustion of coal discards and dumps.

3.3.1.3 Sewage Works

Volatile organic compounds (VOCs) emissions are associated with wastewater treatment works. Species measured at local works have included: hydrogen sulphide, mercaptans, ammonia, formaldehyde, acetone, toluene, ethyl benzene, xylenes, perchloroethylene (tetrachloroethylene), butyric acid, propionic acid, valeric acid and acetic acid. Species that represent the most important odorants included: hydrogen sulphide, mercaptans, ammonia, and various fatty acids (butyric, propionic, valeric and acetic).

3.3.1.4 Household Fuel Burning

Within the Waterberg District Municipality, 92% and 95% of cooking and space heating respectively in rural areas is undertaken by means of wood and paraffin as an energy source (StatsSA, 2011).

Domestic coal burning emits a large amount of gaseous and particulate pollutants including sulphur dioxide, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene. Polyaromatic hydrocarbons are recognised as carcinogens. Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning within South Africa have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons (Terblanche et al., 1992). The main pollutants emitted from the combustion of paraffin are NO_2, particulates, carbon monoxide and polycyclic aromatic hydrocarbons.

3.3.1.5 Veld Burning

Biomass burning is an incomplete combustion process with carbon monoxide, methane and nitrogen dioxide being emitted during the process. About 40% of the nitrogen in biomass is emitted as nitrogen, 10% remains in the ashes and it is assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. Unlike N species, only small amount of sulphur dioxide and sulphate aerosols are emitted. The visibility of smoke plumes from vegetation fires is due to their aerosol content (Helas and Pienaar, 1996).

The extent of emissions from veld burning is dependent on the quantity of material (biomass) available for combustion. The quantity of dry, combustible matter per unit area is on average 4.5 ton per hectare for savannah areas.

Crop-residue burning and general wild fires (veld fires) represent significant sources of combustion-related emissions associated with agricultural areas. Given that livestock agriculture prevails in the Lephalale area, it is anticipated that general wild fires are likely to be more important than controlled burning related to agricultural activities. Fires are however reported to occur relatively infrequently in the area (Scorgie et al, 2006).

3.3.1.6 Vehicle Exhaust Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, particulates and lead. Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, sulphates, nitric acid and nitrate aerosols. Toxic hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses.

3.3.1.7 Fugitive Dust Emissions

Fugitive dust emissions may occur as a result of vehicle entrainment of dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling). The extent, nature and duration of agricultural activities, the moisture and silt content of soils and the extent of open areas is required to be known in order to quantify fugitive emissions from this source. The quantity of windblown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

3.3.1.8 Brickworks operating at Hanglip

Hendrik Pieterse, the owner of the farm Hanglip, runs the existing brickworks in the vicinity of the Medupi Power Station. The brickworks manufactures approximately 2 million bricks per month, fired by using veld ovens (clamp kilns). Firing by clamp is one of the oldest methods of brickmaking. Despite no longer being used in most parts of the world – having been replaced by coal- and gas-fired kiln operations – firing by clamp is still fairly widely used in South Africa.

The manufacturing of bricks involve quarry operations, crushing, screening, blending of raw materials, and the forming of, cutting or shaping, drying or curing, and firing of the final product. Emissions from brick manufacturing facilities (EPA 1997) include particulate matter (PM_{10} and $PM_{2.5}$), SO_2, sulphur trioxide (SO_3), NO_x, CO, CO_2, total organic compounds (TOC) (including methane, ethane, VOC and some hazardous air pollutants (HAP), hydrochloric acid and fluoride compounds). Other factors that may influence emissions are raw material composition and moisture content as well as firing parameters and fuel type.

The primary sources of particulate matter are material handling (grinding, drying, screening and storing), fuel handling and fugitive dust sources such as paved roads, unpaved roads and storage piles. The combustion products (SO_2, NO_x, CO, CO_2) are emitted from fuel combustion during firing. The main source of SO_2 emissions is the raw materials that sometimes contain sulphur compounds. The organic compounds (methane, ethane, VOC and HAP) are emitted from the firing and drying processes. Hydrogen fluoride (HF) is emitted as a result of the fluorine compounds contained in the raw materials (where applicable).

3.3.1.9 Trans-Boundary Transportation of Air Masses over Southern Africa

The two main transport modes of air masses consist of direct transport, in which air masses are advected directly from the subcontinent to the oceans beyond, and re-circulated transport, in which air masses re-circulates to the point of origin (Tyson et al., 1996a, Tyson et al., 1996c) (Figure 3-4). Direct transport is made up of the four cardinal compass directions, viz. westerly, easterly, northerly and southerly. Westerly transport (within the Natal Plume) is influenced by the westerly waves (Fishman, 1991; Pickering et al., 1994; Krishnamurti et al., 1993; Benkovitz et al., 1994; Tyson et al., 1996a, Tyson et al., 1996b) moving air from the highveld to the Indian Ocean at north-to-central Kwa-Zulu Natal or southern Mozambique (Tyson et al., 1996a). Air transported in the Natal Plume takes place at high levels of ~525 hPa (Tyson et al., 1996a). Easterly transport takes place by means of easterly waves to move air masses to the Atlantic Ocean. Air masses that move towards the Atlantic Ocean are transported in the Angolan Plume at low levels due to the subsidence over the western subcontinent and South Atlantic Ocean. Northerly and southerly transport moves air masses to equatorial Africa and to the South Indian Ocean respectively (Tyson et al., 1996a).

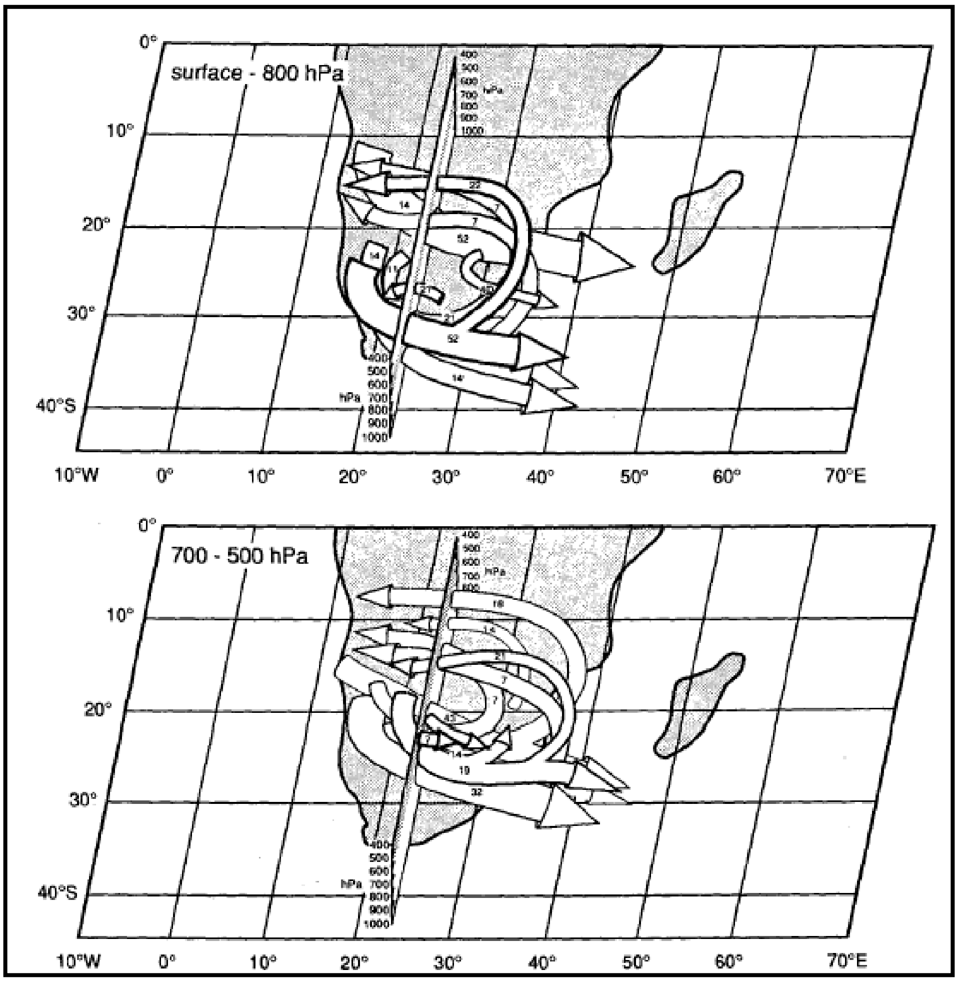

Figure 3-4: Schematic representation of major low-level transport trajectory models likely to result easterly or westerly exiting of material from southern African or in recirculation over the subcontinent (Tyson et al, 1996c)

Re-circulated transport is confined to levels of less than 200 hPa and is mainly anticyclonic (Tyson et al., 1996a). Local and regional recirculation extends over the highveld and surrounding neighbouring countries, such as Mozambique, Zimbabwe and Botswana (Tyson et al., 1996a; Tyson and Gatebe, 2001). Analysis of trajectory fields undertaken by Tyson et al. (1996c) has revealed that air masses emanating from a particular point of origin follow anticyclonic curving streams with radii of 500 – 700 km. The recirculation vortex is evident from the surface to the persistent stable layer of 500 hPa. Above 500 hPa, due to the influence of the circumpolar westerlies, recirculation diminishes rapidly and transport patterns become more zonal. Local and sub-continental re-circulation over the interior makes up for ~44% of total air mass transportation (Tyson et al., 1996c; Tyson and Gatebe, 2001) with a recirculation time frame of 2-9 days (Tyson et al., 1996a). Up to a quarter of re-circulated air masses are observed to re-circulate a second time (Tyson et al., 1996c). Thus, the greatest impact of pollutants on neighbouring countries is under re-circulating air and prolonged residence time (Tyson et al., 1996a).

More than 75% of all air circulating over the southern African continent exits to the Indian Ocean, either by direct or re-circulated transportation (Tyson and Gatebe, 2001).

3.3.2 Measured Ambient Air Pollutant Concentrations

3.3.2.1 Monitoring Stations Operated by the Department of Environmental Affairs

The DEA has ambient monitors to measure the ambient air quality in the Waterberg area. These ambient monitoring stations are located at Lephalale, Mokopane and Thabazimbi. The closest DEA monitoring station, with sufficient data, to the proposed Project is in Lephalale (~12 km east). The measured NO_2, PM_{10}, $PM_{2.5}$ and SO_2 short-term ground level concentrations from the Lephalale monitoring station for the period January 2013 to November 2014 are provided in Figure 3-5 to Figure 3-9 (as obtained from SAAQIS, 2014). A summary of the data availability and compliance with NAAQS is provided in Table 3-2.

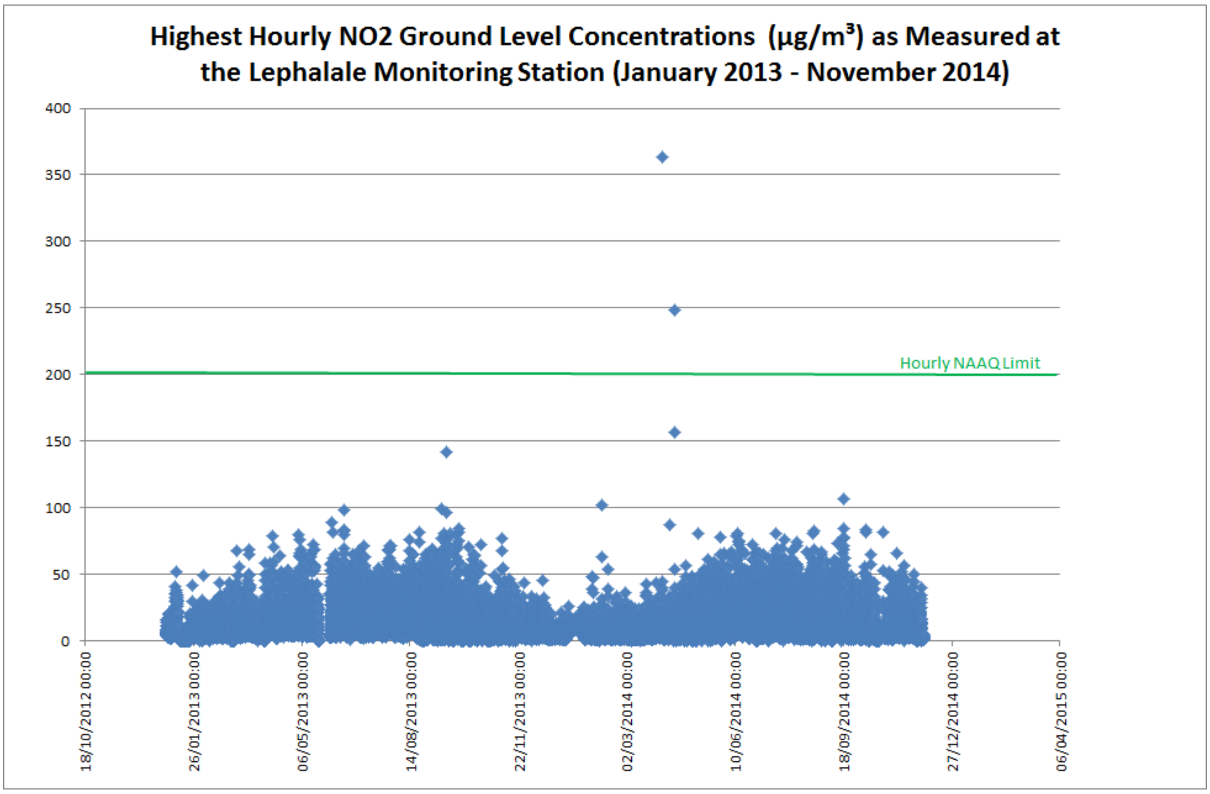

Figure 3-5: Hourly NO_2 measured at the Lephalale monitoring station for the period January 2013 to November 2014

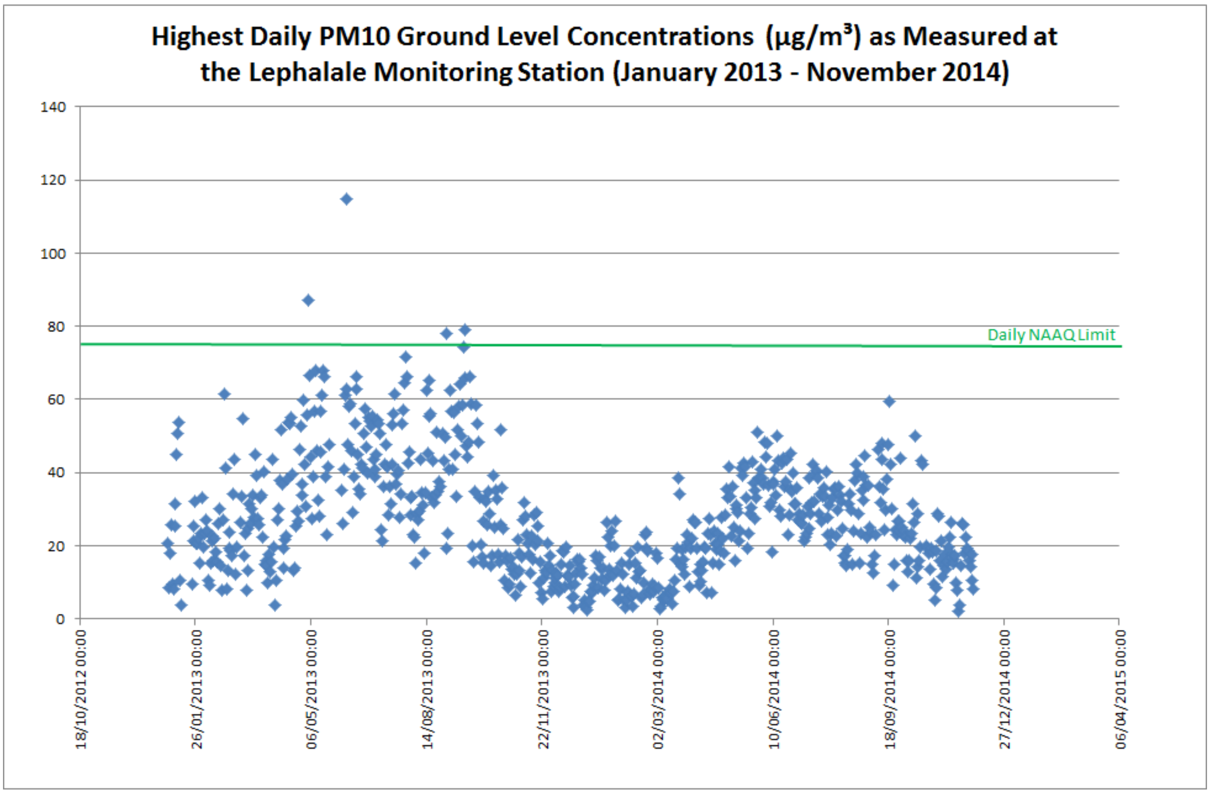

Figure 3-6: Daily PM_{10} measured at the Lephalale monitoring station for the period January 2013 to November 2014

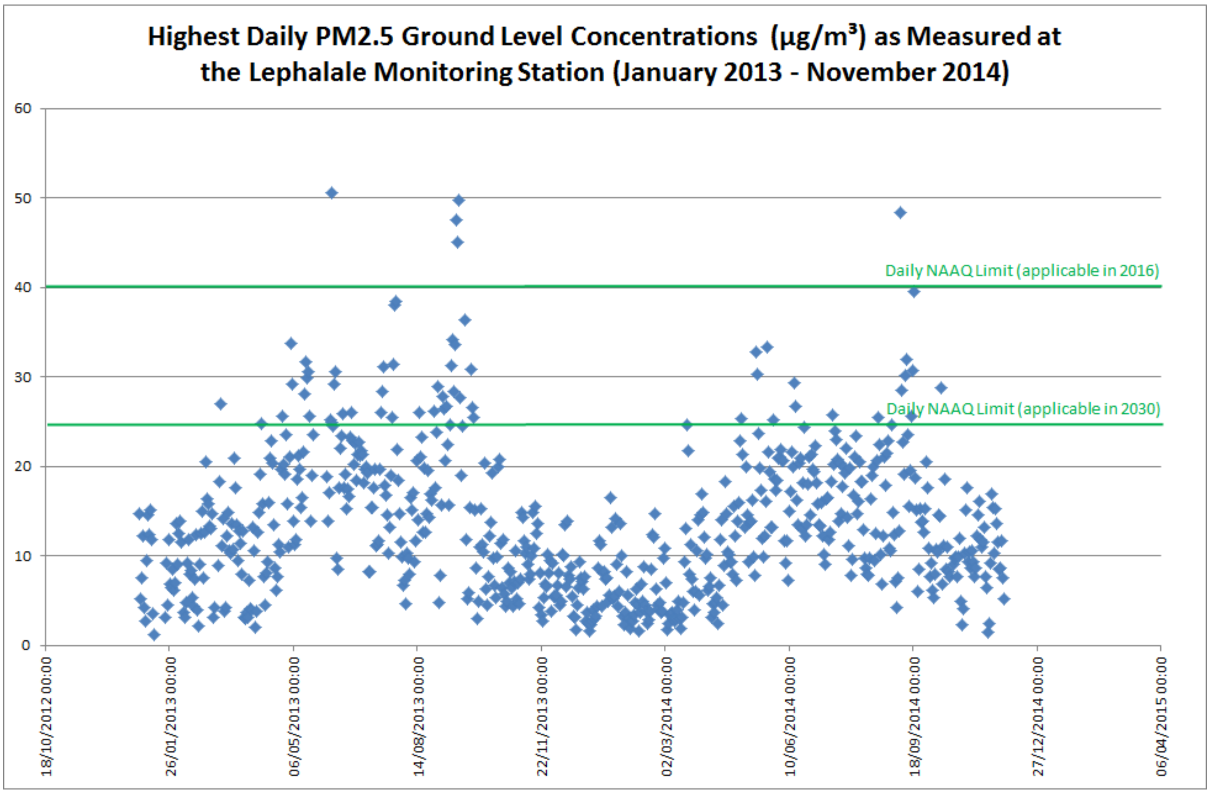

Figure 3-7: Daily $PM_{2.5}$ measured at the Lephalale monitoring station for the period January 2013 to November 2014

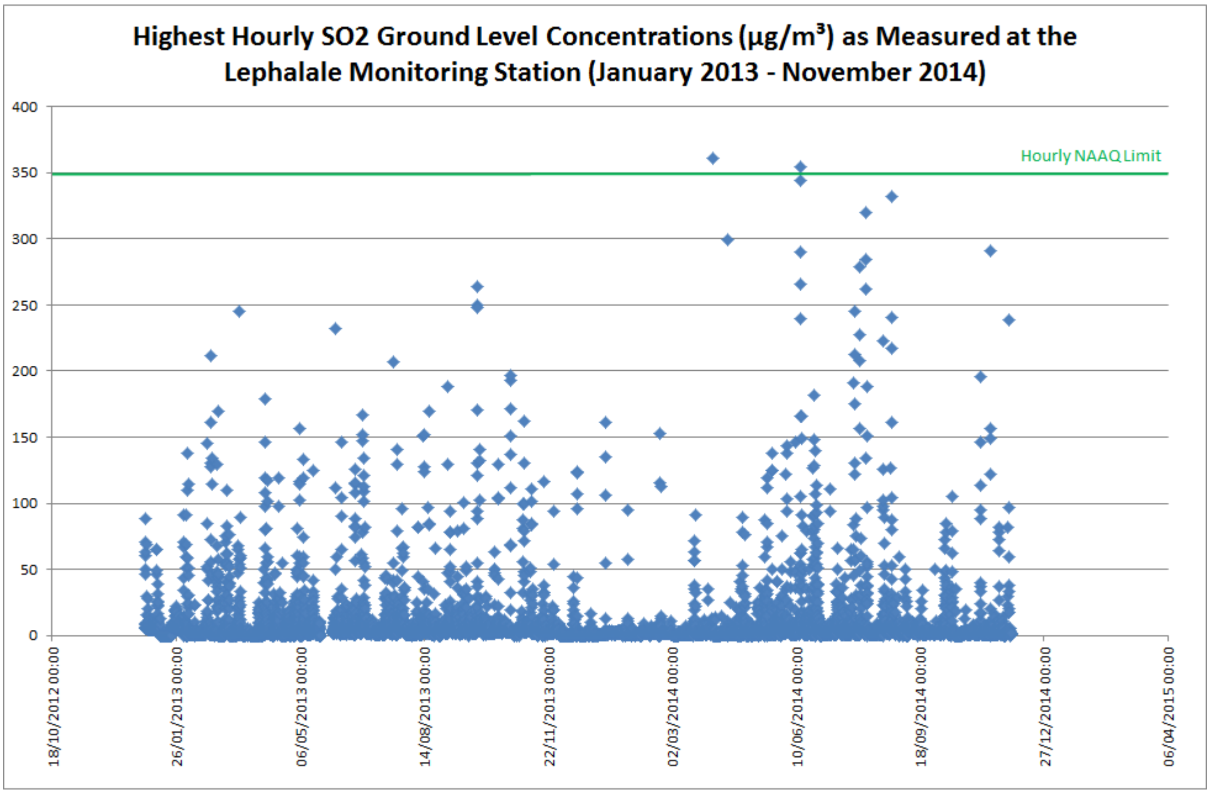

Figure 3-8: Hourly SO_2 measured at the Lephalale monitoring station for the period January 2013 to November 2014

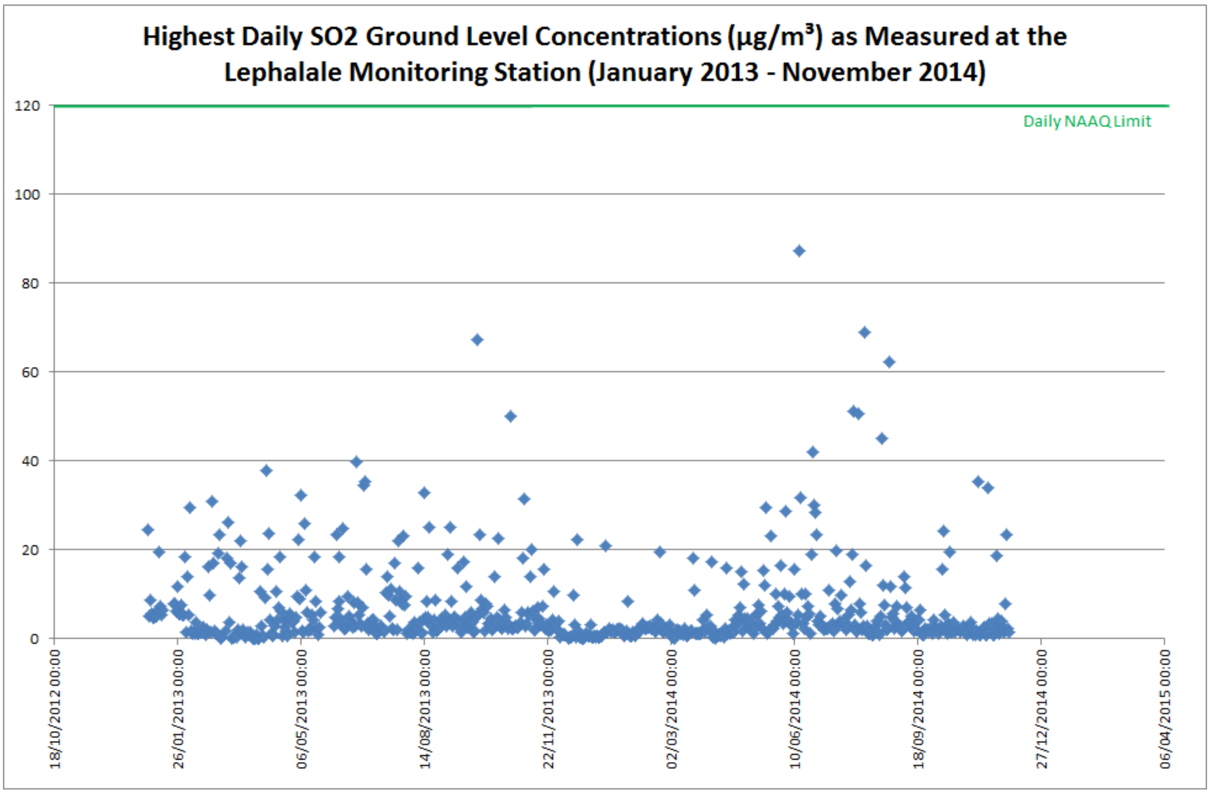

Figure 3-9: Daily SO_2 measured at the Lephalale monitoring station for the period January 2013 to November 2014

Table 3-2: Summary of the data availability and compliance with NAAQS for the ambient data measured at Lephalale

Pollutant	Monitoring Period	Data Availability (%)	Frequency of Exceedance of Hourly NAAQ Limit	Frequency of Exceedence of Daily NAAQ Limit	Annual Average Ground Level Concentrations (µg/m³)	Within Compliance with NAAQS (Y/N)
SO_2	2013	93	0	0	7	Y
	2014	96	2	0	6	Y
NO_2	2013	93	0		14	Y
	2014	98	2		13	Y
PM_{10}	2013	93	NA	4	32	Y
	2014	98	NA	0	23	Y
$PM_{2.5}$	2013	93	NA	0 (a)	14	Y
			NA	4 (b)		Y
			NA	40 (c)		N
	2014	98	NA	0 (a)	12	Y
			NA	1 (b)		Y
			NA	17 (c)		N

NA: Not applicable

(a) Applicable immediately till 31 December 2015

(b) Applicable from 1 January 2016 till 31 December 2029

(c) Applicable from 1 January 2030

The measured SO_2, NO_2 and PM_{10} concentrations are within NAAQS at Lephalale for the period January 2013 to November 2014. The $PM_{2.5}$ concentrations measured at Lephalale are within the NAAQS applicable till 2029 but exceed the more stringent NAAQS applicable in 2030.

3.3.2.2 Monitoring Station Operated by Eskom

Eskom manages an ambient monitoring station located at Marapong. The measured NO_2, PM_{10}, $PM_{2.5}$ and SO_2 short-term ground level concentrations from the Marapong monitoring station for the period January 2013 to November 2014 are provided in Figure 3-10 to Figure 3-14. A summary of the data availability and compliance with NAAQS is provided in Table 3-3.

The data availability (with the exception of $PM_{2.5}$) is poor for the year 2014 and should be kept in mind when assessing the measured data for this period. The measured SO_2 and NO_2 concentrations are within NAAQS at Marapong for the period January 2013 to November 2014. The PM_{10} concentrations exceed the NAAQS at Marapong for the period 2013 and 2014. $PM_{2.5}$ concentrations at Marapong are within the NAAQS applicable till 2029 but exceed the more stringent NAAQS applicable in 2030.

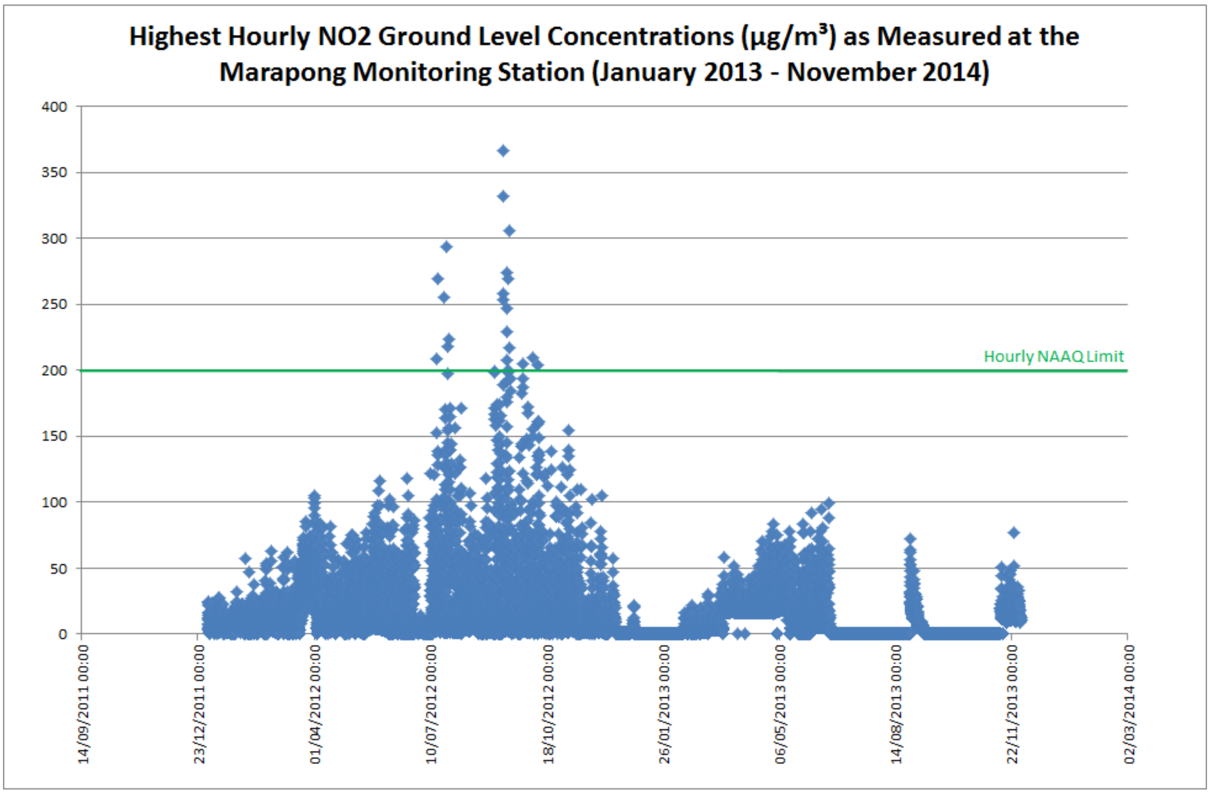

Figure 3-10: Hourly NO_2 measured at the Marapong monitoring station for the period January 2013 to November 2014

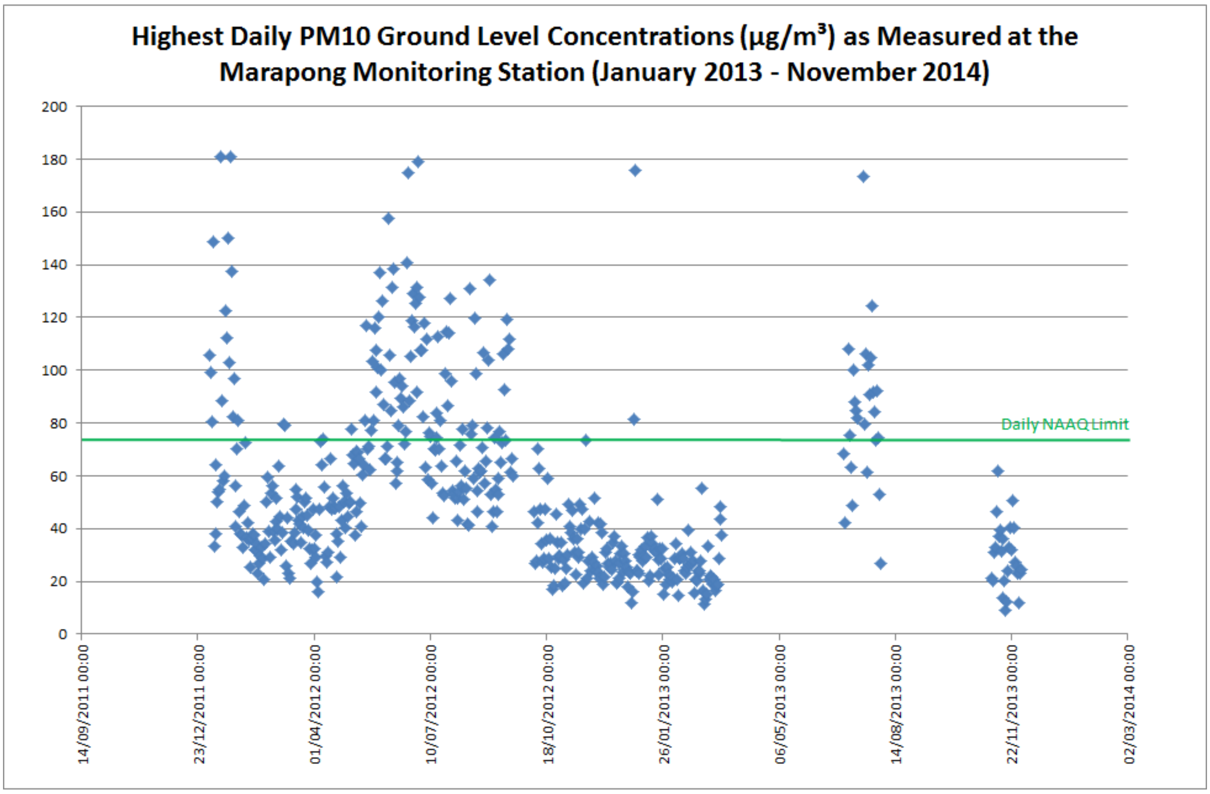

Figure 3-11: Daily PM_{10} measured at the Marapong monitoring station for the period January 2013 to November 2014

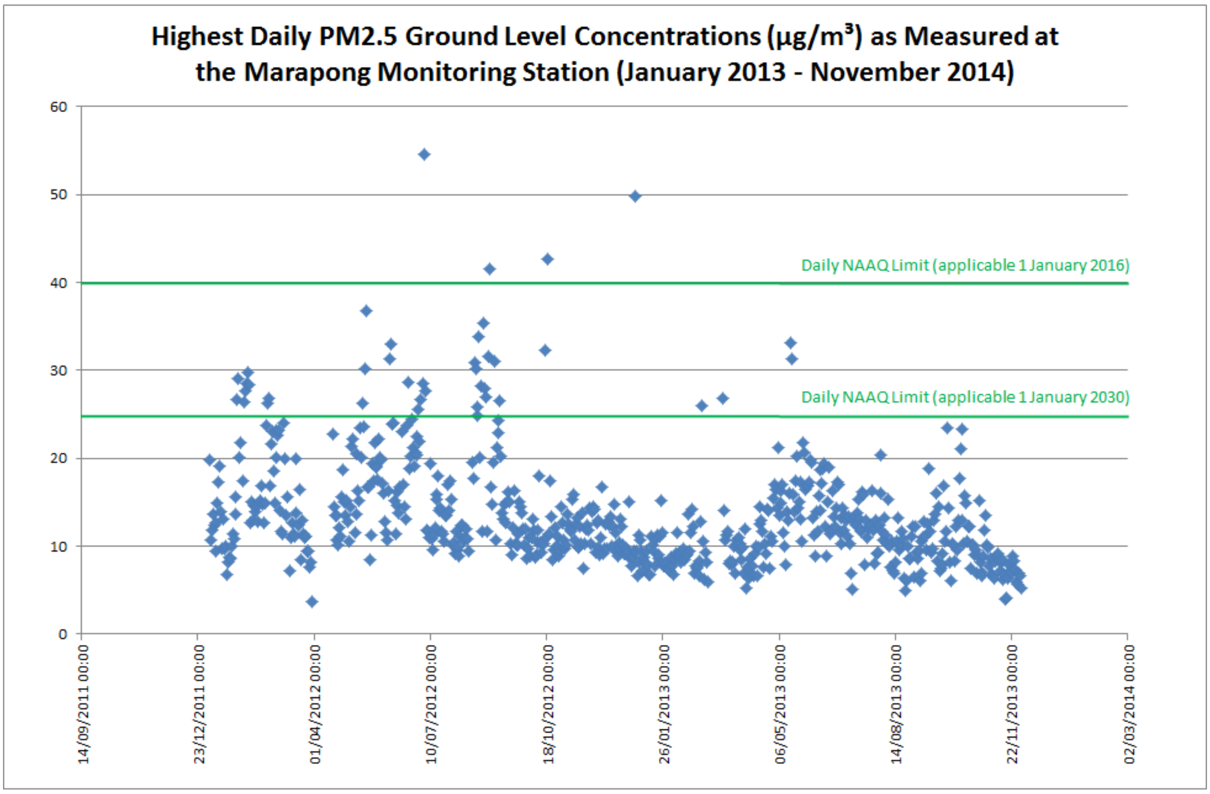

Figure 3-12: Daily $PM_{2.5}$ measured at the Marapong monitoring station for the period January 2013 to November 2014

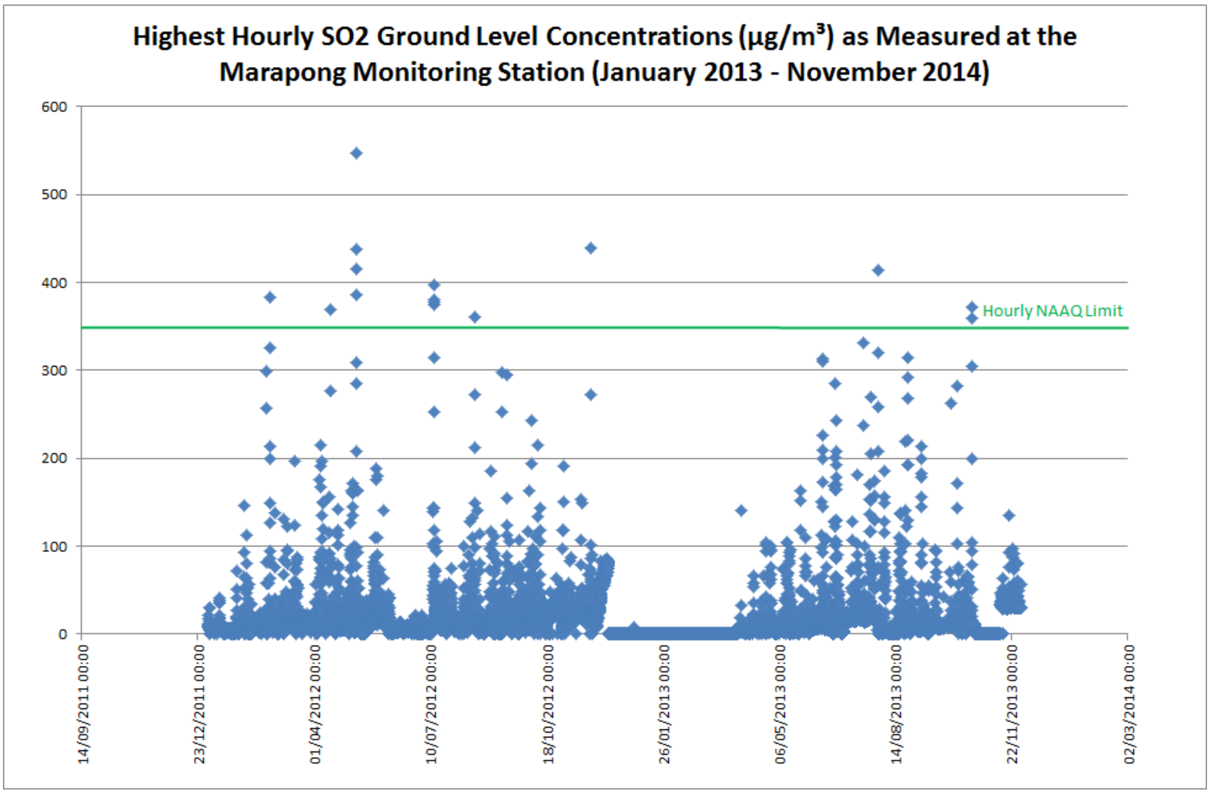

Figure 3-13: Hourly SO_2 measured at the Marapong monitoring station for the period January 2013 to November 2014

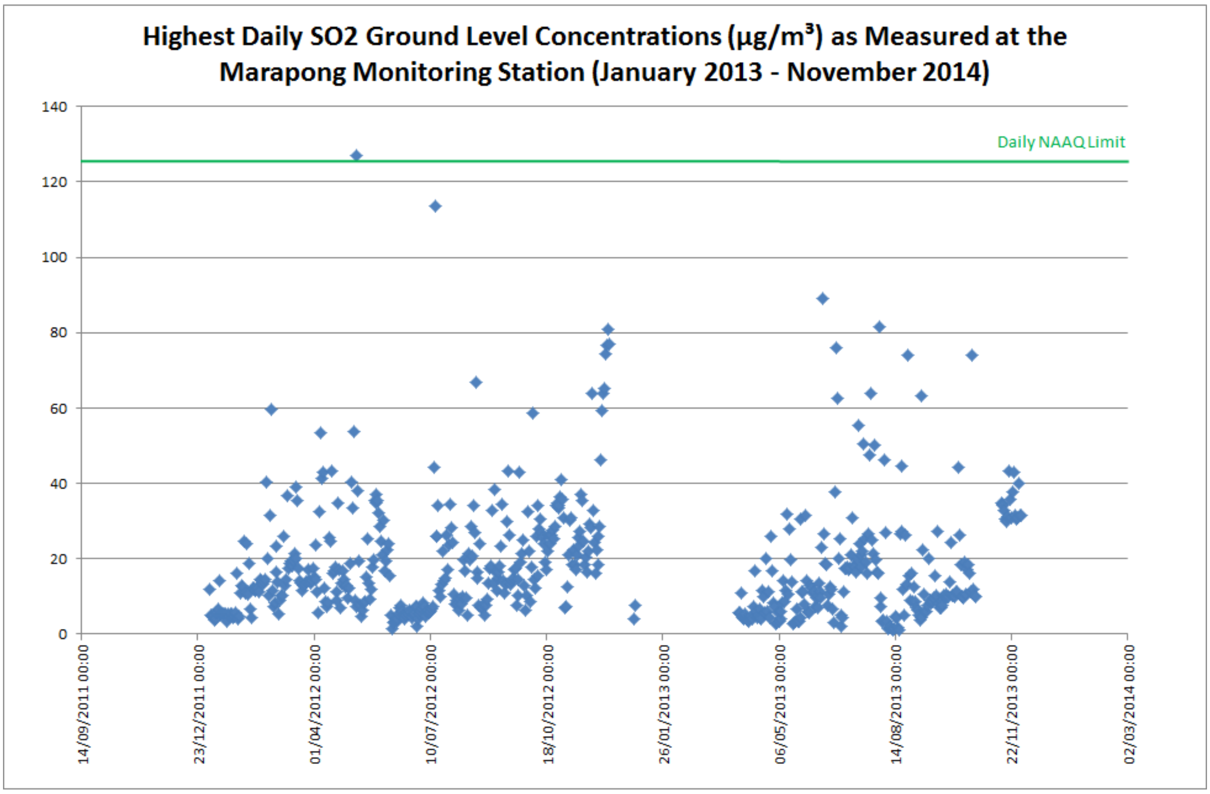

Figure 3-14: Daily SO_2 measured at the Marapong monitoring station for the period January 2013 to November 2014

Table 3-3: Summary of the data availability and compliance with NAAQS for the ambient data measured at Marapong

Pollutant	Monitoring Period	Data Availability (%)	Frequency of Exceedence of Hourly NAAQ Limit	Frequency of Exceedence of Daily NAAQ Limit	Annual Average Ground Level Concentrations (µg/m³)	Within Compliance with NAAQS (Y/N)
SO_2	2013	92	12	1	19	Y
	2014	66	3	0	17	Y
NO_2	2013	98	21		18	Y
	2014	47	0		15	Y
PM_{10}	2013	94	NA	87	59	N
	2014	36		18	40	N
$PM_{2.5}$	2013	90		0 (a)	15	Y
				3 (b)		Y
				34 (c)		N
	2014	94		0 (a)	11	Y
				1 (b)		Y
				5 (c)		N

NA: Not applicable

(a) Applicable immediately till 31 December 2015

(b) Applicable from 1 January 2016 till 31 December 2029

(c) Applicable from 1 January 2030

3.3.3 *Simulated Ambient Air Pollutant Concentrations*

The baseline air quality impact assessment consisted of two scenarios:

- 2014 Baseline: Matimba Power Station operations, and
- 2020 Baseline: Matimba Power Station operations and Medupi Power Station operations including all six units without FGD.

3.3.3.1 *Emissions Inventory*

Matimba Power Station and Associated Ash Facility

The main source of emissions from the Matimba Power Station comprises two stacks. Source parameters for these sources, required for input to the dispersion modelling study, include stack height and diameter, gas exit velocity and gas exit temperature. Such information was obtained from the air quality impact assessment study undertaken for the Medupi Power Station and is provided in Table 3-4 (Scorgie et al, 2006).

Table 3-4: Stack parameters for the Matimba Power Station

Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
2	250	12.82	24.84	405

Estimated emission rates for SO_2, NO_x, and PM, were obtained from the Matimba Atmospheric Impact Report completed in 2014 and are provided in Table 3-5. Although emissions were provided as total particulates released, such emissions were assumed to comprise primarily of PM_{10} given the abatement measures in place (coarser particles readily removed) and as a conservative approach $PM_{2.5}$ for assessment of this pollutant.

Table 3-5: Annual emissions (in tonnes) for the Matimba Power Station operating conditions (as obtained from the Matimba Atmospheric Impact Report (Zunckel & Raghunandan, 2014))

Compound	Quantity (tpa)
SO_2	309 262
NO_x	67 592
PM	4 904

A fugitive source of particulate emissions (in the form of wind erosion) from the Matimba Power Station operations is the ash disposal facility. Wind erosion is a complex process, including three different phases of particle entrainment, transport and deposition. It is primarily influenced by atmospheric conditions (e.g. wind, precipitation and temperature), soil properties (e.g. soil texture, composition and aggregation), land-surface characteristics (e.g. topography, moisture, aerodynamic roughness length, vegetation and non-erodible elements) and land-use practice (e.g. farming, grazing and mining) (Shao, 2008).

Windblown dust is generated from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface, is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne, the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity (Shao, 2008).

Saltation and suspension are the two modes of airborne particles in the atmosphere. The former relates to larger sand particles that hop and can be deposited as the wind speed reduces or changes. Suspension refers to the finer dust particles that remain suspended in the atmosphere for longer and can disperse and be transported over large distances. It should be noted that wind erosion involves complex physics that is not yet fully understood (Shao, 2008).

Airshed has developed an in-house wind erosion model called ADDAS (Burger & Held, 1997; Burger, 2010). This model, developed for specific use by Eskom in the quantification of fugitive emissions from its ash dumps, is based on the dust emission model proposed by (Marticorena & Bergametti, 1995)[8]. The model attempts to account for the variability in source erodibility through the parameterisation of the erosion threshold (based on the particle size distribution of the source) and the roughness length of the surface. In the quantification of wind erosion emissions, the model incorporates the calculation of two important parameters, viz. the threshold friction velocity of each particle size, and the vertically integrated horizontal dust flux, in the quantification of the vertical dust flux (i.e. the emission rate).

Significant emissions arise due to the mechanical disturbance of granular material from open areas. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduce the potential for dust generation. The shape of a disposal dump influences the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated (Burger, 1994; Burger et al., 1995).

An hourly emissions file was created for each source group, i.e. the topsoil and ash sections of the ash dump. The calculation of an emission rate for every hour of the simulation period was carried out using the ADDAS model.

The particle size distribution used in the simulations as obtained from the previous Medupi air quality impact assessment (Scorgie et al, 2006) is provided in Table 3-6.

Table 3-6: Particle size distribution for the ash dump

Size (µm)	Fraction
600	0.0472
404.21	0.0269
331.77	0.0296
272.31	0.0336
223.51	0.0404
183.44	0.0503
150.57	0.0609
123.59	0.0687
101.44	0.0728
83.26	0.0739
68.33	0.072
56.09	0.0669

[8] The applicability of the Marticorena and Bergametti methodology used in ADDAS for use in impact assessments was demonstrated in a PhD thesis (Liebenberg-Enslin, 2014).

Size (µm)	Fraction
46.03	0.0607
37.79	0.0537
31.01	0.0471
25.46	0.0407
17.15	0.0628
14.08	0.0528
7.78	0.0285
3.53	0.0105

Medupi Power Station and Associated Ash Disposal Facility

Sources associated with the construction phase of the Medupi Power Station are discussed in the air quality study undertaken in 2006 (Scorgie et al, 2006). The focus of this study, therefore, investigates the potential impacts due to Medupi Power Station operations only.

The main source of emissions from the Medupi Power Station comprises two stacks. For the 2020 baseline conditions, the Medupi Power Station without FGD is assessed (emissions provided in Table 3-7), with the Matimba Power Station operations (emissions provided above).

Table 3-7: Stack parameters for the Medupi Power Station[(a)]

Scenario	Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
Medupi Power Station without FGD	2	220	15.4	15.81	410

(a) Parameters and emissions provided by Eskom personnel

Emission rates for SO_2, NO_x, and PM, calculated on the basis of information provided by Eskom personnel, are presented in Table 3-8.

Table 3-8: Annual emissions (in tonnes) for Medupi Power Station operating conditions (as calculated based on information provided by Eskom personnel)

Scenario	Compound	Quantity (tpa)
Medupi Power Station without FGD	SO_2	449 396
	NO_x	85 670
	PM	5 711

Fugitive dust from the proposed ash dump was assumed to be similar to 2014 baseline operations with the methodological approach outlined in this Section having been applied. Only the locations at which the emissions occur are different, as will be reflected in the atmospheric dispersion simulation results. This source was assessed as an unmitigated operation (no controls in place) and as a mitigated operation (80% control efficiency in place through active re-vegetation and wetting).

3.3.3.2 Impact Assessment

Isopleth plots illustrating exceedance of the NAAQS are provided in Figure 3-15 to Figure 3-18. A synopsis of compliance with NAAQS for SO_2, NO_2, PM_{10} and $PM_{2.5}$ ground level concentrations occurring due to the 2014 baseline and 2020 baseline conditions is given in Table 3-9.

2014 Baseline Conditions

Simulated SO_2 ground level concentrations exceed NAAQS for hourly and daily averaging periods within the zone of maximum impact (i.e. southwest of the Matimba Power Station) (Figure 3-15 and Figure 3-16). The simulated SO_2 concentrations also exceeded the hourly NAAQ limit infrequently within the residential area of Marapong and the residential settlement to the northwest of the Matimba Power Station but were within the requirements of the NAAQS.

Simulated NO_2, PM_{10} and $PM_{2.5}$ concentrations are well within NAAQS at the closest identified sensitive receptors.

2020 Baseline Conditions

The area of non-compliance of the hourly and daily SO_2 NAAQS extends ~30km southwest of the Medupi Power Station due to the cumulative operations of Matimba Power Station and Medupi Power Station without FGD control (Figure 3-17 and Figure 3-18). Exceedances of the hourly and daily SO_2 NAAQS are simulated at the residential settlement to the northwest of the Matimba Power Station under these conditions.

The simulated NO_2 concentrations at the closest sensitive receptors are within NAAQS due to operations of Matimba Power Station and the Medupi Power Station without FGD (Table 3-9).

Simulated PM_{10} and $PM_{2.5}$ concentrations are similar in magnitude at the closest sensitive receptors (Table 3-9) due to operations of Matimba power Station and the Medupi Power Station with and without controls on the Medupi ash disposal facility and are well within NAAQS.

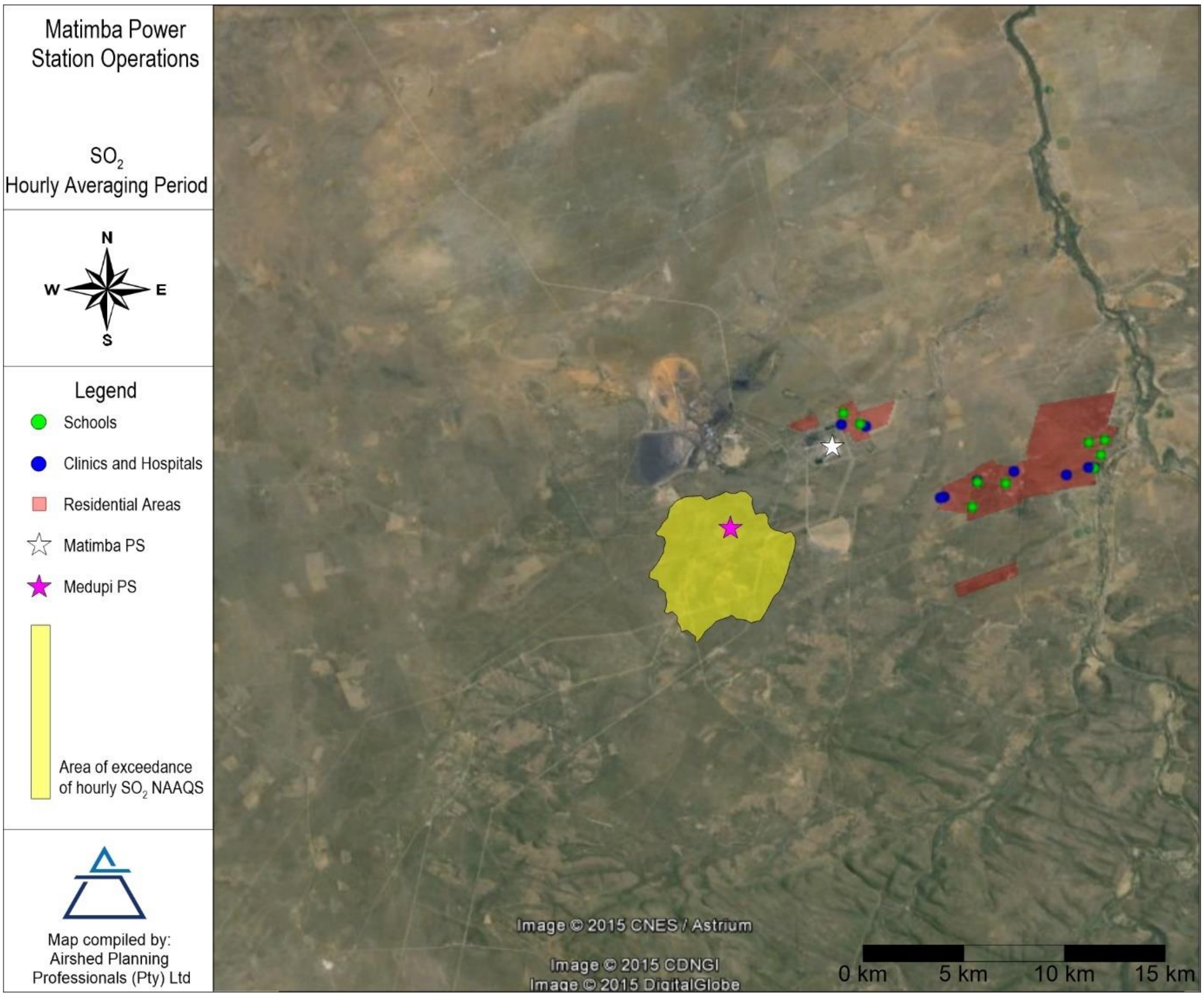

Figure 3-15: Area of exceedance of the hourly SO_2 NAAQS due to the 2014 baseline conditions

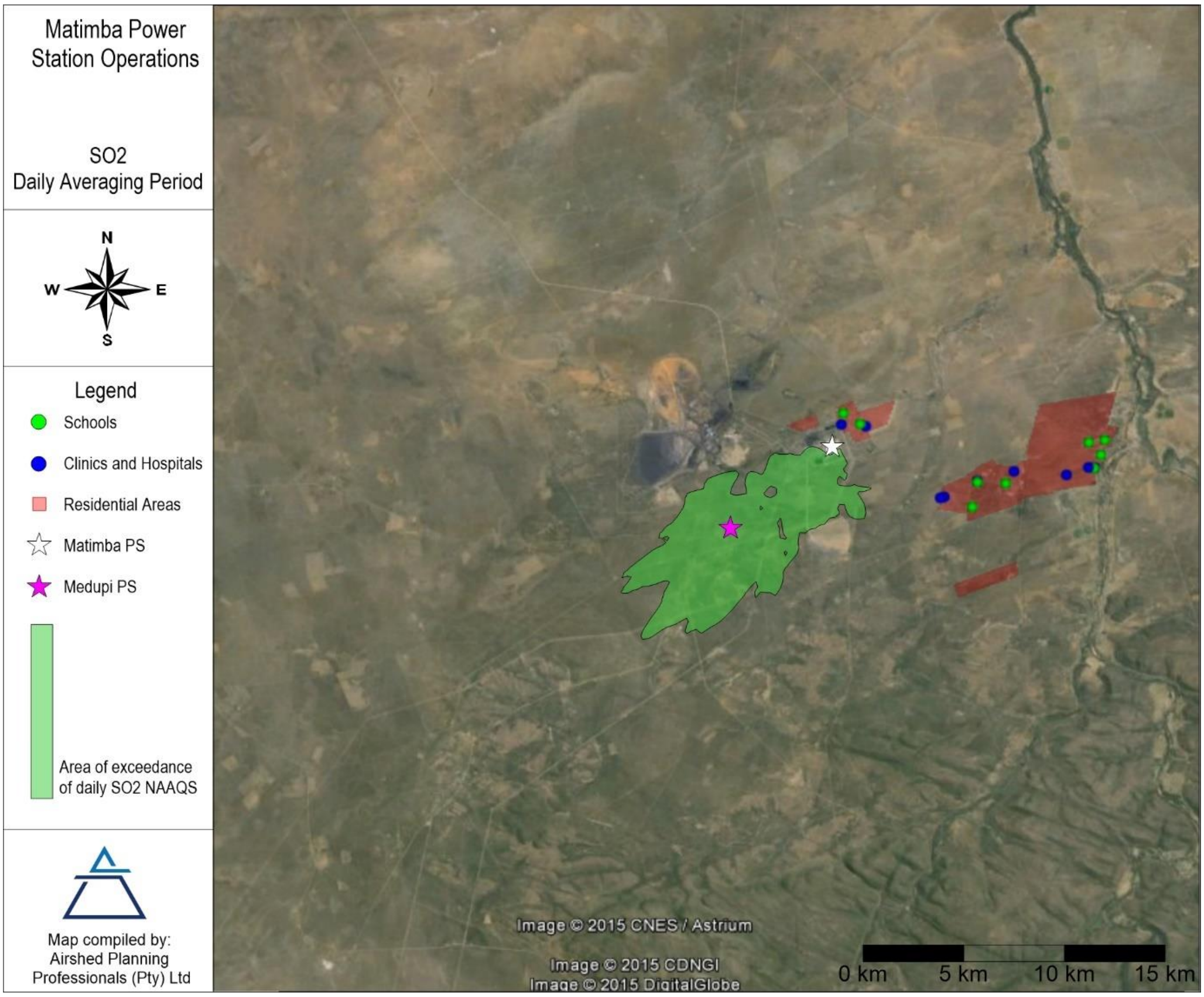

Figure 3-16: Area of exceedance of the daily SO_2 NAAQS due to the 2014 baseline conditions

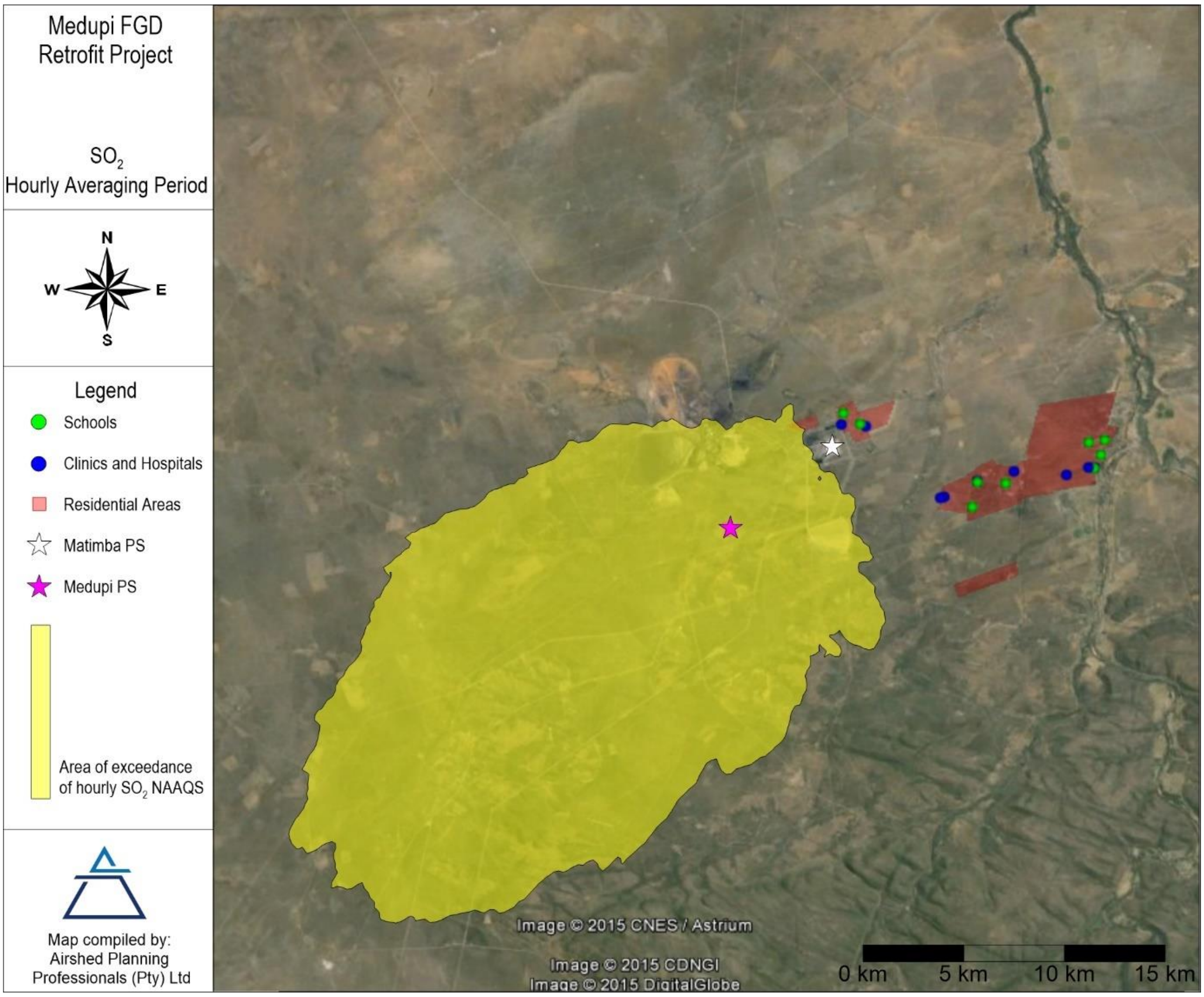

Figure 3-17: Area of exceedance of the hourly SO_2 NAAQS due to the 2020 baseline conditions

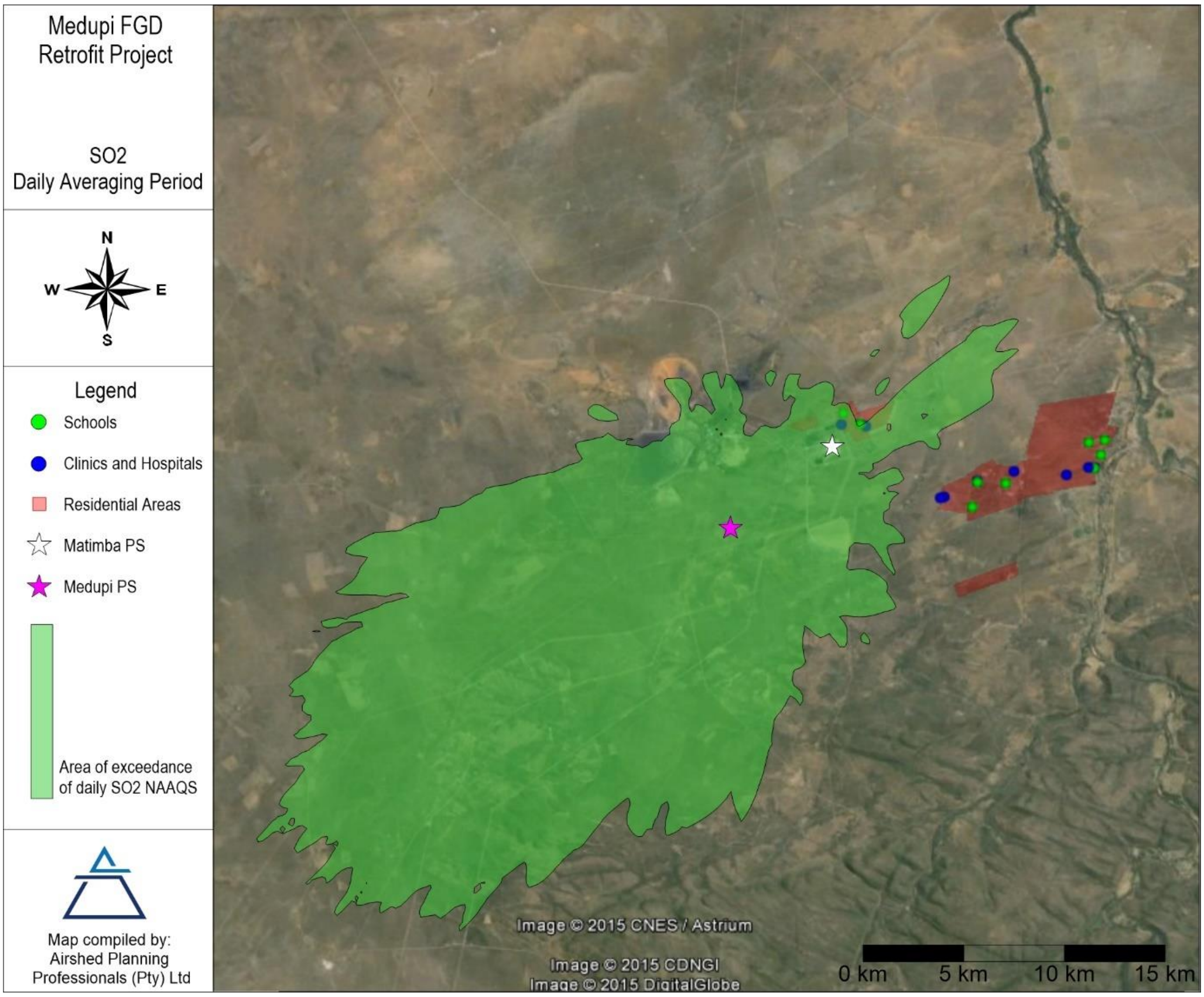

Figure 3-18: Area of exceedance of the daily SO_2 NAAQS due to the 2020 baseline conditions

Table 3-9: Simulated SO_2, NO_2, PM_{10} and $PM_{2.5}$ ground level concentrations at the closest sensitive receptors due to 2014 baseline and 2020 baseline operating conditions

Pollutant	Scenario	Receptor	Frequency of Exceedence of hourly NAAQ limit	Frequency of Exceedence of daily NAAQ limit	Annual Average Concentration (µg/m³)	Within PM_{10} NAAQS (Y/N)
SO_2	**2014 Baseline** (Matimba Power Station operations)	Settlement (NW of Matimba Power Station)	31	1	5.6	Y
		Marapong	22	2	4.3	Y
		Lephalale	24	1	4.2	Y
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD)	Settlement (NW of Matimba Power Station)	89	6	11.8	N
		Marapong	67	4	9.4	Y
		Lephalale	55	1	8.7	Y

Pollutant	Scenario	Receptor	Frequency of Exceedence of hourly NAAQ limit	Frequency of Exceedence of daily NAAQ limit	Annual Average Concentration (µg/m³)	Within PM_{10} NAAQS (Y/N)
NO_2	**2014 Baseline** (Matimba Power Station operations)	Settlement (NW of Matimba Power Station)	3	NA	1.0	Y
		Marapong	4	NA	0.7	Y
		Lephalale	1	NA	0.7	Y
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD)	Settlement (NW of Matimba Power Station)	9	NA	1.9	Y
		Marapong	4	NA	1.5	Y
		Lephalale	1	NA	1.4	Y
PM_{10}	**2014 Baseline** (Matimba Power Station operations)	Settlement (NW of Matimba Power Station)	NA	0	0.4	Y
		Marapong	NA	0	0.3	Y
		Lephalale	NA	0	0.3	Y
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD) - assuming no control on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD) - assuming 80% control efficiency on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
$PM_{2.5}$	**2014 Baseline** (Matimba Power Station operations)	Settlement (NW of Matimba Power Station)	NA	0	0.4	Y
		Marapong	NA	0	0.3	Y
		Lephalale	NA	0	0.3	Y

Pollutant	Scenario	Receptor	Frequency of Exceedence of hourly NAAQ limit	Frequency of Exceedence of daily NAAQ limit	Annual Average Concentration (µg/m³)	Within PM_{10} NAAQS (Y/N)
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD) - assuming no control on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
	2020 Baseline (Matimba Power Station operations and Medupi Power Station operations – all six units without FGD) - assuming 80% control efficiency on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y

NA: Not applicable

3.3.4 Conclusions Regarding Baseline Air Quality

The following conclusions were drawn based on the monitored and modelled baseline air quality levels in the study region:

- SO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits at the monitoring stations located at Marapong and Lephalale. Modelled SO_2 concentrations also indicate infrequent short-term exceedances of the NAAQ limits at these sensitive receptors. There is however compliance with the NAAQS.

- Currently, the Matimba Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. Other sources which may contribute significantly due to their low release level include: spontaneous combustion of coal discards associated with mining operations, clamp firing emissions during brickmaking at Hanglip and potentially household fuel burning within Marapong. The highest ground level SO_2 concentrations due to the Matimba Power Station stack emissions are expected to occur during unstable conditions, usually occurring during the day, when the plume is brought to ground in relatively close proximity to the power station.

- NO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits (but are in compliance with NAAQS) at the monitoring stations located at Marapong and Lephalale, which is reiterated in the modelled results.

Low level sources of NO_x in the region include combustion within coal discard dumps, brick firing operations and possibly also household fuel burning and infrequent veld burning.

- Measured PM_{10} concentrations exceed the daily NAAQS at Marapong for the period 2014 but are lower at Lephalale (where levels comply with daily NAAQS). The measured $PM_{2.5}$ concentrations are within the daily NAAQS applicable till 2030 at Marapong and Lephalale, but exceed the more stringent daily NAAQS applicable in 2030. The annual average PM_{10} and $PM_{2.5}$ concentrations measured at Lephalale are within NAAQS. Measured annual PM_{10} concentrations at Marapong during the period 2013 exceed annual NAAQS.

- 2014 Baseline simulations:
    - The contribution of Matimba Power Station to primary and secondary particulates was simulated, with no exceedances of the SO_2, NO_2, PM_{10} and $PM_{2.5}$ NAAQS at Marapong and Lephalale. Secondary particulates form in the atmosphere through the conversion of SO_x and NO_x emissions to sulfate and nitrate.

- 2020 Baseline simulations:
    - The area of non-compliance with the hourly and daily SO_2 NAAQS extended ~30km southwest of the Medupi Power Station due to the cumulative operations of Matimba Power Station and Medupi Power Station without FGD control. Non-compliance with the hourly and daily SO_2 NAAQS was simulated at the residential settlement to the northwest of the Matimba Power Station under these conditions.

- Various local (informed through observation from site visits) and far-field (informed by literature) sources are expected to contribute to the suspended fine particulate concentrations in the region. Local dust sources include wind erosion from exposed areas, fugitive dust from mining and brickmaking operations, vehicle entrainment from roadways and veld burning. Household fuel burning may also constitute a local source of low-level emissions. Long-range transport of particulates emitted from remote tall stacks and from biomass burning in countries to the north of Republic of South Africa (RSA) and the accumulation and recirculation of such regional air masses over the interior is well documented (Andreae et al., 1996; Garstang et al., 1996; Piketh, 1996) (detail pertaining to the recirculation of air masses is provided in Section 3.3.1.9).

4 Impact of Proposed Project on Human Health

The impact assessment for the proposed Project operations includes activities at the Medupi Power station; six units with FGD. To assess this impact with background concentrations in the area, the proposed Project operations have been considered with the Matimba Power Station operations. In order to understand the reduction in ambient SO_2 impacts that the proposed Project provides, the 2020 baseline activities (Matimba Power Station activities provided in Section 3.3.3 and Figure 3-17 and Figure 3-18) should be compared to the assessment provided in this section (Matimba Power Station activities with proposed Project operations) to realise the differential between the two scenarios.

4.1 Atmospheric Emissions

The emissions for the Matimba Power Station operations are provided in Section 3.3.3.1 and of the Medupi Power Station operations with FGD in Table 4-1.

Table 4-1: Stack parameters for the Medupi Power Station[a]

Scenario	Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
Medupi Power Station with FGD	2	220	15.4	15.96	324

(a) Parameters and emissions provided by Eskom personnel

Emission rates for SO_2, NO_x, and PM, calculated on the basis of information provided by Eskom personnel, are presented in Table 4-2.

Table 4-2: Annual emissions (in tonnes) for Medupi Power Station operating conditions (as calculated based on information provided by Eskom personnel)

Scenario	Compound	Quantity (tpa)
Medupi Power Station with FGD	SO_2	71 605
	NO_x	85 670
	PM	5 711

The gypsum from the FGD activities is proposed to be mixed with the ash on the existing ash disposal facility. The gypsum material is expected to provide a crust when mixed with water. To what extent this material will crust will depend on how the material is disposed (i.e. mixed with the ash or deposited as layers of gypsum material in between the ash material) and how much water is added to the disposal facility. The crust may also be disturbed from time to time with activity on the disposal facility. It is therefore not possible to determine the effectiveness of the gypsum material in mitigating the windblown dust from this source. Fugitive dust from the proposed ash dump were therefore assumed to be similar to 2020 baseline operations with approach outlined in Section 3.3.3.1 having been applied.

Limestone will need to be transported to site for the FGD and the sludge and salts will be temporarily stored on a prepared waste storage facility prior to being transported from site to a licenced facility. The transport of the waste will be undertaken via trucks. The limestone will initially be transported via trucks but will later be transported via rail. The trips per day (as provided by the proponent) were given as 13 and 69 for waste (salts and sludge) and limestone respectively when all six units are operational. The calculated PM_{10} and $PM_{2.5}$ emissions as calculated using the US-EPA emission factor for paved roads was 2.95×10^{-5} g/s/m² and 7.15×10^{-6} g/s/m² respectively. As part of the air quality assessment, a qualitative assessment of the potential impacts from the road was requested and is provided in Section 4.2.

4.2 Impact Assessment

4.2.1 Qualitative Assessment

To provide an indication of the potential distance and significance of impacts from these activities, the US EPA screening model (Screen View version 3.5.0) is used. This model represents a quick method to calculate and “flag” the “worst-case” concentration that might occur. Screening models require very little input and have a built-in set of meteorological conditions based on stability classes. It is a quick screening tool to identify possible sources that might require more detailed modelling. It is important to note that these models do not use actual meteorological data, but rather set stability classes that will produce the highest impacts. The impacts are therefore not related to the actual wind directions or speeds. More sophisticated Gaussian plume and puff models such as the US EPA regulatory AERMOD and CALPUFF models use actual meteorological conditions. For the purpose of providing a professional opinion on the potential impacts from the road (due to vehicle entrainment), a screening model is sufficient as the focus is merely to provide an indication of the potential significance of the operations on the surrounding environment.

The output from the screening model is provided as highest hourly concentrations. In order to obtain the highest daily and annual average concentrations to compare to ambient air quality guidelines, equivalent concentrations were extrapolated. For extrapolating time averaging periods from 1 hour to 24 hours and 1 year, Beychock (2005) recommends the following equation:

$$C_x / C_p = \left(t_p / t_x \right)^{0.2}$$

where:

Cx and Cp are concentrations over any two averaging periods;
tx and tp are corresponding averaging times.

Figure 4-1 and Figure 4-2 provides a graphic representation of the possible PM_{10} and $PM_{2.5}$ concentrations at set distances from the proposed road. The concentrations are irrespective of actual wind speed and direction and reflect the worst-case scenario. The PM_{10} and $PM_{2.5}$ concentrations due to vehicle entrainment as a result of transporting limestone, salts and sludge on a paved road surface (assuming all six units are operational) are well below the NAAQS.

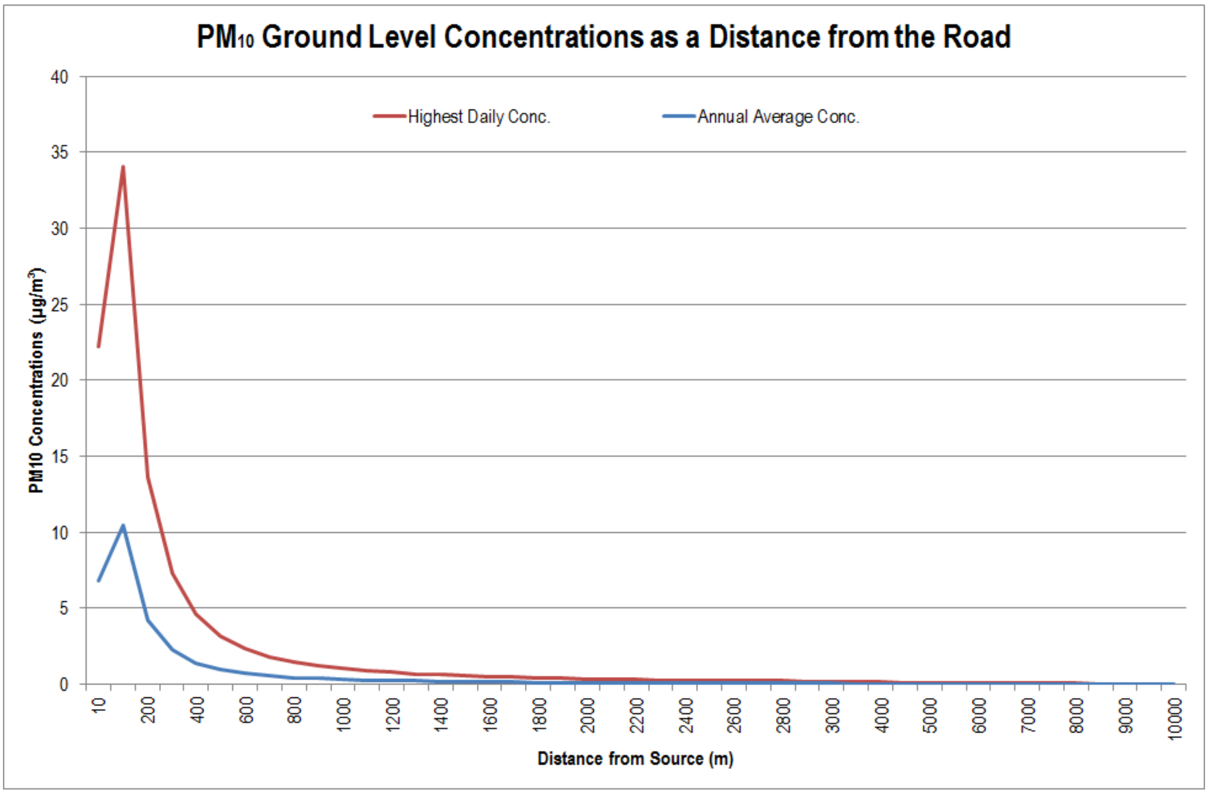

Figure 4-1: Estimated highest daily and annual average PM_{10} ground level concentrations, due to vehicle entrainment, at set distances from the emission source

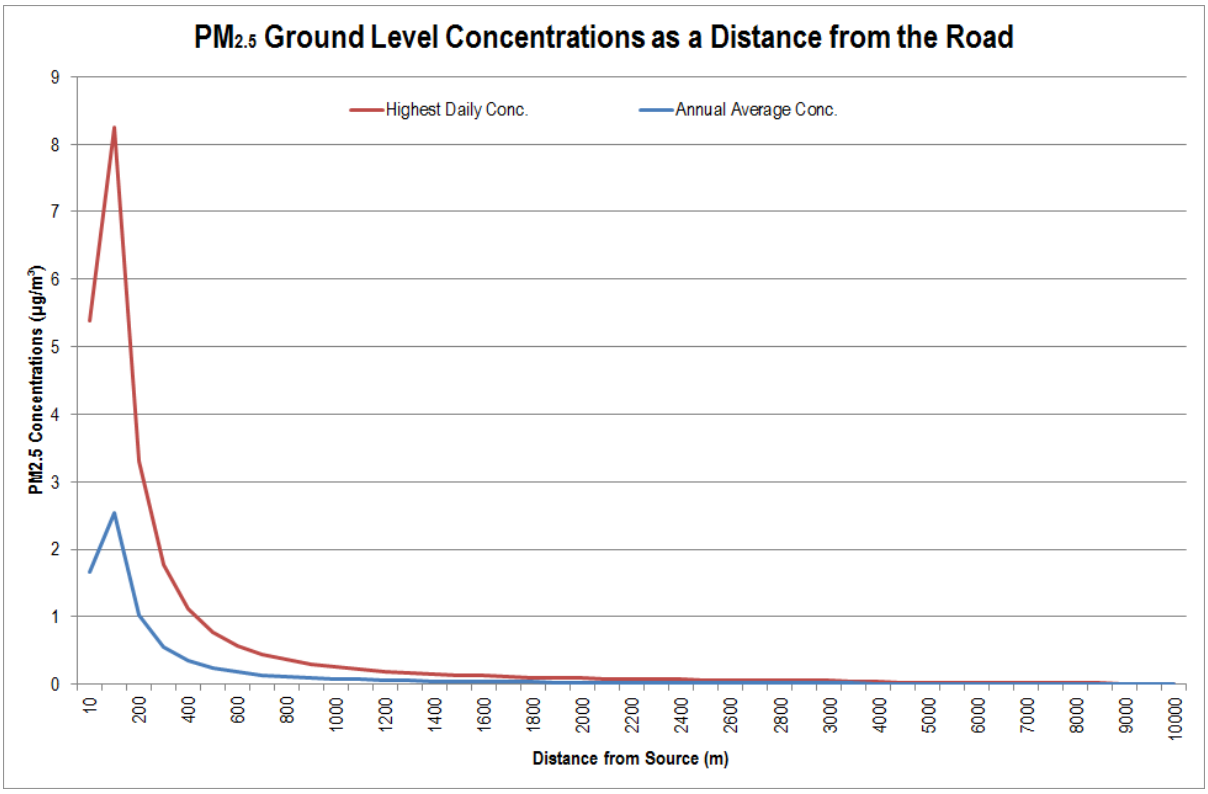

Figure 4-2: Estimated highest daily and annual average $PM_{2.5}$ ground level concentrations, due to vehicle entrainment, at set distances from the emission source

4.2.2 Quantitative Assessment

Isopleth plots illustrating exceedance of the NAAQS for the operations of Matimba and Medupi with FGD are provided in Figure 4-3 and Figure 4-4 (to be seen in comparison with 2020 baseline – Figure 3-17 and Figure 3-18). A synopsis of the compliance of SO_2, NO_2, PM_{10} and $PM_{2.5}$ concentrations with the NAAQS due to proposed Project operations is provided in Table 4-3 (to be seen in comparison to Table 3-9 – 2020 baseline).

The area of exceedance of the SO_2 NAAQS due to Matimba Power Station and Medupi with FGD (Figure 4-3 and Figure 4-4) is significantly reduced from the 2020 baseline operations (Figure 3-17 and Figure 3-18) bringing the simulated ground level concentrations into compliance with the hourly and daily NAAQS at all sensitive receptors in the study area.

Simulated NO_2 ground level concentrations due to proposed Project operations (Table 4-3) increase slightly from the 2020 baseline conditions due to the decrease in dispersion potential with the introduction of FGD (i.e. with FGD, the stack exit temperature decreases). The simulated NO_2 concentrations at the closest sensitive receptors are, however, within NAAQS due to Matimba Power Station activities and proposed Project operations.

Simulated PM_{10} and $PM_{2.5}$ concentrations due to Matimba Power Station activities and proposed Project operations (Table 4-3) are similar in magnitude to the 2020 baseline operations (Table 3-9) and are well within NAAQS.

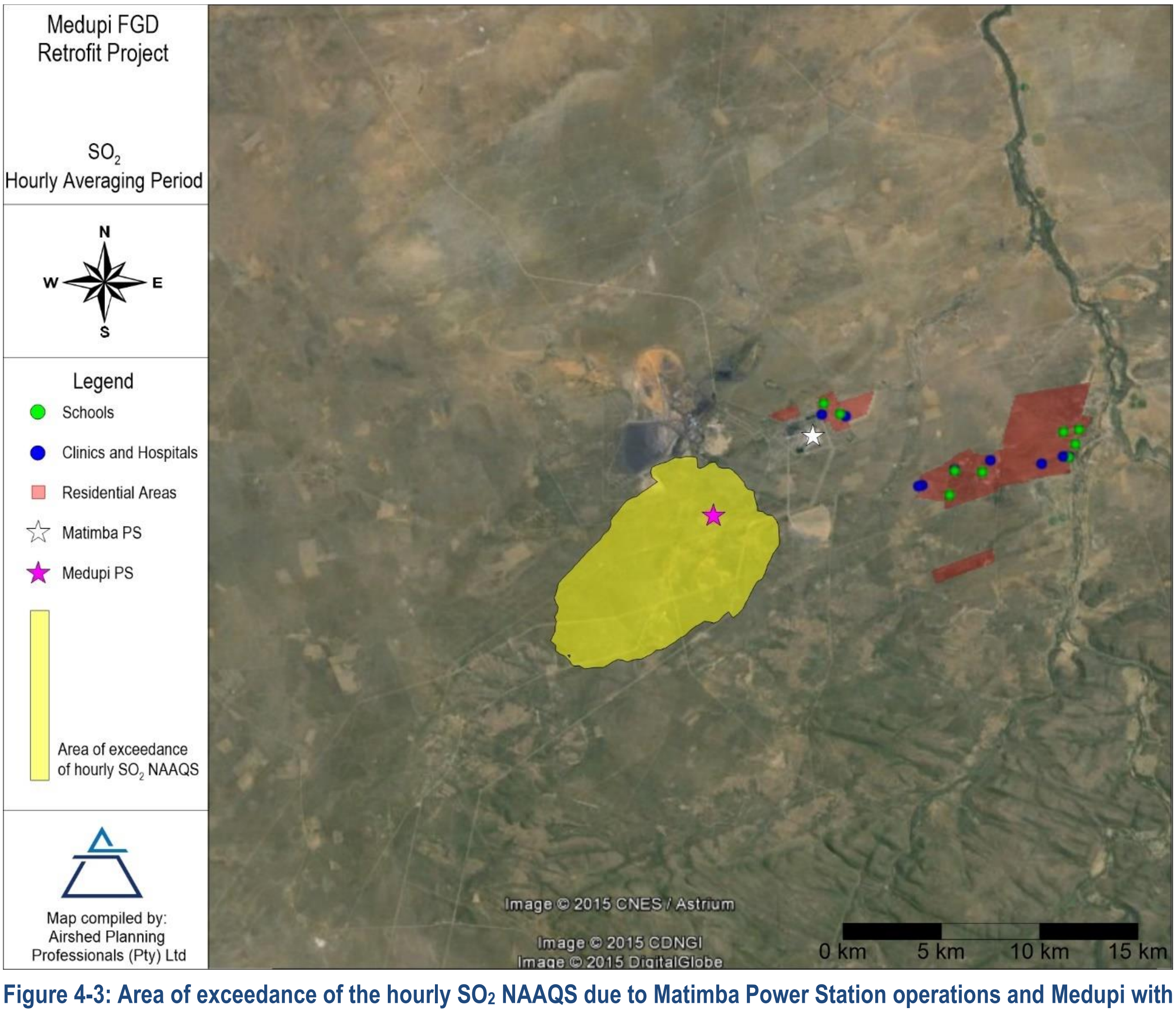

Figure 4-3: Area of exceedance of the hourly SO_2 NAAQS due to Matimba Power Station operations and Medupi with FGD

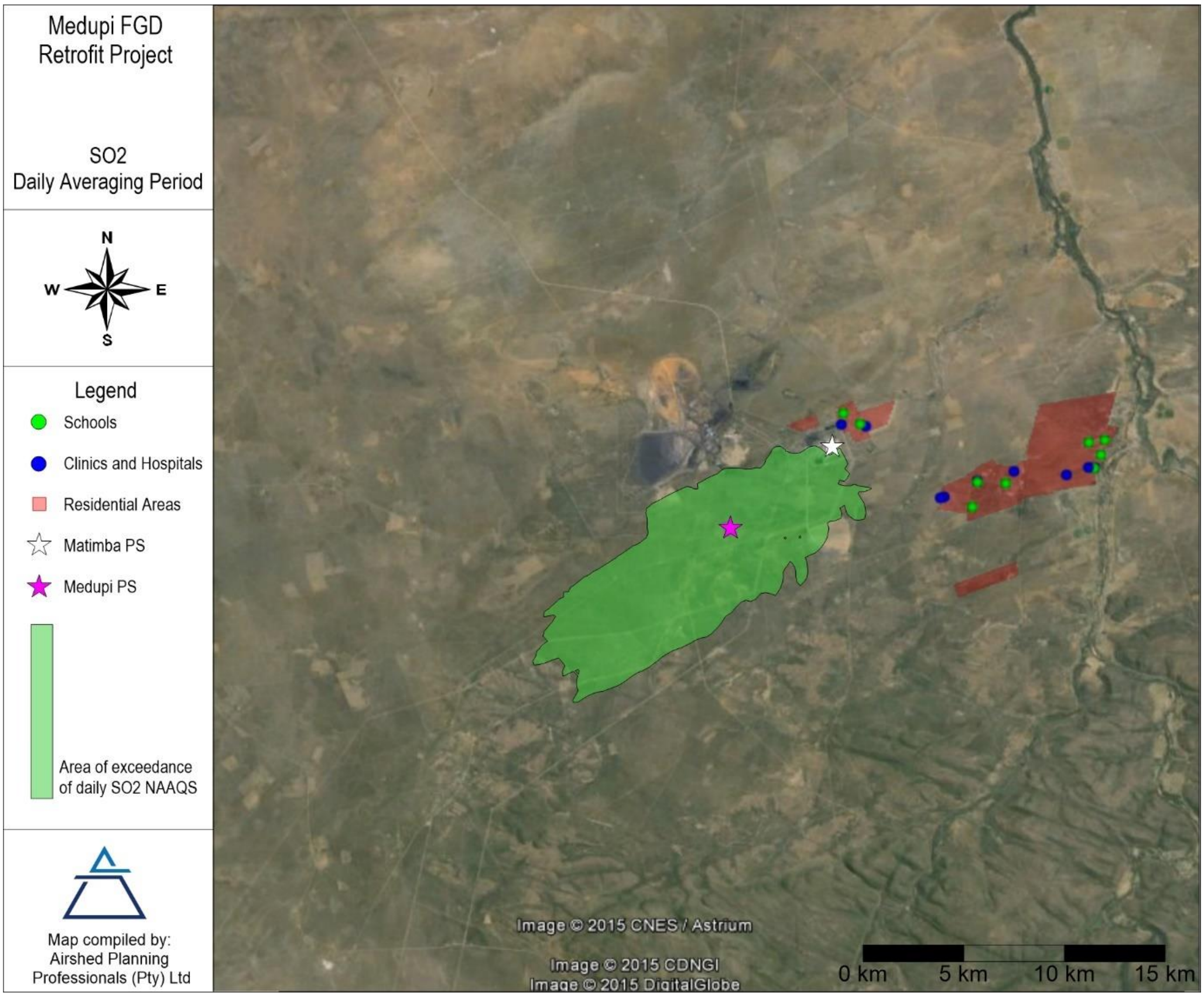

Figure 4-4: Area of exceedance of the daily SO_2 NAAQS due to Matimba Power Station operations and Medupi with FGD

Table 4-3: Simulated SO_2, NO_2, PM_{10} and $PM_{2.5}$ ground level concentrations at the closest sensitive receptors due to Matimba Power Station operations and Medupi with FGD

Pollutant	Scenario	Receptor	Frequency of Exceedence of hourly NAAQ limit	Frequency of Exceedence of daily NAAQ limit	Annual Average Concentration (µg/m³)	Within PM_{10} NAAQS (Y/N)
SO_2	**Proposed Project operations:** Matimba Power Station and Medupi Power Station (with FGD)	Settlement (NW of Matimba Power Station)	34	2	8.0	Y
		Marapong	22	2	5.8	Y
		Lephalale	25	1	5.6	Y
NO_2	**Proposed Project operations:** Matimba Power Station and Medupi Power	Settlement (NW of Matimba Power Station)	27	NA	3.4	Y
		Marapong	14	NA	2.6	Y
		Lephalale	5	NA	2.0	Y

Pollutant	Scenario	Receptor	Frequency of Exceedence of hourly NAAQ limit	Frequency of Exceedence of daily NAAQ limit	Annual Average Concentration (µg/m³)	Within PM_{10} NAAQS (Y/N)
	Station (with FGD)					
PM_{10}	**Proposed Project operations:** Matimba Power Station and Medupi Power Station (with FGD) – assuming no control on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
	Proposed Project operations: Matimba Power Station and Medupi Power Station (with FGD) – assuming 80% control efficiency on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
$PM_{2.5}$	**Proposed Project operations:** Matimba Power Station and Medupi Power Station (with FGD) – assuming no control on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y
	Proposed Project operations: Matimba Power Station and Medupi Power Station (with FGD) – assuming 80% control efficiency on the proposed Medupi ash disposal facility	Settlement (NW of Matimba Power Station)	NA	0	0.7	Y
		Marapong	NA	0	0.6	Y
		Lephalale	NA	0	0.6	Y

NA: Not applicable

Although the quantification of trace element emissions from the coal combustion process did not form part of the scope of the assessment, an overview of these emissions and the control thereof are provided in Appendix B.

4.3 Impact Significance Rating

The operational phase is considered to be the phase with the largest impact on ambient air quality. The Construction and Rehabilitation (Closure) phases are not likely to impact the ambient air quality more than the existing (status quo) status. All impacts are based on the dispersion modelling results. The impact significance rating for the operational scenario is presented in Table 4-4.

4.3.1 Existing Status

The 2020 baseline conditions were assessed as the existing status which includes the operations of the Matimba Power Station and the Medupi Power Station including six units without FGD.

Simulated impacts from the Matimba Power Station and the Medupi Power Station without FGD (2020 baseline) was in non-compliance with SO_2 NAAQS on a regional scale resulting in a MODERATE significance.

No exceedances of the NAAQS for NO_2, PM_{10} and $PM_{2.5}$ were simulated at sensitive receptors due to 2020 baseline operations resulting in LOW significance.

4.3.2 Cumulative Impact

The proposed Project operations were assessed as the cumulative impact which includes the operations of the Matimba Power Station and the Medupi Power Station including six units with FGD.

The area of non-compliance of cumulative SO_2 concentrations reduces significantly with FGD with no exceedances of the NAAQS at sensitive receptors, reducing the significance to LOW.

No exceedances of the NAAQS for NO_2, PM_{10} and $PM_{2.5}$ were simulated at sensitive receptors due to proposed Project operations resulting in LOW significance.

4.3.3 Mitigation Measures

Effective mitigation of particulate emissions on the Medupi ash disposal facility will include:

- Regular wetting of exposed areas of disposal facility;
- Stabilization of the exposed areas with a top-soil covering;
- Wetting of exposed top-soil for additional mitigation of dust emissions from the top-soil layer;
- Re-vegetation of the ash disposal facility through application of a deeper top-soil layer and seeding with appropriate grass seeds.

4.3.4 Residual Impact

The residual impact of the ash disposal facility (including the increase in height of 12 m) shows little impact in magnitude at the sensitive receptors (located upwind of the facility) on a daily and annual averaging period providing no change in significance on PM from cumulative to residual operations. As only mitigation of PM is considered, it is the only pollutant that could be assessed in terms of residual.

Table 4-4: Impact rating matrix for the proposed project operations

OPERATIONAL PHASE									
Activity	**Description of Impact**	**Impact type**	**Spatial Scale**	**Duration**	**Significance**	**Probability**	**Rating**	**Mitigation Measures**	**Interpretation**
Operational phase for the proposed Project	SO_2	Existing[(a)]	4	3	4	4	2.9 - MOD	The FGD control is considered a scenario of the assessment and not a mitigation measure for the significance rating as it is an operational activity that is to take place. The significance of the residual impact for SO_2 and NO_2 therefore remain unchanged.	The significance rating was provided taking into consideration the area of non-compliance with current NAAQS and the location of residential areas. No significant change in PM daily and annual impact in terms of magnitude were simulated at residential areas for mitigated and unmitigated ash facility activities providing little change in significance for cumulative and residual impacts. This is due to high incidental impacts occurring due to ash disposal facility operations, but the incidental impacts average over daily and annual time frames. The measured ambient air quality for PM_{10} is currently in non-compliance with NAAQS at Marapong but no significant change in magnitude and spatial distribution from measured ambient concentrations is simulated due to proposed Project operations.
		Cumulative[(b)]	3	3	3	3	1.8 - LOW		
		Residual	3	3	3	3	1.8 - LOW		
	NO_2	Existing[(a)]	2	3	3	3	1.6 - LOW		
		Cumulative[(b)]	2	3	3	3	1.6 - LOW		
		Residual	2	3	3	3	1.6 - LOW		
	PM_{10}	Existing[(a)]	2	3	3	3	1.6 - LOW	An unmitigated and mitigated (80% control efficiency) scenario on the proposed Medupi ash disposal facility was considered. The mitigation that can be implemented in continual re-vegetation and wetting of the disposal facility.	
		Cumulative[(b)]	2	3	3	3	1.6 - LOW		
		Residual	2	3	3	3	1.6 - LOW		
	$PM_{2.5}$	Existing[(a)]	2	3	3	3	1.6 - LOW		
		Cumulative[(b)]	2	3	3	3	1.6 - LOW		
		Residual	2	3	3	3	1.6 - LOW		

(a) Existing conditions is based on the simulated 2020 baseline operations which includes the activities of the Matimba Power Station and the Medupi Power Station operations with six units excluding FGD

(b) Cumulative conditions are based on the simulated proposed Project operations which includes the activities of the Matimba Power Station and the Medupi Power Station operations with six units including FGD

5 CONCLUSIONS

5.1 Baseline Air Quality Study Findings

The main findings from the baseline air quality characterisation study, which was based on information from both monitoring and modelling studies, are as follows:

- SO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits at the monitoring stations located at Marapong and Lephalale. Modelled SO_2 concentrations also indicate infrequent short-term exceedances of the NAAQ limits at these sensitive receptors. There is however compliance with the NAAQS.

- Currently, the Matimba Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. Other sources which may contribute significantly due to their low release level include: spontaneous combustion of coal discards associated with mining operations, clamp firing emissions during brickmaking at Hanglip and potentially household fuel burning within Marapong. The highest ground level SO_2 concentrations due to the Matimba Power Station stack emissions are expected to occur during unstable conditions, usually occurring during the day, when the plume is brought to ground in relatively close proximity to the power station.

- NO_2 concentrations have been measured to infrequently exceed short-term NAAQ limits (but are in compliance with NAAQS) at the monitoring stations located at Marapong and Lephalale, which is reiterated in the modelled results. Low level sources of NO_x in the region include combustion within coal discard dumps, brick firing operations and possibly also household fuel burning and infrequent veld burning.

- Measured PM_{10} concentrations exceed the daily NAAQS at Marapong for the period 2014 but are lower at Lephalale (where levels comply with daily NAAQS). The measured $PM_{2.5}$ concentrations are within the daily NAAQS applicable till 2030 at Marapong and Lephalale, but exceed the more stringent daily NAAQS applicable in 2030. The annual average PM_{10} and $PM_{2.5}$ concentrations measured at Lephalale are within NAAQS. Measured annual PM_{10} concentrations at Marapong during the period 2013 exceed annual NAAQS.

- 2014 Baseline simulations:
  - The contribution of current Matimba Power Station operations to primary and secondary particulates was simulated, with no exceedances of the SO_2, NO_2, PM_{10} and $PM_{2.5}$ NAAQS at Marapong and Lephalale. Secondary particulates form in the atmosphere through the conversion of SO_x and NO_x emissions to sulfate and nitrate.

- 2020 Baseline simulations:
  - The area of non-compliance with the hourly and daily SO_2 NAAQS extended ~30km southwest of the Medupi Power Station due to the cumulative operations of the current Matimba Power Station and proposed Medupi Power Station (all 6 units) without FGD control. Non-compliance with the hourly and daily SO_2 NAAQS was simulated at the residential settlement to the northwest of the Matimba Power Station under these conditions.

- Various local (informed through observation from site visits) and far-field (informed by literature) sources are expected to contribute to the suspended fine particulate concentrations in the region. Local dust sources include wind erosion from exposed areas, fugitive dust from mining and brickmaking operations, vehicle entrainment from roadways and veld burning. Household fuel burning may also constitute a local source of low-level emissions. Long-range transport of particulates emitted from remote tall stacks and from biomass burning in countries to the north of Republic of South Africa (RSA) and the accumulation and recirculation of such regional air masses over the interior is well documented (Andreae et al., 1996; Garstang et al., 1996; Piketh, 1996) (detail pertaining to the recirculation of air masses is provided in Section 3.3.1.9).

5.2 Impact Assessment for Proposed Project

It should be noted that proposed impacts were assessed taking into consideration current Matimba Power Station operations and the proposed Medupi Power Station operations (all 6 units) with FGD. The main findings of the impact assessment for the proposed Project are provided as follows:

- The area of exceedance of the hourly and daily SO_2 NAAQS was significantly reduced when FGD controls on the Medupi Power Station is considered, bringing the simulated ground level concentrations within compliance of the hourly and daily SO_2 NAAQS at all sensitive receptors in the study area.

- Simulated impacts from the Matimba Power Station and the Medupi Power Station without FGD (2020 baseline) was in non-compliance with SO_2 NAAQS on a regional scale resulting in a MODERATE significance. The area of non-compliance of SO_2 concentrations reduces significantly for proposed Project operations (i.e. Matimba Power Station operations and Medupi Power Station operations with FGD) and reduces the significance to LOW as no exceedances of the NAAQS are simulated at the closest sensitive receptors in the study area. No exceedances of the NAAQS for NO_2, PM_{10} and $PM_{2.5}$ were simulated at sensitive receptors due to proposed Project operations resulting in LOW significance. The available monitoring data shows that the PM_{10} concentrations are in non-compliance with the daily NAAQS at Marapong. Simulated impacts due to proposed Project operations, however, do not contribute significantly to current ambient particulate concentrations.

5.3 Recommendation

As the proposed Project operations will significantly reduce SO_2 impacts from the Medupi Power Station, it is recommended that the FGD Retrofit Project (including the increase in height of the ADF with 12 m) be implemented. The movement of sludge and salt off-site to a licenced facility will contribute to fugitive vehicle entrainment emissions. It is recommended that the access road being used is properly maintained to minimise the impacts from this source.

6 REFERENCES

Andreae, M.O., Atlas, E., Cachier, H., Cofer, W.R., Harris, G.W., Helas, G., Koppman, R., Lacaux, J. and Ward, D.E., (1996): Trace gas and aerosol emissions from savanna fires, J.S. Levine (ed.), Biomass Burning and Global Change, MIT Press, Cambridge, 278-294.

Burger L W (1994). Ash Dump Dispersion Modeling, in Held G: Modeling of Blow-Off Dust From Ash Dumps, Eskom Report TRR/S94/185, Cleveland, 40 pp.

Burger, L. (2010). *Complexities in the estimation of emissions and impacts of wind generated fugitive dust.* Polokwane: NACA.

Burger L W, Held G and Snow N H (1995). Ash Dump Dispersion Modeling Sensitivity Analysis of Meteorological and Ash Dump Parameters, Eskom Report TRR/S95/077, Cleveland, 18 pp.

Burger, L., & Held, G. S. (1997). *Revised User's Manual for the Airborne Dust Dispersion Model from Area Sources (ADDAS).* Eskom TSI Report No. TRR/T97?066.

Garstang, M., Tyson, P.D., Swap, R. and Edwards, M., (1996). Horizontal and vertical transport of air over southern Africa, submitted to Journal of Geophysical Research.

Godish T. (1990). Air Quality, Lewis Publishers, Michigan, 422 pp.

Goldreich Y and Tyson P D (1988). Diurnal and Inter-Diurnal Variations in Large-Scale Atmospheric Turbulence over Southern Africa, South African Geographical Journal, 70(1), 48-56.

Liebenberg-Enslin, H. (2014). *A Functional Dependence Analysis of Wind Erosion Modelling System Parameters to Determine a Practical Approach for Wind Erosion Assessments.* Johannesburg: Doctoral dissertation: University of Johannesburg.

Marticorena, B., & Bergametti, G. (1995). Modelling the Atmospheric Dust Cycle 1 Design of a Soil-Derived Dust Emission Scheme. *Journal of Geophysical Research, 100*, 16415 - 16430.

Oke T T (1990). Boundary Layer Climates, Routledge, London and New York, 435 pp.

Pasquill F and Smith F B (1983). Atmospheric Diffusion: Study of the Dispersion of Windborne Material from Industrial and Other Sources, Ellis Horwood Ltd, Chichester, 437 pp.

Piketh, S.J., Annegarn, H.J. and Kneen, M.A., (1996). Regional scale impacts of biomass burning emissions over southern Africa, in J.S. Levine (ed.), Biomass Burning and Global Change, MIT Press, Cambridge, 320-326.

Scire, J. and Borissova M (2011). *An Empirical Method for Modeling Short-Term and Annual NO_2 Concentrations in Regulatory Models*, TRC Energy & Environment Conference (EUEC), Phoenix, Arizona.

Scorgie, Y; Krause, N and Petzer, G (2006). Air Quality Impact Assessment for the Proposed New Coal-Fired Power Station in the Lephalale Area, Limpopo Province. Report No. APP/06/BWK-01 Rev 1.0.

Seinfeld, J.H. and S. N. Pandis, 1998: Atmospheric Chemistry and Physics. John Wiley & Sons, New York.

Shao, Y. (2008). *Physics ad Modelling of Wind Erosion. Atmospheric and Oceanographic Science Library, 2nd Revised and Expanded Edition.* Springer Science.

Shaw, R. W., & Munn, R. E. (1971). Air Pollution Meteorology. In B. M. McCormac, *Introduction to the Scientific Study of Air Pollution* (pp. 53-96). Dordrecht-Holland: Reidel Publishing Company.

Strimaitis D.G., Scire J.S. and Chang J.C., (1998). Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets, Preprints 10th Joint Conference on the Applications of Air Pollution Meteorology, 11-16 January 1998, Phoenix, Arizona.

Xua, M., Yanb, R., Zhengaa, C., Qiaoa, Y., Hana, J., & Shenga, C. (2003). Status of Trace Element Emission in Coal Combustion Process. *Fuel Processing Technology*.

Zunckel, M., & Raghunandan, A. (2014). *Atmospheric Impact Report in support of Eskom's application for postponement of the Minimum Emission Standards compliance timeframes for the Matimba Power Station.* uMoya-NILU Consulting (Pty) Ltd.

U.S. EPA (1992). *Protocol for Determining the Best Performing Model*. U.S. Environmental Protection Agency. Research Triangle Park, 2 NC. EPA-454/R-92-025.

US EPA (1998). Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts, U.S. Environmental Protection Agency EPA-454/R-98-019, Research Triangle Park, NC.

US EPA (2005). Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions. North Carolina, U.S. Environmental Protection Agency, 2005. Federal Register / Vol. 70, No. 216 / Rules and Regulations. Appendix W of 40 CRF Part 51.

7 APPENDIX A - THE NO_2/NO_x CONVERSION RATIOS FOR NO_2 FORMATION

As a starting basis, the NO_2/NO_x conversion factors described by Scire and Borissova (2011) as given in Table A-1 will be employed. Observed NO_2/NO_x ratios at the Marapong monitoring station were also analysed and compared to the factors in the table (Figure A-1).

Table A-1: NO_2/NO_x conversation ratios for NO_2 formation

Bin	Concentration (ppb)			NO_2/NO_x Ratios		
				Eskom	Scire and Borissova 2011	
	Min	Max	Ave	Marapong 2012-2014	Bin Average	1-Hour Max
1	0	10	5	0.722	0.798	0.994
2	10	20	15	0.647	0.813	0.992
3	20	40	30	0.629	0.731	0.984
4	40	60	50	0.500	0.554	0.909
5	60	80	70	0.430	0.437	0.748
6	80	100	90	0.360	0.355	0.609
7	100	125	112.5	0.312	0.301	0.498
8	125	150	137.5	0.270	0.256	0.417
9	150	175	162.5	0.248	0.228	0.354
10	175	200	187.5	0.203	0.208	0.306
11	200	225	212.5	0.235	0.185	0.268
12	225	250	237.5	0.187	0.181	0.240
13	250	275	262.5	0.189	0.177	0.219
14	275	300	287.5		0.155	0.204
15	300	325	312.5	0.156	0.152	0.191
16	325	350	337.5		0.148	0.181
17	350	375	362.5		0.140	0.173
18	375	400	387.5		0.136	0.165
19	400	450	425		0.142	0.153
20	450	500	475		0.122	0.151
21	500	600	550		0.109	0.147
22	600	700	650		0.111	0.143
23	700	800	750		0.111	0.139
24	800	950	875		0.117	0.134

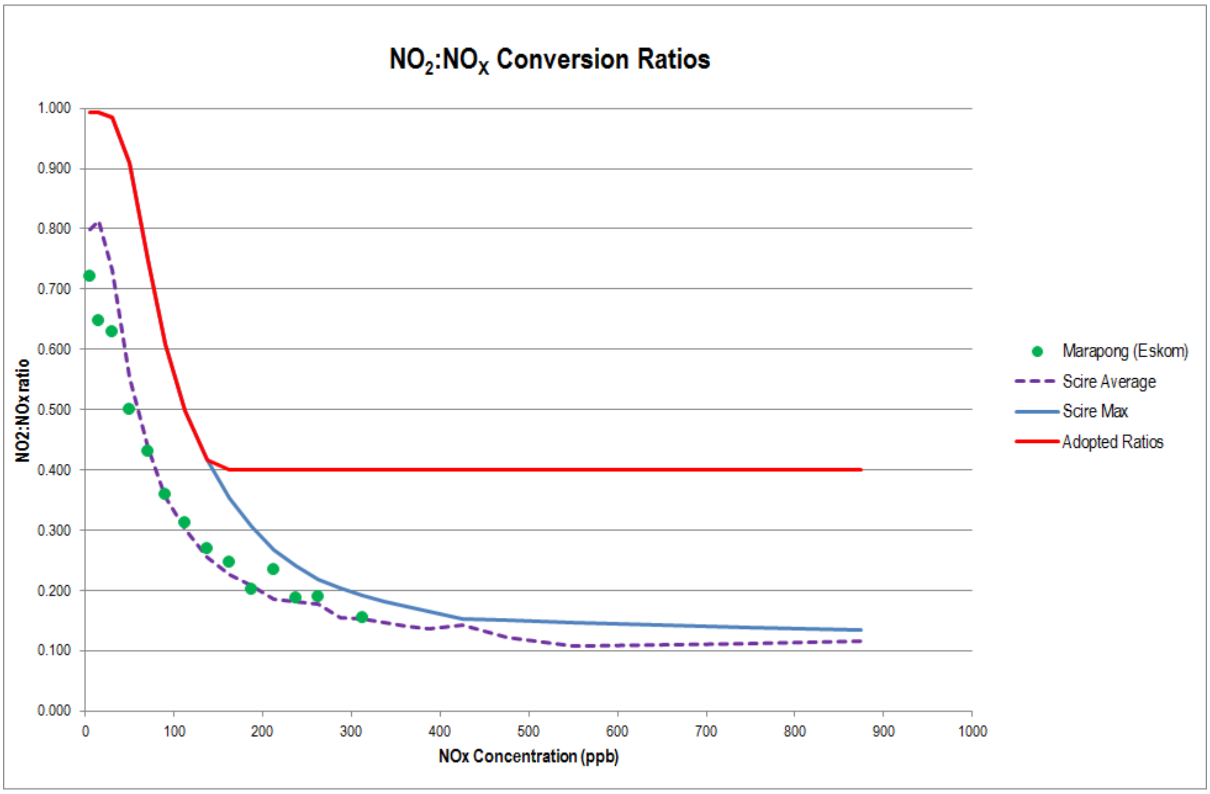

Figure A-1: NO_2/NO_x conversation ratios for the Marapong monitoring station

8 APPENDIX B - SUMMARY OF: STATUS OF TRACE ELEMENT EMISSION IN A COAL COMBUSTION PROCESS: A REVIEW (XUA, ET AL., 2003)

After numerous studies carried out on the occurrence and distribution of trace elements in coal, it is accepted that the trace elements (TEs') combination and contents differ from one coal to another due to the different coalification processes. However, knowledge of TE distribution in coal is very important since it permits the possible prediction of TE release from combustion. Both TE concentration and their chemical affinity vary strongly with the coals from different sources. The comparison between results concerning studies about worldwide coals is useful to find out some general rules. However, it still needs a long time to achieve a general understanding of partitioning in the coal-fired flue gases.

The main proportion of almost all elements is bound with the fly ash and collected in the electrostatic precipitator (ESP). Boron (B) and selenium (Se) are partially discharged in the vapour phase, and mercury (Hg), which exhibits a very high vapour pressure at typical stack outlet temperature, is almost fully released with the flue gas. The elements associated mostly with the organic and sulfide fractions (for example As, Cd, Hg) tend to vaporise firstly and then adsorb onto fine particles during flue gas cooling. In contrast elements combined with the discrete mineral matter (such as Mn) more possibly remain in the ash matrix.

The TE enrichment trends in submicron particles have been reported by many authors. Most TEs, which are partially or fully vaporized during coal combustion, tend to condense and enrich in the submicron particles with a significant surface-to-volume ratio. The submicron particles have more harmful impacts than the super-micron particles since they have long residence time in the atmosphere and a high probability to deposit in human being lungs. Moreover, they can be collected by air pollution control devices (APC) with very low efficiency only.

Based on partition and enrichment behaviour of elements, three basic classes of trace elements can be defined:

- Class I: Elements approximately equally distributed between the bottom ash and fly ash, or show no significant enrichment or depletion in the bottom ash.
- Class II: Elements enriched in the fly ash and depleted in the bottom ash, or show increasing enrichment with decreasing fly ash particle size.
- Class III: Elements totally emitted in the vapor phase.

Mercury is present in coal in trace amounts. During combustion the mercury is released into the exhaust gas as elemental mercury vapour Hg^0. As the combustion gases cool, this elemental mercury is then oxidized to Hg^{2+} via homogeneous mercury chlorination reaction or heterogeneous reaction promoted by fly ash and unburnt carbon. Oxidised mercury is more easily captured in PM control device. Factors affecting the oxidation processes include: coal chlorine content, gas temperature, surface reaction with ash and unburnt carbon and plant operating conditions. There seems to be an important relationship between the chlorine content of coal and the percentage of oxidized mercury. Coals with higher chlorine contents produced greater amounts of oxidized mercury. It has also been reported that other flue gas species especially SO_3 and H_2O tend to suppress the oxidation to Hg^{2+}. This is probably due to competition for active sites on the surface of carbon or other flue gas solids.

The most volatile TEs (Hg, Se, As), to which we have often paid more attention, and halogens, etc., remain mostly in the vapour phase as they pass through heat transfer sections of a boiler. The percentages of the total in-stack concentrations of these elements in the vapour phase have been reported to be: Cl, up to 99% as HCl; F, up to 90% as HF; Br, 25–98% as HBr; Hg, up to 98% as Hg, HgO and CH_3Hg; Se, up to 59% as Se and SeO_2; As, 0.7–52% as As_2O_3; and I, 90–99% as HI. Although mercury (Hg) concentration in coal is usually extremely low, significant attention is focused on its emission because its capture by APC systems is problematic, and moreover, it is highly toxic to human health and it bioaccumulates.

Emission controls

Donnelly reported a review about metal emission control technologies for waste incineration. The major fraction of toxic metals found in flue gases exists as fine-particle matter; nevertheless, a significant fraction of certain metals (such as B, Hg, Se) exists in the vapour phase at typical incinerator (or boiler) exit flue gas conditions. The control of the particulate fraction is achieved by utilizing traditional particulate control devices. Fabric filter and electrostatic precipitators (ESPs) efficiently trap trace elements in the particulate phase with removal efficiency of the order of 99-99.9% for Class I elements, 95-99% for some Class II elements such as Pb, Cd, Ni & Mn and less for the Class III elements.). As the efficiencies of particulate control devices are generally low in the 0.1–1.5 μm particle size range, there has been concern that trace elements may escape ESPs if they are 'preferentially enriched' on these fine particles.

Control of the vapour phase fraction is achieved through cooling of the flue gas and collection of the fine particulate thus formed. Below, more details about the control methods of toxic metals are given.

Spray dryer absorption systems

Spray dryer absorption (SDA) has been widely applied for waste incinerator emission control, and it has demonstrated high collection efficiencies for most toxic metals present in the flue gas. SDA has been specified as the best available control technology in a number of municipal waste incinerator air permits.

Toxic metal removal in the dust collector is enhanced by cooling the incoming flue gas (from 2000 to 450 jC) as it passes through the spray dryer. Because of the cooling, some vaporized metals condense to form fine particulates, which grow through impaction and agglomeration with the very high number of lime droplets produced by atomization devices. Then these agglomerated particles are easily removed. Generally, the lower the spray dryer outlet temperature, the higher the efficiency of the acid gas absorption and the vaporized toxic metal removal. The minimum reliable operating outlet temperature depends on the spray dryer and dust collector design, and on the composition of the dry fly ash reaction product. The spray dryer outlet temperature must be maintained high enough to ensure complete reagent evaporation and the production of a free-flowing product.

Wet scrubbers

Wet scrubbers control the vapour phase emissions through gas cooling and collection of the resulting condensed fine toxic metal particulates. The most commonly used wet scrubbers for this type of service are the electrostatically (or ionizing) enhanced wet scrubbers and the condensing wet scrubber.

Sorbent injection

It should be noticed that the high volatility and existence in the vapour phase make such trace element control a very difficult task to accomplish. In principle, trace elements in vapour phase can be condensed by lowering the temperature. However, as indicated above, the resulting loss in buoyancy of the flue gas would require reheating the flue gas, which would not be economical. Furthermore, the resultant particles may be in the sub-micrometre sizes, and these particles are not effectively captured in conventional particulate control devices. Capture of these species on sorbents by physical or chemical means is therefore a very attractive alternative.

The sorbent–metal interaction can be physical or chemical in nature, or it can be a combination of these two processes depending on the temperature under consideration. Mineral sorbents such as hydrated lime, limestone and kaolinite were shown to be effective for arsenic, cadmium and lead capture at 1000–1300 °C range. In a fluidized bed combustor, optimum capture of lead and cadmium using mineral sorbents takes place at around 700 °C. Other sorbents such as fly ash and activated carbon have shown to be possible alternatives to these mineral sorbents. Trace elements such as As, Cu, Mo, Pb and Zn have been shown to be concentrated on fly ash in a power station flue gas.

In the past few years, dry sorbent injection for in situ capture of metal from hot flue gas has been studied with the aim of developing a potential control technique. Due to the occurrence of multiple trace elements in flue gas in addition to SO_2, NO_x, etc. recent efforts of the research community have been geared towards developing a multifunctional sorbent which is capable of reducing emission of most of the pollutants below a certain acceptable standard. Activated carbon offers an attractive option for use as a multifunctional sorbent in the low temperature range because of its performance in capturing mercury and SO_2. Direct injection of activated carbon into the flue gas stream in the duct region has been proposed to be an effective technology since it has the potential for high mercury removal efficiencies. Calcium-based sorbents, because of their low cost, have been used extensively for the capture of acidic species such as sulfur dioxide. These sorbents also offer an attractive option to be used as multifunctional sorbents because of their ability to capture sulfur species as well as trace elements such as selenium and arsenic species. When used as a sorbent to capture the toxic species in the flue gas, the sorbent interacts with various components and the extent of interaction kinetics depends on the individual sorbent species.

Emissions levels of toxic metals from incinerators equipped with modern air-pollution control systems are several orders of magnitude lower than levels in 1980. High collection efficiencies are achieved for the 10 toxic metals proposed for regulation (Ag, As, Ba, Be, Cd, Cr, Hg, Pb, Sb and Tl).

Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project

Project done for **Zitholele Consulting**

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Report No: 14ZIT08_N Rev 0 | **Date:** February 2018

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Report Details

Report Title	Noise Specialist Report for the Proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project
Client	Zitholele Consulting
Report Number	14ZIT08_N
Report Version	Rev 0.3
Date	February 2018
Prepared by	Reneé von Gruenewaldt *(Pr. Sci. Nat.)*, MSc (University of Pretoria)
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Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
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Revision Record

Version	Date	Section(s) Revised	Summary Description of Revision(s)
Rev 0	24 November 2016	Draft report	For client review
Rev 0.1	5 December 2016	Whole report	Grammatical changes
Rev 0.2	18 January 2018	Section 4	Incorporation of changes to authorisation and licencing approach in 2017
Rev 0.3	7 February 2018	Executive summary and Section 1	Incorporation of comments from client

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Section 7: Annex A – Specialist's Curriculum Vitae
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1.1: Purpose Section 1.2: Scope of Work
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3.3: Sampled Baseline and Representative Pre-Development Noise Levels Note: Seasonal changes immaterial to study outcome
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.5: Approach and Methodology
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3: Description of the Receiving Environment
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Not applicable
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.6: Limitations and Assumptions
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4: Impact Assessment Site alternatives were not considered
Any mitigation measures for inclusion in the EMPr.	Section 5: Management, Mitigation and Recommendations
Any conditions for inclusion in the environmental authorisation	Section 5: Management, Mitigation and Recommendations
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 5.3: Monitoring
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 5: Management, Mitigation and Recommendations
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan.	Section 5: Management, Mitigation and Recommendations
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
A summary and copies if any comments that were received during any consultation process.	No comments received
Any other information requested by the competent authority.	Not applicable

Glossary and Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure that has been A-weighted to simulate human hearing.
EMP	Environmental Management Plan
FGD	Flue Gas Desulphurisation
IFC	International Finance Corporation
ISO	International Standards Organisation
kW	Power in kilo Watt
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{AIeq} (T)	The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
$L_{Req,d}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
$L_{Req,n}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
$L_{R,dn}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.
L_{A90}	The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period
L_P	Sound pressure level (in dB)
L_{PA}	A-weighted sound pressure level (in dBA)
L_{PZ}	Un-weighted sound pressure level (in dB)
L_W	Sound Power Level (in dB)
MW	Power in mega Watt
NEMAQA	National Environment Management Air Quality Act
NSR	Noise sensitive receptor
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
WHO	World Health Organisation

Executive Summary

Airshed Planning Professionals (Pty) Limited was appointed by Zitholele Consulting to undertake a noise impact assessment for a proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project (hereafter referred to as the project).

Confirmed scope of work includes assessment of the following activities and infrastructure:

1. Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
2. Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
3. The construction and operation of the wet FGD system that will reduce the SO2 content in the flue gas emitted;
4. Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of storm water infrastructure and conservancy tanks for sewage;
5. The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant.
6. Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the waste water treatment plant (WWTP) that will be located close to the FGD infrastructure within the Medupi Power Station;
7. Construction and operation of the WWTP;
8. Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility.
9. The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system.
10. Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

The main objective of this study was to establish baseline/pre-development noise levels in the study area and to quantify the extent to which ambient noise levels will change as a result of the project. The baseline and impact study then informed the noise management and mitigation measures recommended for adoption as part of the project's Environmental Management Plan (EMP).

To achieve this objective, the following tasks were included in the scope of work (SoW):

1. A review of technical project information;
2. A review of the legal requirements and applicable environmental noise guidelines;
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of noise sensitive receptors (NSRs) from available maps;
    b. A study of environmental noise attenuation potential by referring to available weather records and land use data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from a survey conducted in September 2015.
4. An impact assessment, including:
    a. The establishment of a source inventory for the project;
    b. Noise propagation simulations to determine environmental noise levels; and,
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements; and,
6. A specialist noise impact assessment report.

In the assessment of sampled and simulated noise levels reference was made to the International Finance Corporation (IFC) guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) since these (a) are applicable to nearby NSRs and (b) in-line with South African National Standards (SANS) 10103 guidelines for urban districts. The IFC's 3 dBA increase criterion is used to determine the potential for noise impact.

The baseline acoustic environment was described in terms of the location of NSRs in relation to proposed activities, the ability of the environment to attenuate noise over long distances and existing or pre-development noise levels. The following was found:

- Several individual residential dwellings are located within a few kilometres from the Medupi Power Station. There are also residential areas to the north and northeast of the Matimba Power Station.
- Baseline noise levels are affected by road traffic, mining activities, birds and insects. Noise levels in the vicinity of the Medupi Power Station are currently comparable to levels typically found in suburban districts. Representative day- and night-time as well as 24-hour baseline noise levels of 48.3 dBA, 43.7 dBA and 50.9 dBA respectively were calculated from survey results.

Sound power levels for main equipment were determined from equipment specifications. The source inventory, local meteorological conditions and information on local land use were used to populate the noise propagation model (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 10 km east-west by 10 km north-south. The area was divided into a grid matrix with a 10 m resolution and NSRs were included as discrete receptors. The following was found:

- Noise impacts during the operational phase will be more notable at night.
- The operational phase will result in noise levels that do not exceed the selected impact criteria at the nearest NSR. 'Little' to no reaction from individuals within this impacted area may be expected.

It is important to note the following conservative assumption when interpreting results summarised above. Shielding effects due to infrastructure and land topography were also not taken into account providing a conservative aspect in the simulated noise levels.

It was concluded that, given the conservative nature of the assessment, the implementation of the basic good practice management measures recommended in this report will ensure low noise impact levels. From a noise perspective, the project may proceed.

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1 Introduction

Airshed Planning Professionals (Pty) Limited was appointed by Zitholele Consulting to undertake a noise impact assessment for a proposed Medupi Flue Gas Desulphurisation (FGD) Retrofit Project (hereafter referred to as the project).

1.1 Purpose

The main purpose of the noise study is to determine the potential impact on the acoustic climate and noise sensitive receptors (NSRs) given activities proposed as part of the project.

1.2 Scope of Work

Confirmed Scope of Work (SoW) includes assessment of the following activities and infrastructure:

1. Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
2. Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
3. The construction and operation of the wet FGD system that will reduce the SO_2 content in the flue gas emitted;
4. Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of storm water infrastructure and conservancy tanks for sewage;
5. The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant.
6. Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the waste water treatment plant (WWTP) that will be located close to the FGD infrastructure within the Medupi Power Station;
7. Construction and operation of the WWTP;
8. Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility.
9. The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system.
10. Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

The following tasks were included in the SoW:

1. A review of technical project information;
2. A review of the legal requirements and applicable environmental noise guidelines;
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps;
    b. A study of environmental noise attenuation potential by referring to available weather records and land use data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from a survey conducted in September 2015.
4. An impact assessment, including:
    a. The establishment of a source inventory for the project;
    b. Noise propagation simulations to determine environmental noise levels; and,
    c. The screening of simulated noise levels against environmental noise criteria.

5. The identification and recommendation of suitable mitigation measures and monitoring requirements; and,
6. A specialist noise impact assessment report.

1.3 Description of Activities from a Noise Perspective and Selection of Assessment Scenarios

Noise will be generated during the project's construction, operational and decommissioning/closure phases. Construction and decommissioning/closure phase activities, however, will be for limited time frames and was not assessed in detail for the current study.

1.3.1 Construction Phase

During the construction phase several facilities need to be established. These include; contractor's laydown areas, workshops, stores for the storing and handling of construction materials, a parking area for cars and equipment, etc. These facilities will likely be removed at the end of the construction phase.

It is anticipated the construction phase activities would result in noise from mobile construction equipment, metal and masonry/concrete works, ancillary equipment such as welders, compressors and generators as well as traffic for the delivery of materials and construction staff transport.

1.3.2 Operational Phase

The proposed project will comprise of operations at the Power Station including boilers, turbines, ball mills, pumps, fans, conveyors, stackers, and road activity. The detail of the sources is provided in Section 4.1.

1.3.3 Decommissioning and Closure Phase

The removal of infrastructure will take place during the decommission phase. Diesel mobile equipment and demolition activities will generate noise.

1.4 Background to Environmental Noise and the Assessment Thereof

Before more details regarding the approach and methodology adopted in the assessment is given, the reader is provided with some background, definitions and conventions used in the measurement, calculation and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

Noise is reported in decibels (dB). "dB" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in this equation.

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Where:

L_p is the sound pressure level in dB;
p is the actual sound pressure in Pa; and
p_{ref} is the reference sound pressure (p_{ref} in air is 20 µPa)

1.4.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing of a young, healthy person ranges between 20 Hz and 20 000 Hz.

In terms of L_P, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.2 Frequency Weighting

Since human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies (Figure 1). "dBA" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities, that have the same units (in this case sound pressure) that has been A-weighted.

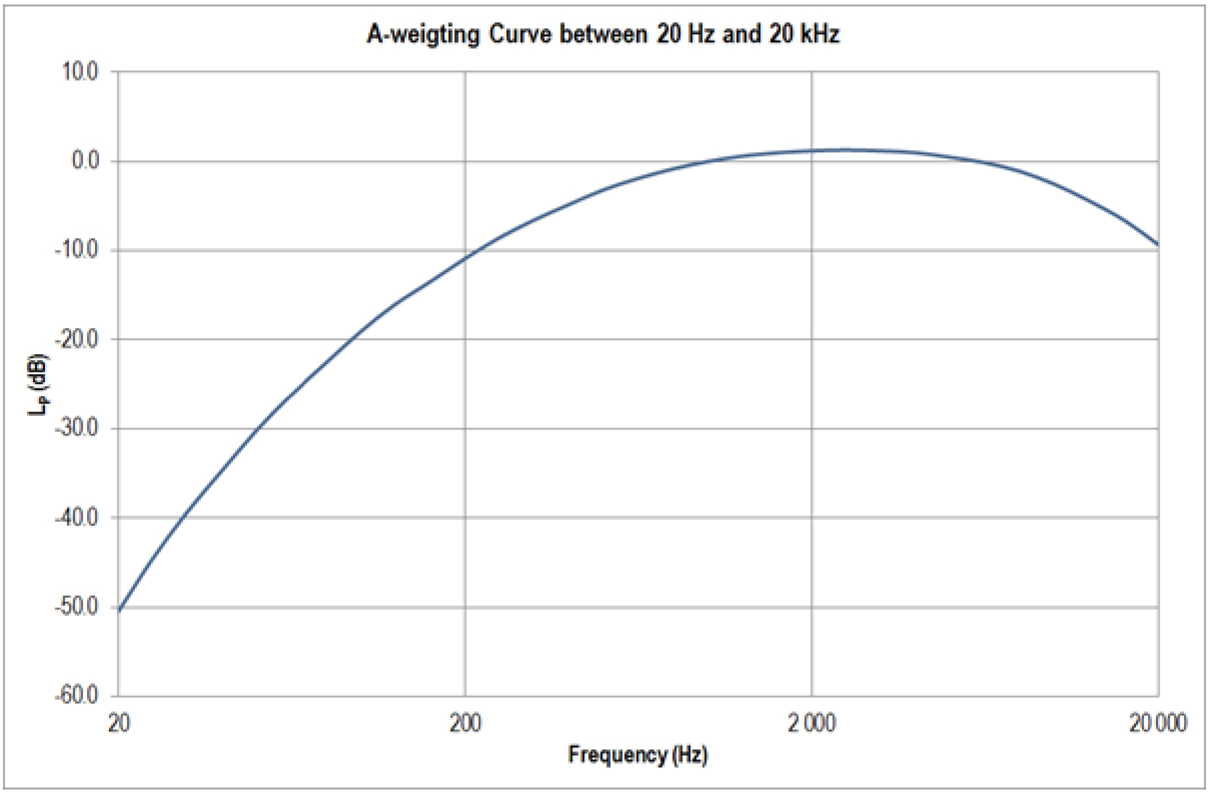


Figure 1: A-weighting curve

1.4.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot just simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using:

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power (L_W);
- The distance between the source and the receiver;
- Atmospheric conditions (wind speed and direction, temperature and temperature gradient, humidity etc.);
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption; and
- Reflections.

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is generally made to the following indices:

- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). The International Finance Corporation (IFC) provides guidance with respect to L_{Aeq} (1 hour), the A-weighted equivalent sound pressure level, averaged over 1 hour.
- **L_{AIeq} (T)** – The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). In the South African Bureau of Standards' (SABS) South African National Standard (SANS) 10103 of 2008 for 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' prescribes the sampling of L_{AIeq} (T).
- **$L_{Req,d}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
- **$L_{Req,n}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
- **$L_{R,dn}$** – The L_{Aeq} rated for impulsive sound (L_{AIeq}) and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night.

- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.
- **L_{AFmax}** – The maximum A-weighted noise level measured with the fast time weighting. It's the highest level of noise that occurred during a sampling period.
- **L_{AFmin}** – The minimum A-weighted noise level measured with the fast time weighting. It's the lowest level of noise that occurred during a sampling period.

1.5 Approach and Methodology

The assessment included a study of the legal requirements pertaining to noise impacts, a study of the physical environment of the area surrounding the project and the analyses of existing noise levels in the area. The impact assessment focused on the estimation of sound power levels (L_W's) (noise 'emissions') and sound pressure levels (L_P's) (noise impacts) associated with the operational phase. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology are discussed in more detail below.

1.5.1 Review of Assessment Criteria

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to South African National Standard (SANS) 10103 of 2008 '*The measurement and rating of environmental noise with respect to annoyance and to speech communication*'. These guidelines, which are in line with those published by the International Finance Corporation (IFC) and World Health Organisation (WHO), were considered in the assessment.

1.5.2 Study of the Receiving Environment

NSRs generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside the industrial facility's property. Homesteads and residential areas which were included in the assessment as NSRs were identified from available maps and satellite imagery.

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology and land use. The atmospheric attenuation potential was described based on MM5 meteorological data for the period 2011 to 2013. Land cover data was obtained from Google Earth satellite.

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. Data from a baseline noise survey conducted by Airshed as part of the scope of work was studied to determine representative baseline noise levels for use in the assessment of cumulative impacts.

1.5.3 Source Inventory

The source noise inventory was informed by:

- Equipment specific L_W predictive equations for industrial equipment as published by Crocker (1998);

- Generic area wide L_W's for industrial areas as published by the European Commission (EC WG-AEN, 2003); and
- Sound power levels measured by acoustic consultants.

1.5.4 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of the International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable to propagation from sources of known sound emission.

These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground based temperature inversion, which commonly occurs at night.

The method also predicts an average A-weighted sound pressure level. The average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions. The method specified in ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects. A basic representation of the model is given:

$$L_P = L_W - \sum [K_1, K_2, K_3, K_4, K_5, K_6]$$

Where;

L_P *is the sound pressure level at the receiver*
L_W *is the sound power level of the source*
K_1 *is the correction for geometrical divergence*
K_2 *is the correction for atmospheric absorption*
K_3 *is the correction for the effect of ground surface*
K_4 *is the correction for reflection from surfaces*
K_5 *is the correction for screening by obstacles*

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources.

To apply the method of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources at noise at the proposed plant were quantified as point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source, and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level. The impact of an intruding industrial/mining noise on the environment will therefore rarely extend over more than 5 km from the source and is therefore always considered “local” in extent.

The propagation of noise was calculated over an area of 10 km east-west by 10 km north-south with the proposed project located centrally. The area was divided into a grid matrix with a 10 m resolution and NSRs were included as discrete receptors. The model calculates L_P's at each grid and discrete receptor point at a height of 1.5 m above ground level.

1.5.5 Presentation of Results

Noise impacts were calculated in terms of:

- Equivalent continuous day, night and day-night rating levels ($L_{Req,d}$, $L_{Req,n}$ and $L_{R,dn}$) in comparison with guidelines. These levels were assessed for the project activities;
- The effective increase ambient day, night and day-night noise levels over estimated baseline $L_{Req,d}$, $L_{Req,n}$ and $L_{R,dn}$ as a result of the project.

Results are presented in isopleth form. An isopleth is a line on a map connecting points at which a given variable (in this case L_P) has a specified constant value. This is analogous to contour lines on a map showing terrain elevation. In the assessment of environmental noise, isopleths present lines of constant noise level as a function of distance.

Simulated noise levels were assessed according to guidelines published in SANS 10103 and by the IFC. To assess annoyance at nearby places of residence, reference was made to guidelines published in SANS 10103.

1.5.6 Recommendations of Management and Mitigation

The findings of the noise specialist study informed the recommendation of suitable noise management and mitigation measures.

1.6 Limitations and Assumptions

The main assumptions and limitations for the current assessment are as follows:

- The quantification of sources of noise was restricted to activities associated with the project scope.
- Shielding effect of infrastructure was not considered in simulations. This approach will provide a conservative estimate of the estimated sound pressure levels from the project.
- Terrain was not accounted for in this assessment, providing a conservative estimate of noise levels as no natural shielding is taken into account.
- Source strength calculations were based on theoretical estimates not taking into account acoustic shielding or mitigation as a conservative estimate.
- The background used for the estimation of cumulative change in noise levels was selected from measured data points within the study area.

2 LEGAL REQUIREMENTS AND NOISE LEVEL GUIDELINES

2.1 SANS 10103 (2008)

SANS 10103 (2008) successfully addresses the manner in which environmental noise measurements are to be taken and assessed in South Africa, and is fully aligned with the WHO guidelines for Community Noise (WHO, 1999). The values given in Table 1 are typical rating levels that should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be considered to be annoying to local noise sensitive receptors.

Table 1: Typical rating levels for outdoor noise, SANS 10103 (2008)

Type of district	Equivalent Continuous Rating Level ($L_{Req,T}$) for Outdoor Noise		
	Day/night $L_{R,dn}$[(c)] (dBA)	Day-time $L_{Req,d}$[(a)] (dBA)	Night-time $L_{Req,n}$[(b)] (dBA)
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following; business premises; and main roads	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Notes

(a) $L_{Req,d}$ =The L_{Aeq}[1] rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.

(b) $L_{Req,n}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.

(c) $L_{R,dn}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- "$\Delta \leq 0$ dB: There will be no community reaction;
- 0 dB < $\Delta \leq$ 10 dB: There will be 'little' reaction with 'sporadic complaints';
- 5 dB < $\Delta \leq$ 15 dB: There will be a 'medium' reaction with 'widespread complaints'. Δ = 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq$ 20 dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change.

[1] $L_{Aeq,T}$ is the A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).

2.2 IFC Guidelines on Environmental Noise

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines.

The IFC states that noise impacts should not exceed the levels presented in Table 2, or result in a maximum increase above background levels of 3 dBA at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.

It is further important to note that the IFC noise level guidelines for residential, institutional and educational receptors correspond with the SANS 10103 guidelines for urban districts.

Table 2: IFC noise level guidelines

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional and educational receptors	55	45

2.3 Criteria Applied in this Assessment

Reference is made to the IFC guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) since these are -

(a) applicable to nearby NSRs; and
(b) in-line with SANS 10103 guidelines for urban districts.

For that reason, the SANS 10103 24-hour limit of 55 dBA for urban districts is also used. The IFC's 3 dBA increase criterion is used to determine the potential for noise impact together with the SANS 10103 guideline for community response of 'little' reaction with 'sporadic complaints' (0 dB < $\Delta \leq$ 10 dB).

3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

This chapter provides details of the receiving acoustic environment which is described in terms of:

- Local NSRs;
- The local environmental noise propagation and attenuation potential; and
- Sampled baseline or pre-development noise levels.

3.1 Noise Sensitive Receptors

Noise sensitive receptors generally include places of residence and areas where members of the public may be affected by noise generated by industrial activities. Those within the vicinity of the Medupi Power Station are presented in Figure 2 and include individual residential dwellings and residential settlements to the north and northeast of the Matimba Power Station.

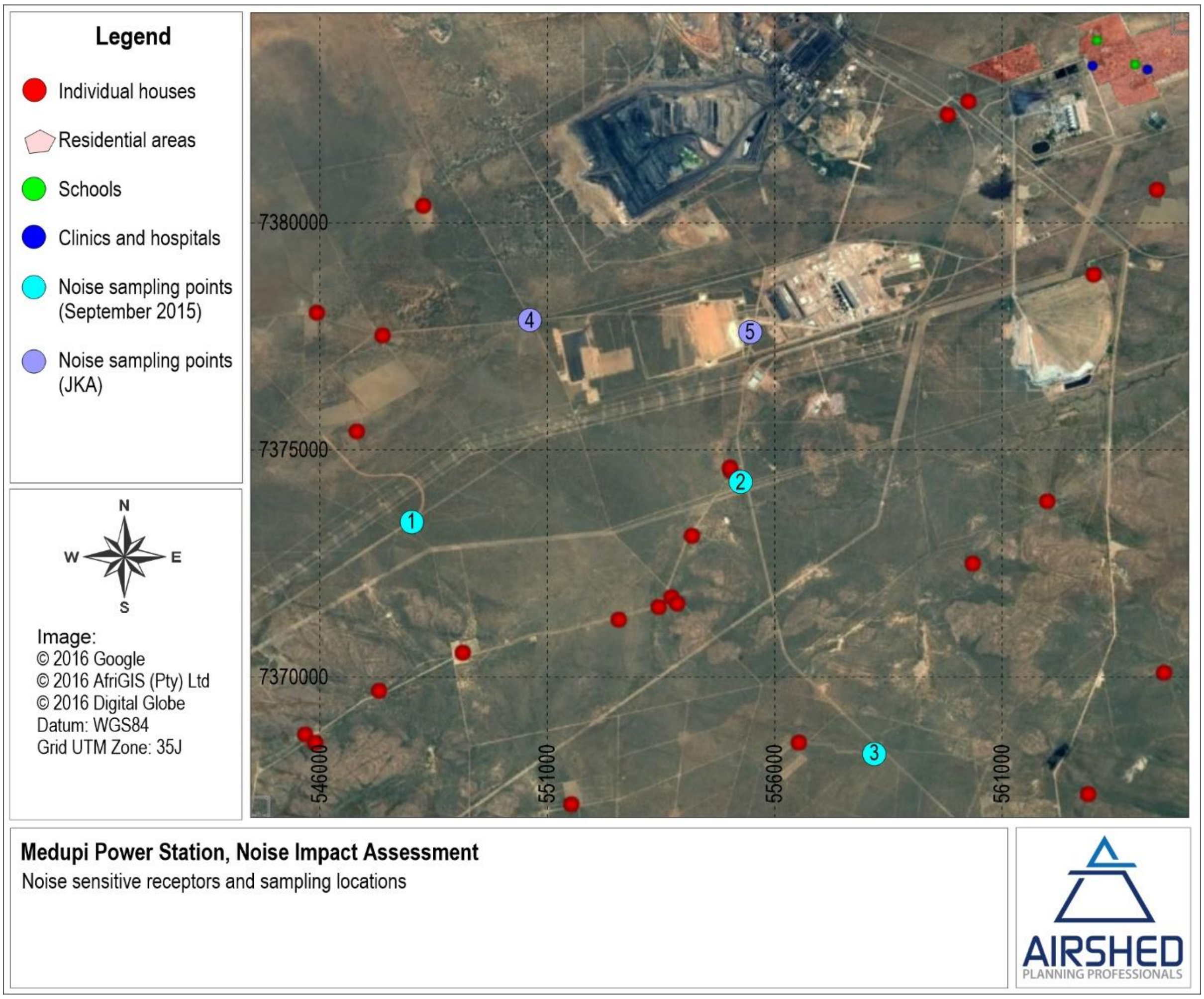


Figure 2: Location of NSRs

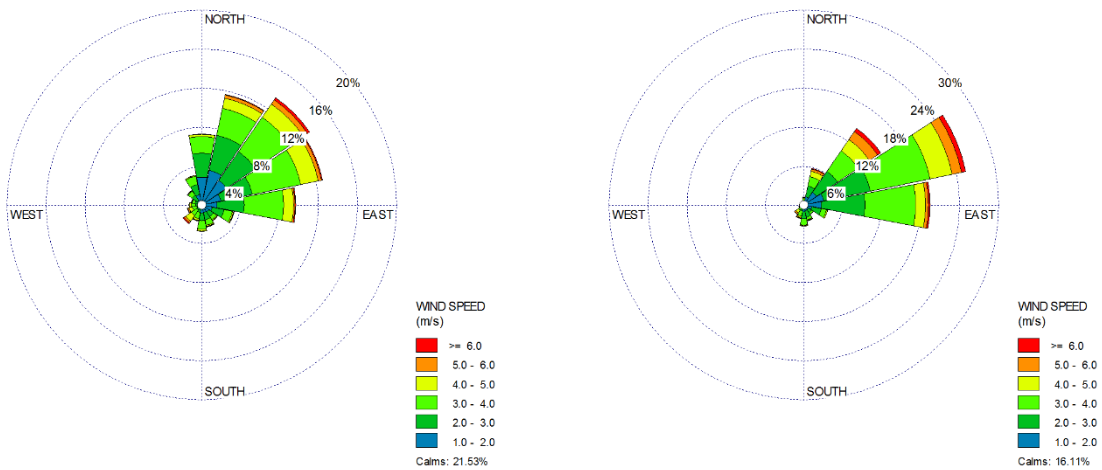
3.2 Environmental Noise Propagation and Attenuation Potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to its role in the propagation on noise from a source to receiver (Section 1.4.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. Reference is made to MM5 modelled data for the period 2011 to 2013.

Wind speed increases with altitude. This results in the 'bending' of the path of sound to 'focus' it on the downwind side and creating a 'shadow' on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). It should be noted that at wind speeds of more than 5 m/s ambient noise levels are mostly dominated by wind generated noise.

The diurnal wind field is presented in Figure 3. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.



(a) Day-time wind field (06:00 to 22:00) **(b) Night-time wind field (22:00 to 06:00)**

Figure 3: Wind roses for day- and night-time conditions at the Medupi Power Station site (MM5 data)

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night. An average temperature of 15°C and a humidity of 62% were applied in simulations.

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely the path difference of the sound waves as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). With exception of the boiler building, shielding effect of other infrastructure was not taken into account for this assessment. Terrain and thus natural shielding effect was conservatively not included in this study.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Based on observations, the ground cover was taken to be acoustically mixed.

3.3 Sampled Baseline and Representative Pre-Development Noise Levels

Airshed conducted a baseline noise survey on 3 September 2015 at three locations (Figure 2). Pictures of these locations and surround areas are presented in Figure 4. The survey consisted of 60 minute samples during the day and 30 minute samples during the night (results summarised in Table 3 with measured levels provided in Figure 5 to Figure 10).

For noise measurements conducted in September, the equivalent day/night noise levels at location 1 and 2 correspond to typical noise levels prevalent in suburban districts. The equivalent day/night noise levels at location 3 correspond to typical noise levels prevalent in a central business district. This is as a result of fast travelling heavy vehicles on the road in the vicinity of the sampler.

Noise measurements for the area were also conducted by Jorgens Keet Associates (JKA) (as documented in Noise Impact Assessment for the ash disposal facility at Matimba Power Station (Jorgens Keet Associates, 2014)). In the vicinity of the potential Medupi waste disposal facility sites, two noise measurements from this study have been extracted and provided in Table 4 (see Figure 2). It should be noted that these measurements were taken in April 2005 (prior to the construction of the Medupi Power Station) and may not be representative of the current noise levels at the study area. It is unlikely however that the current noise levels at these sites will be lower than the JKA 2005 measurements.

For the JKA noise measurements conducted in April 2005, the equivalent day/night noise levels at location 4 correspond to typical noise levels prevalent in suburban to urban districts. The equivalent day/night noise levels at location 5 correspond to typical noise levels prevalent in rural to suburban districts.

For estimating the increase in ambient noise levels as a result of the project, the following representative background noise levels (based on Site 1, 2, 4 and 5) were calculated from survey results.

- $L_{Req,d}$ – 48.3 dBA;
- $L_{Req,n}$ – 43.7 dBA; and
- $L_{R,dn}$ – 50.9 dBA.

Table 3: Summary of the noise survey conducted by Airshed on 3 September 2015

Site	1		2		3	
Time of Day	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Description	Cloudy, warm conditions with gusting moderate wind. Measurements mostly affected by heavy and light vehicle traffic on the adjacent main road. Birds also contributed to measured noise levels.	Cool, partly cloudy conditions with gusting moderate wind. Audible sources included constant humming of mining equipment and power station.	Cloudy, warm conditions with moderate wind. Birds, insects, vehicle traffic and continuous humming from the Medupi Power Station contributed to measured noise levels.	Cool, overcast conditions with moderate winds. Noise generated by cattle grazing and moving in the vicinity and vehicle traffic from nearby road.	Partly cloudy, warm conditions with gusting moderate winds. Measurements mostly affected by heavy and light vehicle traffic on the adjacent main road and occasional air traffic.	Cold, partly cloudy conditions with low wind. Low humming from the power station, bats, jackals, and insects contributed to measured noise levels.
Project Name	150903-001	150903-005	150903-002	150903-006	150903-003	150904-001
Start Time	03/09/2015 8:54	03/09/2015 22:19	03/09/2015 10:29	03/09/2015 23:30	03/09/2015 11:52	04/09/2015 0:33
Elapsed Time	01:00:03	00:30:11	01:00:00	00:30:08	01:00:00	00:30:14
L_{AIeq} (dBA)(a)	45.26	43.47	49.45	40.06	62.57	34.35
L_{Aeq} (dBA)(b)	42.68	41.98	45.95	38.17	58.55	33.39
L_{A90} (dBA)(c)	29.07	34.93	35.33	35.39	28.62	30.12
$L_{Req,T}$ (dBA)(d)	45.26	43.47	49.45	40.06	62.57	34.35
$L_{R,dn}$ (dBA)(e)	49.8		49.7		60.8	
C_t(f)	5	0	0	0	5	0
$L_{Req,T}$ (dBA)(g)	50.26	43.47	49.45	40.06	67.57	34.35
$L_{R,dn}$ (dBA)(h)	51.6		49.7		65.8	

Notes:

(a) The impulse corrected, A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)

(b) The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)

(c) The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)

(d) Equivalent continuous rating (in dBA)

(e) The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night

(f) Correction factor for tonal character determined in accordance with SANS 10103 (2008)

(g) Equivalent continuous rating (in dBA) with tonal character penalty

(h) The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein tonal character penalty has been taken into account and the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night

Location Site1
Eskom property; leased to farmer. Opposite entrance to Eskom game farm

Location Site2
~3 km south of the existing ADF

Location Site 3
Approximately ~10 km south east of the existing ADF

Figure 4: Pictures of baseline noise measurement locations undertaken for the project

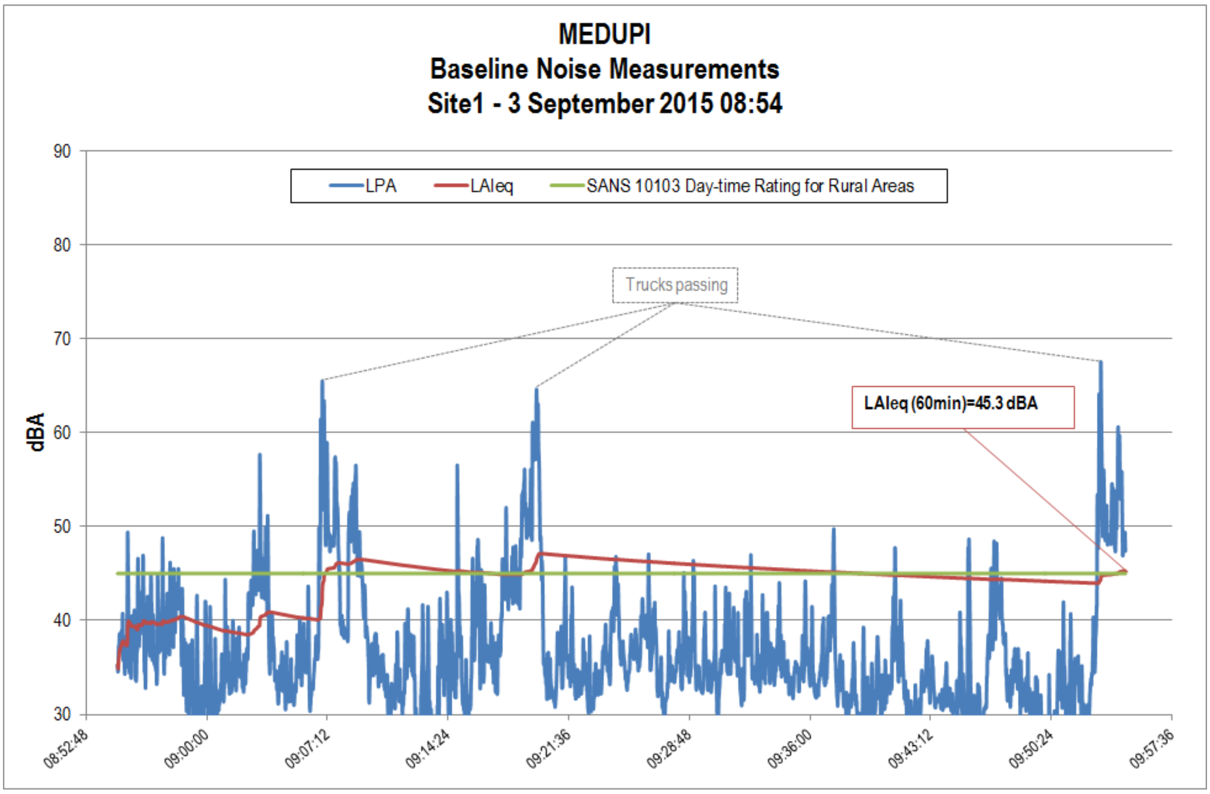


Figure 5: Baseline day-time noise measurement at noise sampling site 1

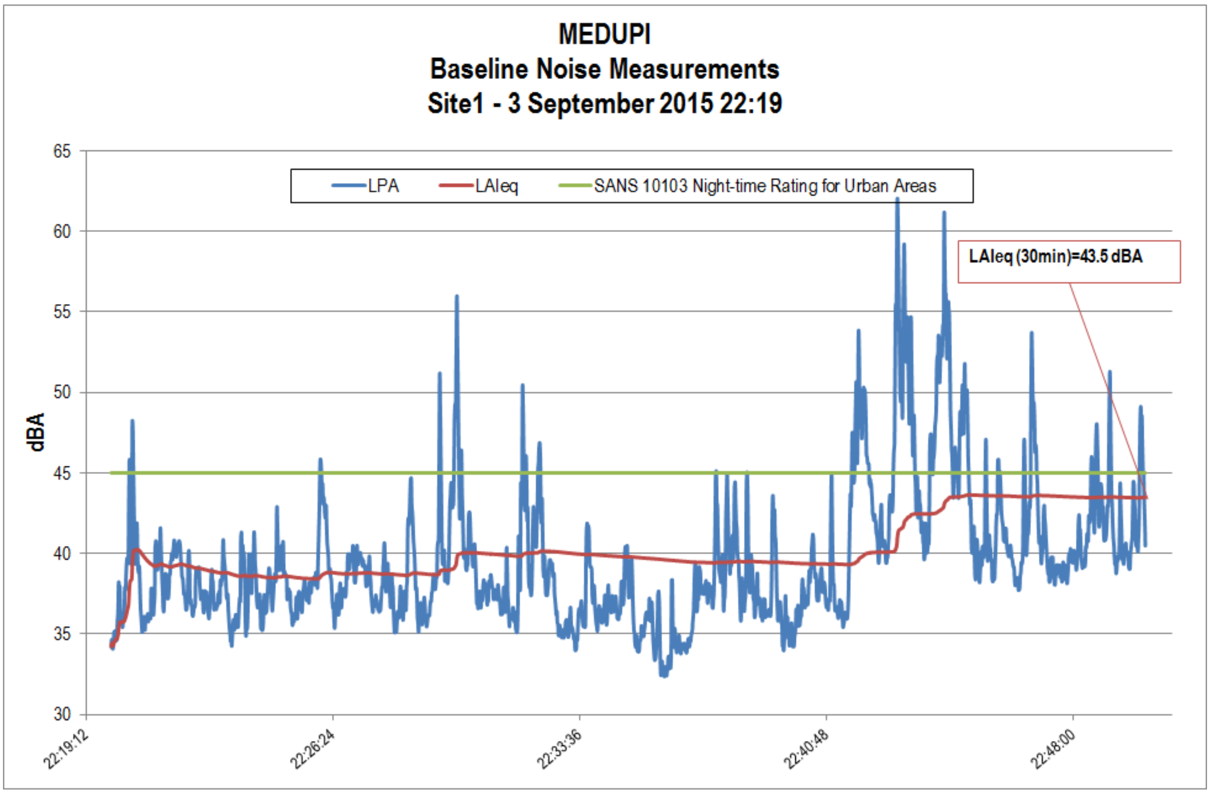


Figure 6: Baseline night-time noise measurement at noise sampling site 1

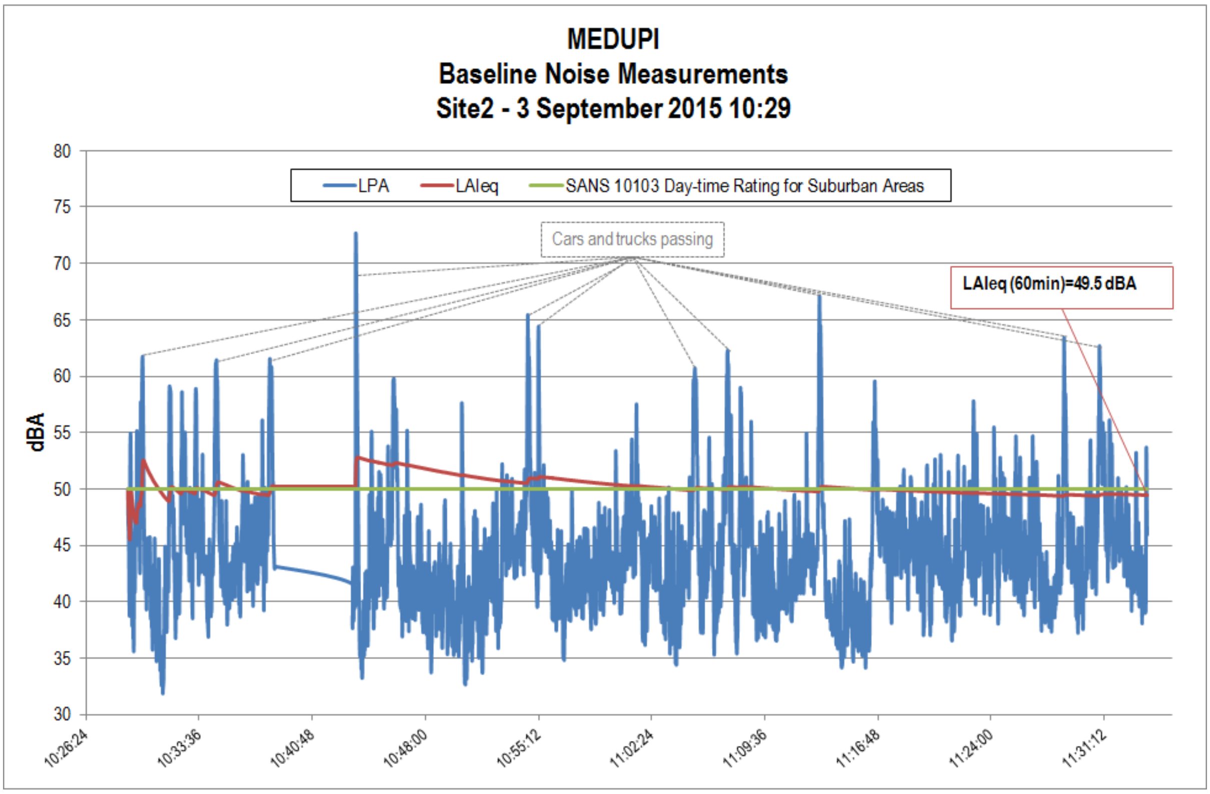


Figure 7: Baseline day-time noise measurement at noise sampling site 2

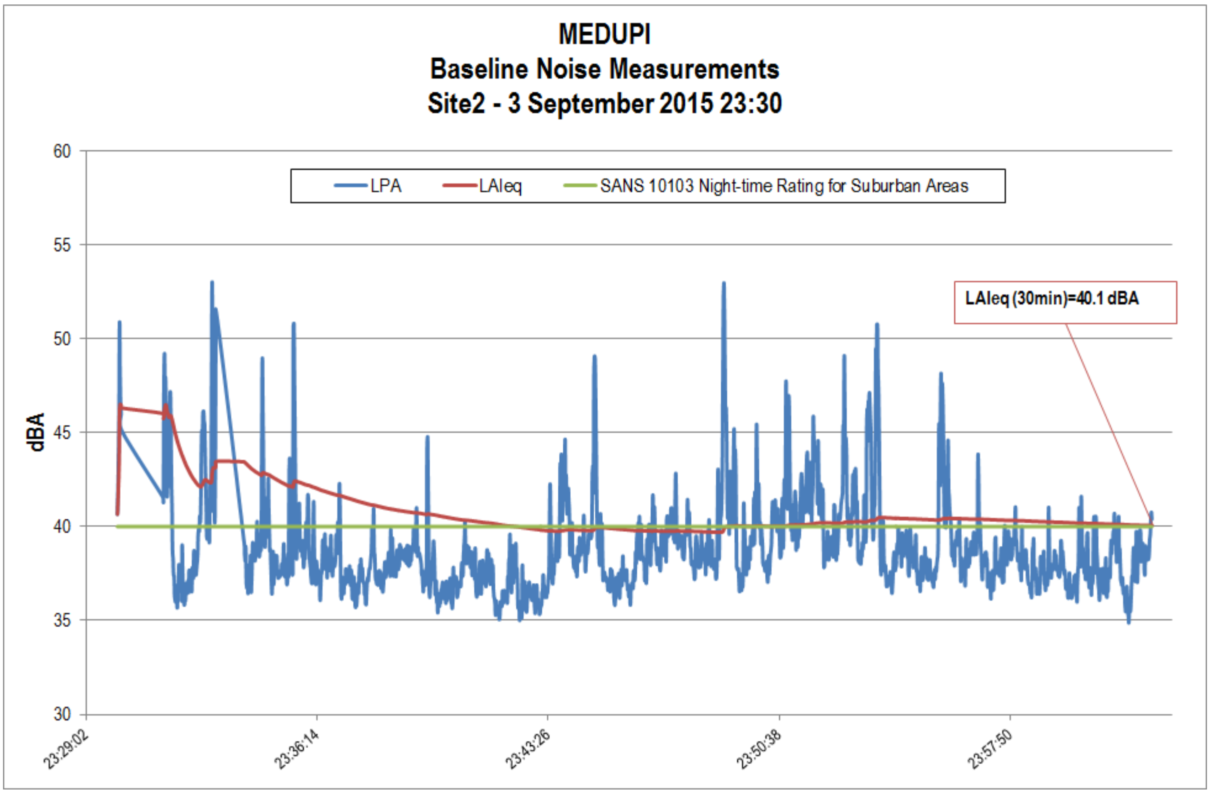


Figure 8: Baseline night-time noise measurement at noise sampling site 2

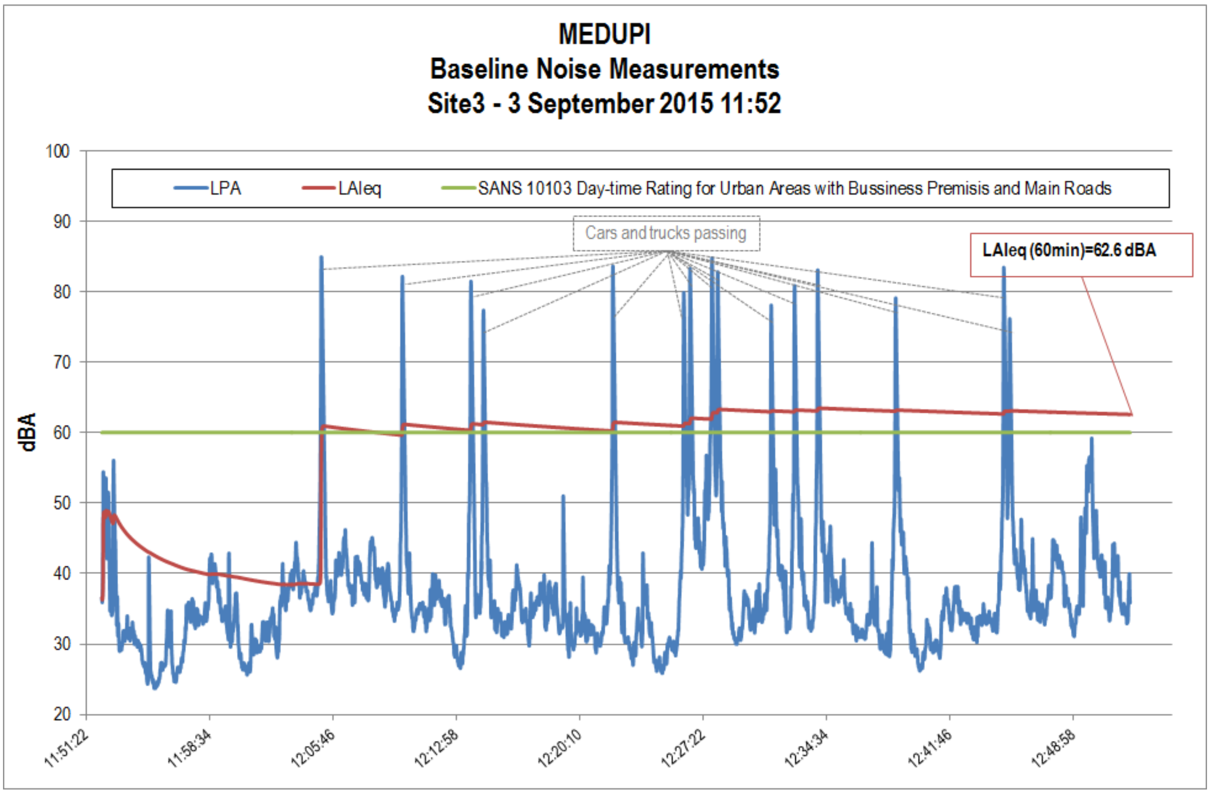


Figure 9: Baseline day-time noise measurement at noise sampling site 3

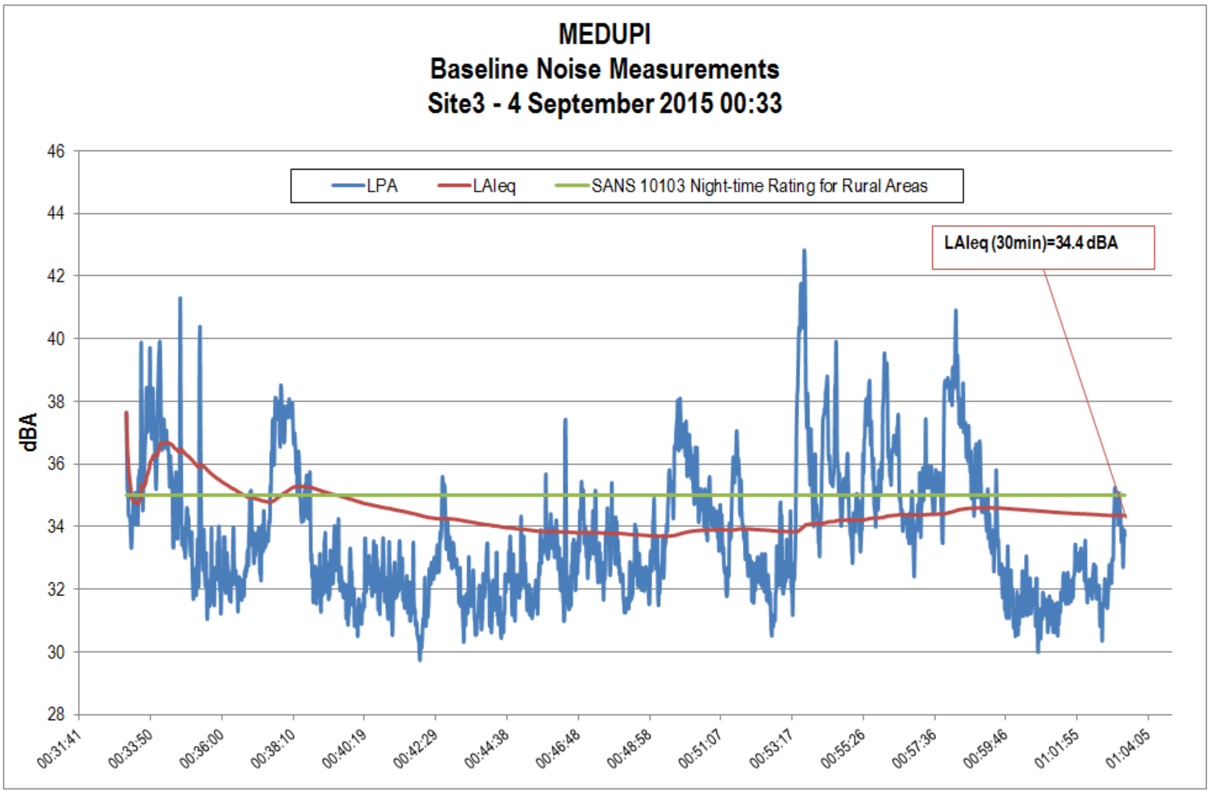


Figure 10: Baseline night-time noise measurement at noise sampling site 3

Table 4: Equivalent continuous ratings for measured noise levels in the existing Medupi waste disposal facility area undertaken by JKA during April 2005 (Jorgens Keet Associates, 2014)

Location	$L_{Req,d}$ (dBA)	$L_{Req,n}$ (dBA)	$L_{R,dn}$ (dBA)
4	46.2	47.2	53.1
5	45.1	39.6	47.2

4 IMPACT ASSESSMENT

The noise source inventory, noise propagation modelling and results for the operational phase of the project are discussed in Section 4.

4.1 Noise Sources and Sound Power Levels

Sound power levels (LW's or noise "emissions") from activities associated with the project were estimated based on technical source data from information gathered during the document review, sound power level predictions for industrial machinery as published in the 'Handbook of Acoustics' (Crocker, 1998), sound power level measurements as undertaken by acoustic consultants F Malherbe and B van Zyl and the 'Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure' (EC WG-AEN, 2003).

The following noise sources were included in simulations; main steam boilers, steam turbine-generator units, ball mills, ash stacker, coal and ash conveyors, conveyor transfer stations, general industrial noise (i.e. small pumps, conveyors, motors, coal handling etc.) and access road to transport the salts and sludge offsite. LW's for these sources are summarised in Table 5. It should be noted that if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded. Other less notable sources of noise such as pumps, fans, electrical motors, etc. were included as an area wide industrial source emitting 65 dBA/m².

Table 5: Operational phase source noise inventory for the project

Source Type	Description and information used in calculations	Qty	L_{Wi} (in dB) at octave band centre frequencies (in Hz)									L_{WA} (dBA)	Source
			31.5	63	125	250	500	1000	2000	4000	8000		
Main Steam Boilers	800 MW	8	123.5	122.5	117.5	111.5	110.5	108.5	106.5	106.5	106.5	114.9	LW Equation,Handbook of Acoustics,Crocker (2008)
Steam-Turbine Generator Units	800 MW	8	115.6	121.6	119.6	114.6	110.6	106.6	103.6	95.6	89.6	113.1	LW Equation,Handbook of Acoustics,Crocker (2008)
Ball Mills		3		106.9	108.2	109.3	106.8	106.2	101.1	97.2		110.1	F Malherbe Acoustic Consulting
Ash Stacker		1		108.1	103.4	102.3	103.1	99.9	97.3	89.6		104.9	Airshed Database, Kendal Ash Stacker Measurements
Highway Truck	300 kW assuming speed of 60 km/h	82/day	119.8	108.8	113.8	116.8	111.8	109.8	106.8	100.8	94.8	115.1	LW Equation,Handbook of Acoustics,Crocker (2008)
Heavy Industry		1	18.6	31.8	41.9	49.4	54.8	58	59.2	59	56.9	65	EC WG-AEN (2006)
Standard Conveyor	5 m/s	9		83.4	86.5	84.5	88.7	82.9	76.5	67.3		88.2	Francois Malherbe Acoustic Consulting & B van Zyl
Conveyor Transfer Station		10		102.7	102.6	107.6	104.6	102.4	99.2	94.4		107.3	Francois Malherbe Acoustic Consulting
Handling at railway yard and siding		6		80	90	98.8	97.6	100.7	101.4	95.4		105.8	Francois Malherbe Acoustic Consulting

4.2 Noise Propagation and Simulated Noise Levels

The propagation of noise generated during the operational phase was calculated with CadnaA in accordance with ISO 9613. Meteorological and site specific acoustic parameters as discussed in Section 3.2.1 along with source data discussed in 4.1, were applied in the model.

Results are presented in isopleth form (Figure 11 to Figure 16). An isopleth is a line on a map connecting points at which a given variable (in this case L_P) has a specified constant value. This is analogous to contour lines on a map showing terrain elevation. In the assessment of environmental noise, isopleths present lines of constant noise level as a function of distance.

For the assessment, an access road was assumed for the transport of the sludge and salts from the site for illustrative purposes. The simulated equivalent continuous day-time rating level (LReq,d) of 55 dBA (noise guideline level) extends ~70m from the road. The simulated equivalent continuous night-time rating level (LReq,n) of 45 dBA (noise guideline level) extends ~100m from the road. These distances can be assumed for any road that will be utilised for the transport of the sludge and salts from the site.

Operational phase related noise due to the project is not predicted to exceed the selected noise guidelines at NSR surrounding the Medupi Power Station with an increase above the baseline of less than 3 dBA at all of the identified NSR. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. According to SANS 10103 (2008); 'little' reaction with 'sporadic complaints' may be expected from the community for increased noise levels up to 10 dBA. With the conservative approach adopted for the assessment (detailed in Section 1.6) the predicted increase in noise levels is not expected to be higher than 1 dBA at any of the identified NSR. *'Little' reaction is therefore expected from the community due to the project with changes in the general ambient noise levels barely being detectable (for a person with average hearing acuity).*

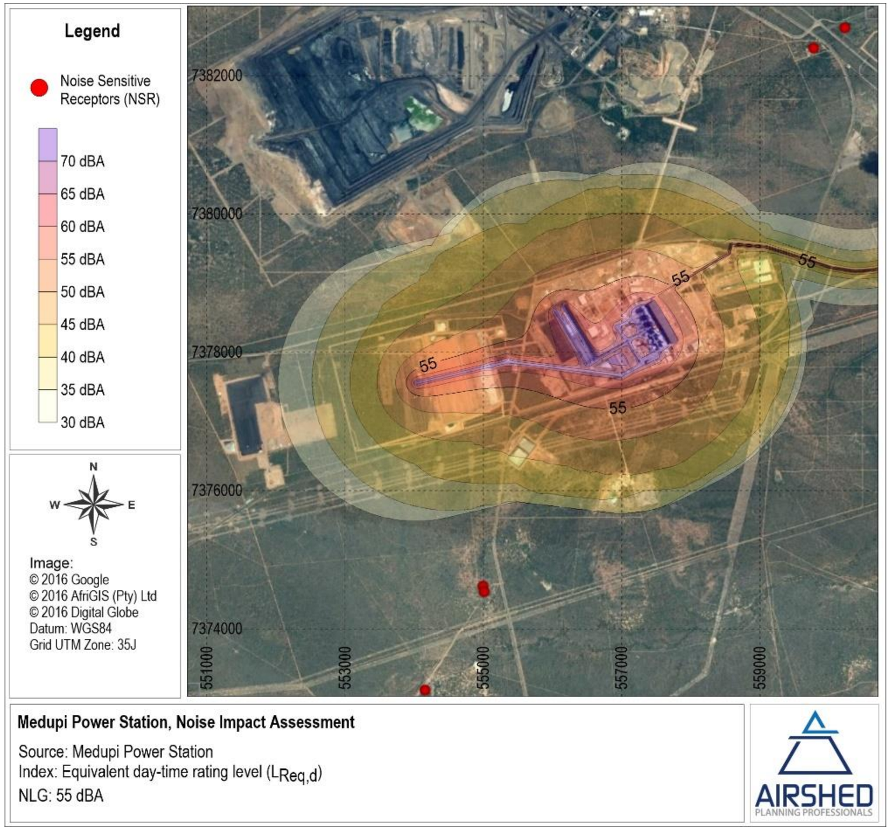


Figure 11: Simulated equivalent continuous day-time rating level ($L_{Req,d}$) for project activities

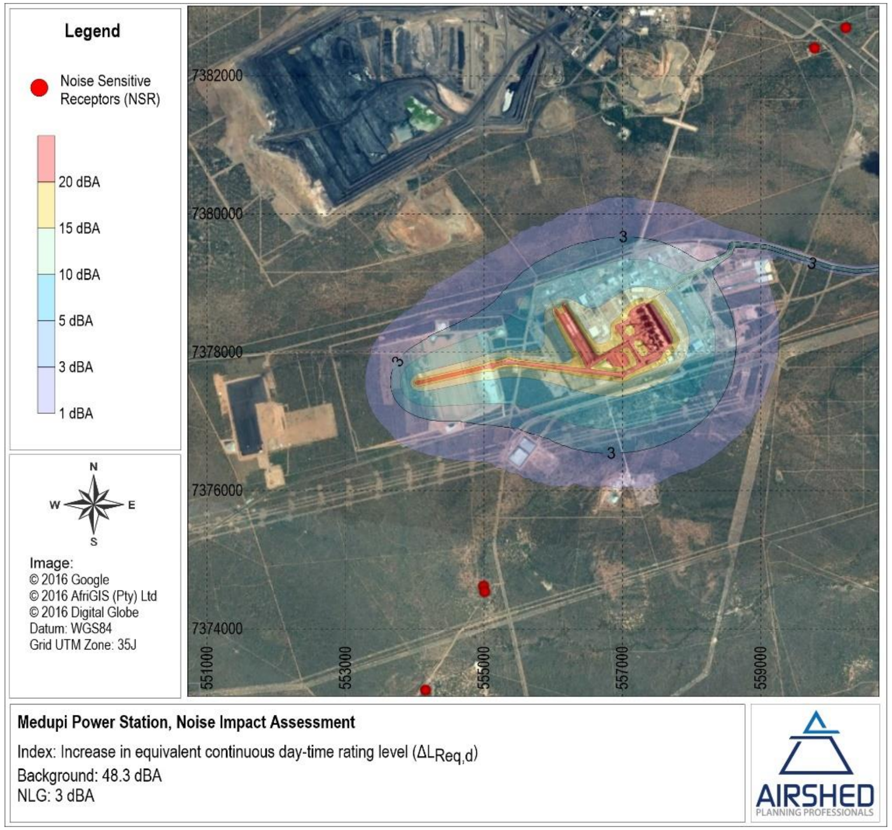


Figure 12: Simulated increase in equivalent continuous day-time rating level ($\Delta L_{Req,d}$) above the baseline

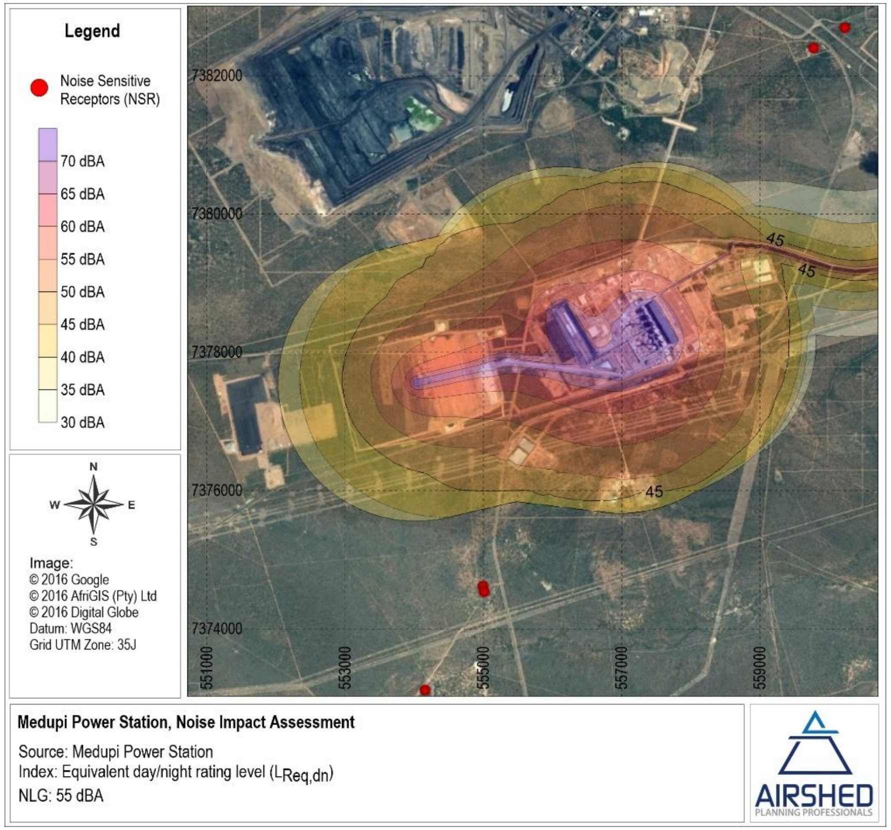


Figure 13: Simulated equivalent continuous night-time rating level ($L_{Req,n}$) for project activities

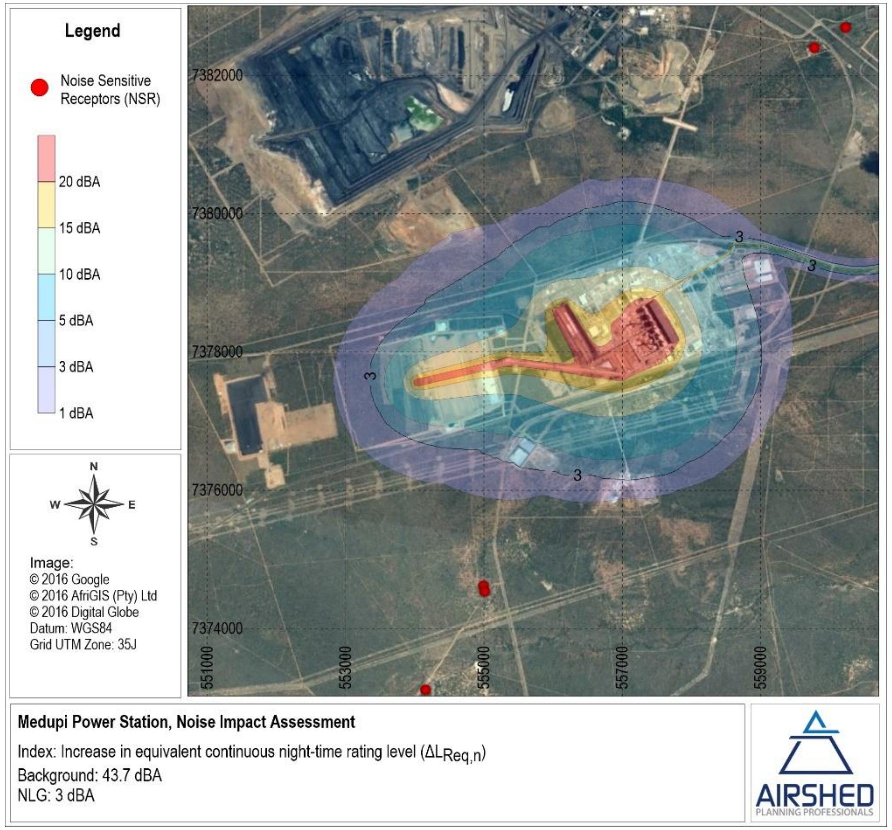


Figure 14: Simulated increase in equivalent continuous night-time rating level ($\Delta L_{Req,n}$) above the baseline

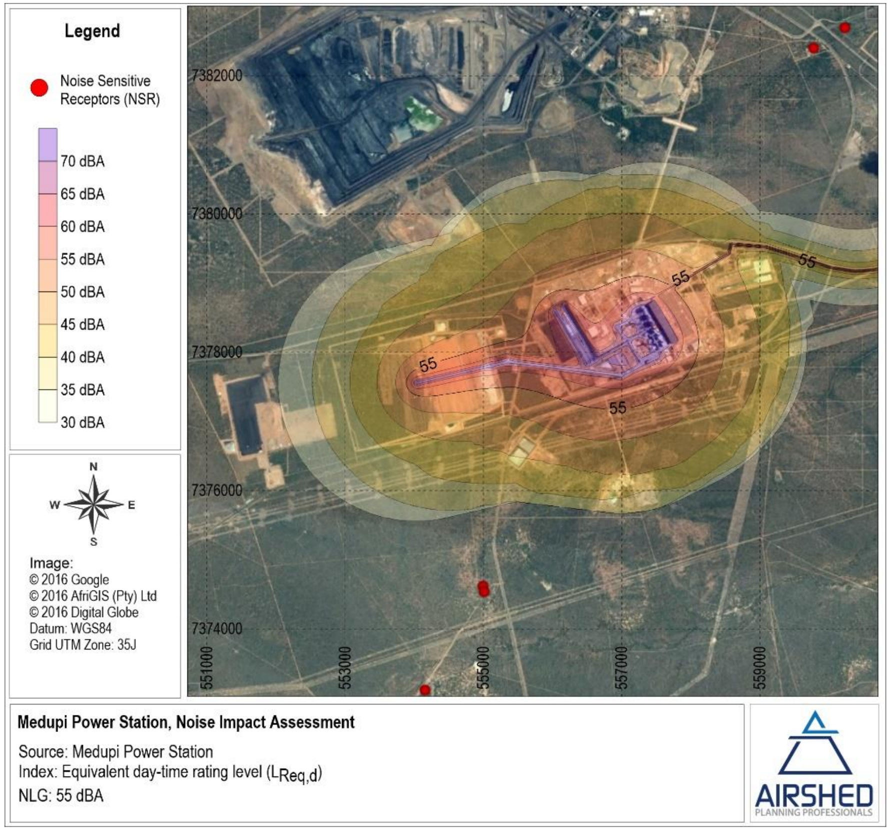


Figure 15: Simulated equivalent continuous day/night rating level ($L_{Req,dn}$) for project activities

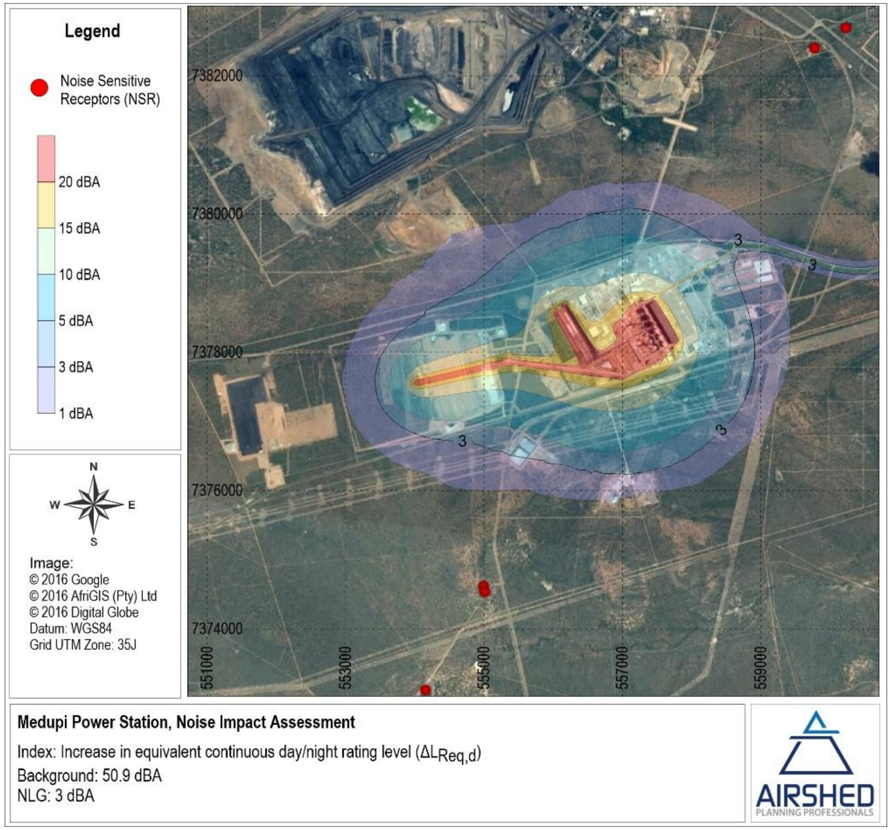


Figure 16: Simulated increase in equivalent continuous day/night rating level ($\Delta L_{Req,dn}$) above the baseline

4.3 Impact Significance Rating

The impact significance rating for the project is presented in Table 6.

Table 6: Impact rating matrix for the proposed project operations

Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
PRE-CONSTRUCTION PHASE									
Noise Levels	Indirect Impact: Increase in noise levels	Existing	2	1	1	0.5	2 - LOW	With noise mitigation, noise levels from the project will be low.	Noise levels in the area are representative of suburban districts.
		Cumulative	2	1	1	0.5	2 - LOW		Noise levels due to pre-construction will be similar to baseline levels.
		Residual	2	1	1	0.5	2 - LOW		Not applicable as no activities will have taken place.
CONSTRUCTION PHASE									
Noise Levels	Indirect Impact: Increase in noise levels	Existing	2	1	1	0.5	2 - LOW	With noise mitigation, noise levels from the project will be low.	Noise levels in the area are representative of suburban districts.
		Cumulative	2	1	2	0.5	3 - MOD		Noise levels due to construction will be local and can be notable.
		Residual	2	1	1	0.5	2 - LOW		With mitigation, the residual noise impact will be reduced (similar to existing levels).
OPERATIONAL PHASE									
Noise Levels	Indirect Impact: Increase in noise levels	Existing	2	1	1	0.5	2 - LOW	With noise mitigation, noise levels from the project will be low.	Noise levels in the area are representative of suburban districts.
		Cumulative	2	1	1	0.5	2 - LOW		Change in noise levels due to operation is slight at NSRs.
		Residual	2	1	1	0.5	2 - LOW		With mitigation, the residual noise impact will be reduced (similar to existing levels).
DECOMMISSIONING PHASE									
Noise Levels	Indirect Impact: Increase in noise levels	Existing	2	1	1	0.5	2 - LOW	With noise mitigation, noise levels from the project will be low.	Noise levels in the area are representative of suburban districts.
		Cumulative	2	1	2	0.5	3 - MOD		Noise levels due to decommissioning will be local and can be notable.

Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
		Residual	2	1	1	0.5	2 - LOW		With mitigation the residual noise impact will be reduced (similar to existing levels).

5 MANAGEMENT, MITIGATION AND RECOMMENDATIONS

In the quantification of noise emissions and simulation of noise levels as a result of the proposed project, it was calculated that ambient noise evaluation criteria for human receptors will not be exceeded at NSRs. 'Little' reaction can be expected from members of the community within this impact area.

From a noise perspective, the project may proceed. It is recommended, however, that mitigation measures be implemented to ensure minimal impacts on the surrounding environment.

5.1 Good Engineering and Operational Practices

For general activities, the following good engineering practice should be applied:

- To minimise noise generation, vendors should be required to guarantee optimised equipment design noise levels.
- A mechanism to monitor noise levels, record and respond to complaints and mitigate impacts should be developed.

5.2 Traffic

The measures described below are considered good practice in reducing traffic related noise. In general, road traffic noise is the combination of noise from individual vehicles in a traffic stream and is considered as a line source if the density of the traffic is high enough to distinguish it from a point source. The following general factors are considered the most significant with respect to road traffic noise generation:

- Traffic volumes i.e. average daily traffic.
- Average speed of traffic.
- Traffic composition i.e. percentage heavy vehicles.
- Road gradient.
- Road surface type and condition.
- Individual vehicle noise including engine noise, transmission noise, contact noise (the interaction of tyres and the road surface, body, tray and load vibration and aerodynamic noise

In managing transport noise specifically related to trucks, efforts should be directed at:

- Minimizing individual vehicle engine, transmission and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
- Minimize slopes by managing and planning road gradients to avoid the need for excessive acceleration/deceleration.
- Maintain road surface regularly to avoid corrugations, potholes etc.
- Avoid unnecessary idling times.
- Minimizing the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur. Alternatives to the traditional reverse 'beeper' alarm such as a 'self-adjusting' or 'smart' alarm should be considered. These alarms include a mechanism to detect the local noise level and automatically adjust the output of the alarm is so that it is 5 to 10 dB above the noise level in the vicinity of the moving equipment. The promotional material for some smart alarms does state that the ability to adjust the level of the alarm is of advantage to those sites 'with low ambient noise level' (Burgess & McCarty, 2009).

5.3 Monitoring

In the event that noise related complaints are received, short term (24-hour) ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions.

The following procedure should be adopted for all noise surveys:

- Any surveys should be designed and conducted by a trained specialist.
- Sampling should be carried out using a Type 1 sound level meter (SLM) that meets all appropriate International Electrotechnical Commission (IEC) standards and is subject to annual calibration by an accredited laboratory.
- The acoustic sensitivity of the SLM should be tested with a portable acoustic calibrator before and after each sampling session.
- Samples of at least 24 hours in duration and sufficient for statistical analysis should be taken with the use of portable SLM's capable of logging data continuously over the time period. Samples representative of the day- and night-time acoustic climate should be taken.
- The following acoustic indices should be recoded and reported:
    - L_{Aeq} (T)
    - L_{AIeq} (T)
    - Statistical noise level L_{A90}
    - L_{Amin} and L_{Amax}
    - Octave band or 3rd octave band frequency spectra.
- The SLM should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- Efforts should be made to ensure that measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer. It is good practice to avoid conducting measurements when the wind speed is more than 5 m/s, while it is raining or when the ground is wet.
- A detailed log and record should be kept. Records should include site details, weather conditions during sampling and observations made regarding the acoustic climate of each site.

5.4 Conclusion

It was concluded that, given the conservative nature of the assessment, the implementation of the basic good practice management measures recommended in this report will ensure low noise impact levels. From a noise perspective, the project may proceed.

6 REFERENCES

Brüel & Kjær Sound & Vibration Measurement A/S, 2000. *www.bksv.com.* [Online] Available at: http://www.bksv.com [Accessed 14 October 2011].

Burgess, M. & McCarty, M., 2009. *Review of Alternatives to 'Beeper' Alarms for Construction Equipment,* Canberra: University of New South Wales.

Crocker, M. J., 1998. *Handbook of Acoustics.* s.l.:John Wiley & Sons, Inc.

EC WG-AEN, 2003. *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure,* s.l.: s.n.

IFC, 2007. *General Environmental, Health and Safety Guidelines,* s.l.: s.n.

Jongens Keet Associates (2014). Noise Impact Assessment of the Proposed Continuous Ash Disposal Facility for the Matimba Power Station, Lephalale, Limpopo Province. Report No. JKA627r006.

SANS 10103, 2008. *The measurement and rating of environmental noise with respect to annoyance and to speech communication,* Pretoria: Standards South Africa.

WHO, 1999. *Guidelines to Community Noise.* s.l.:s.n.

7 ANNEX A – SPECIALIST'S CURRICULUM VITAE

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	René von Gruenewaldt (*nee* Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 14 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

René von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over thirteen (14) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and three (3) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the industrial source complex models (ISCST3 and SCREEN3), AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise.

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt) René has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE

Mining and Ore Handling

René has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein and Hartogshoop cola collieries in SA, Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi) and Kusile Rail (SA).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC) and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification and Petro SA.

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the Kusile ash Project, Hendrina Power Station Coal Fines Project, Komati Power Station, Grootvlei and Tutuka Fabric Filter Plants, Tutuka and Lethabo Power Stations, the proposed Kusile, Medupi and Vaal South Power Stations and the cumulative assessment of the existing and return to service Eskom power stations assessment over the Highveld. René was also involved in the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of PBMR and nuclear plants at Duynefontein, Bantamsklip and Thyspunt (still on-going).

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill and the Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town) and the Ergo Rubber Incinerator.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas.

Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

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English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

22/04/2016

Signature of staff member

Date (Day / Month / Year)

Full name of staff member: René Georgeinna von Gruenewaldt

CURRICULUM VITAE

Name	Nicolette von Reiche (nee Krause)
Date of Birth	22 October 1982
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Mechanical Engineer employed as a Air Quality and Environmental Noise Assessment Consultant
Years with Firm	9 Years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Acoustic Institute (SAAI), 2006 to present
- National Association for Clean Air (NACA), 2006 to present
- International Institute for Acoustics and Vibration (IIAV), 2014 to present

EXPERIENCE

Nicolette has over nine years of experience in both air quality and noise impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, atmospheric dispersion modelling, air pollution mitigation and management, and air pollution impact work. Airshed Planning Professionals is affiliated with Francois Malherbe Acoustic Consulting cc and in assisting with numerous projects she has gained experience in environmental noise measurement, modelling and assessment as well.

A list of projects competed in various sectors is given below:

Power Generation, Oil and Gas

eni East Africa S.p.A Rovuma Area 4 baseline for offshore gas (Mozambique), Staatsolie Power Company Suriname (Suriname), Benga Coal Fired Power Station (Mozambique), Zuma Energy Project (Nigeria), Anglo Coal Bed Methane Project, Eskom Ash Disposal Projects for Kusile Power Station, Camden Power Station and Kendal Power Station, Hwange Thermal Coal Fired Power Station Project (Zimbabwe), Eskom Ankerlig Gas Power Station.

Industrial Sector

Scantogo Cement Project (Togo), Boland Bricks, Brits Ferrochrome Smelter Project, Samancor Chrome's Ferrometals, Middelburg Ferrochrome and Tubatse Ferrochrome, BHP Billiton Metalloys Ferromanganese Projects and Mamatwan Sinter Plant Projects, Tharisa Minerals Concentrator Plant Project, Obuasi Gold Processing Plant (Ghana), Obuasi Gold Mine Pompora Treatment Plant Project (Ghana), Afrisam Saldanha Project, Scaw Metals Projects, including a Co-generation Plant and Steel Wire Rope Plant Project, Delta EMD Project, Dense Medium Separation (DMS) Powders Project, Transalloys Silica Manganese, Dundee Precious Metals Tsumeb (Namibia), Rössing Uranium Desalination Plant (Namibia), Otavi Steel Project (Namibia)

Air Quality and Environmental Noise Management

- Saldanha Industrial Development Zone (IDZ) – Part of an integrated team of specialists that developed the proposed development and management strategies for the IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The investigation included the establishment of the current air emissions and air quality impacts (baseline) with the objective to further development in the IDZ and to allow equal opportunity for development without exceeding unacceptable air pollution levels.
- Gauteng Department of Transport air quality and noise management plan - The plan involved the identification of main traffic related sources of noise and air pollution, the identification of intervention strategies to reduce traffic related noise and emissions to air and the theoretical testing of intervention strategies through emission quantification and dispersion modelling of selected case studies.
- Erongo Strategic Environmental Impact Assessment (Namibia) and Air Quality Management Plan

Mining Sector

- **Coal mining:** Elders Colliery, Grootgeluk Colliery, Inyanda Colliery, Boschmanspoort Colliery, Benga Mine (Mozambique), Vangatfontein Colliery Dust Monitoring, T-Project Underground Coal Mine, Lusthof Colliery
- **Metalliferous mines:** Samancor Chrome's Eastern and Western Chrome Mines, Kinsenda Copper Mine (DRC), Bannerman Uranium Mine (Namibia), Sadiola Gold Mine Deep Sulphides Project (Mali), Kolomela Iron Ore Mine Noise Monitoring, Mamatwan Manganese Mine, Ntsimbintle Manganese Mine, Tharisa Minerals Chrome and Platinum Group Metals Open-pit Mine Project, Obuasi Gold Mine (Ghana), Omitiomire Copper Mine (Namibia), Perkoa Zinc Project (Burkina Faso), Tschudi Copper Mine (Namibia), Rössing Uranium Mine (Namibia), WCL Iron Ore Mines (Liberia), Fekola Gold Project (Mali), Esaase Gold Project (Ghana), Xstrata Paardekop and Amersfoort Underground Coal Mines, Mampon Gold Mine (Ghana), Husab Uranium Mine (Namibia), Mkuju River Uranium Project (Tanzania), Impala Platinum Mine, Angola Exploration Mining Resources Project (Angola), Kanyika Niobium Mine (Malawi)
- **Quarries:** Scantogo Limestone Quarry, Lion Park Quarries Dustfall Monitoring

Waste Disposal and Treatment Sector

Aloes Hazardous Waste Disposal Site, Holfontein Hazardous Waste Disposal Site, Shongweni Hazardous Waste Disposal Site, Coega General and Hazardous Waste Disposal Site, Umdloti Waste Water Treatment Works, Waltloo Medical Waste Incinerator

Transport and Logistics Sector

Saldanha Iron Ore Port Projects and Railway Line, Gautrain Environmental Noise Monitoring Project, Guinea Port and Railway Project (Guinea), Kenneth Kaunda International Airport Expansion (Zambia), Zambia Dry Port Project in Walvis Bay (Namibia)

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling
- Environmental noise sampling
- Source noise measurements

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Noise Propagation Modeling: Integrated Noise Model (for airport noise), CONCAWE, South African National Standards (SANS 10210) for Calculating and Predicting Road Traffic Noise
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Mechanical Engineering), 2005, *University of Pretoria*
- BEng (Hons): (Mechanical Engineering) 2010, *University of Pretoria*; specializing in:
    - Advance Heat and Mass Transfer
    - Advanced Fluid Mechanics
    - Numerical Thermo-flow
    - Tribology

COURSES COMPLETED AND CONFERENCES ATTENDED

- Course: Air Quality Management. Presented by the University of Johannesburg (March 2006)
- Course: AERMET/AERMAP/AERMOD Dispersion Model. Presented by the University of Johannesburg (March 2010)
- Conference: NACA (October 2007), Attended and presented a paper
- Conference: NACA (October 2008), Attended and presented a paper
- Conference: NACA (October 2011), Attended and presented a poster
- Conference: NACA (October 2012), Attended and presented a paper
- Conference: IUAPPA (October 2013), Attended and presented a paper

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Zimbabwe, Zambia, Namibia, the Democratic Republic of the Congo, Botswana, Ghana, Liberia, Togo, Mali, Burkina Faso, Tanzania, Malawi, Angola, Nigeria and Suriname

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English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

REFERENCES

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CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

28/03/2015

NGT Holdings

DEPARTMENT: NGT SOCIAL & SOCIO-ECONOMIC SOLUTIONS

POJECT TITLE:
Medupi PS FG Retrofit Project

PROJECT NUMBER:
12949

DATE OF ISSUE:
17 February 2018

SPECIALIST REPORT:

Social Impact Assessment for the Proposed Medupi Power Station Flue Gas Desulphurisation Retrofit Project and the Existing Medupi Power Station Ash Disposal Facility, Lephalale, Limpopo Province, South Africa

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NGT takes full liability for its specialists working on the project for all the social impact assessment related matters. We will not take any liability for any other environmental related issues or challenges for the project other than those services appointed for - these are the liability of the client.

This report has been compiled by NGT on behalf of Zitholele and Eskom. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision-making process for the project.

EXECUTIVE SUMMARY

NGT was appointed by Zitholele Consulting to undertake a Social Impact Assessment (SIA) study for the proposed Medupi Flue Gas Desulphurisation retrofit project (FGD-RP) and the associated ancillary infrastructure. The associated ancillary infrastructure includes the use of the existing Ash Disposal Facility (ADF) for gypsum disposal and the railway yard for lime and gypsum off-loading (Annexure 10). The aim of the FGD is to reduce sulphur dioxide (SO_2). The role of the ADF is for the final disposal of ash (conventional by-product of coal fired station) and gypsum (by-product of the FGD). According to Eskom, the proposed FGD will reduce SO_2 emissions from Medupi Power Station by 93% from worst case coal. Water allocation and demand for operation of the Medupi Power Station with and without the implementation of the FGD is interrogated

The objectives of this SIA study include:

- The assessment of social impacts of the proposed Medupi Power Station Flue Gas Desulphurisation retrofit project;
- The assessment of potential social impacts of the FGD retrofit (**Annexure 9 – FGD Retrofit layout**), the existing ash disposal facility (ADF) and the prosed railway yard The impact assessment will focus on the social benefits of the proposed FGD on the surrounding communities and industries as well as impacts on the ecosystem such as the biosphere and its natural resources like water and ecology. With regards to water, the SIA looks at the current allocation and future demand for optimal operation of Medupi Power Station (MPS) and the potential pollution resulting from the project. Water is considered one of the ecological services under threat from the project.
- The study aims to make conclusions on the nature of identified social impacts resulting from the associated with the implementation of the FGD (e.g. with water demand flagged as key important issues to consider with the operationalisation of the FGD), the potential environmental threats associated with the AFD (e.g. surface overflow and spillages to the surrounding which has happened more recently). It also make conclusion on impacts associated with the development of the railway siding and the disposal of the FGD by-products such as gypsum, salts and sludge.
- To make recommendations on strategies that should be implemented to enhance the significance of positive social benefits that result with the implementation of the FGD, the associated ADF and

railway siding while reducing the negative impacts. In line with the proposed recommendations, it is acknowledged that the information and the output of this SIA should assist with problem solving solutions rather than only mentioning the negative effects of the project. It also acknowledges that the recommendations made should be acceptable and practical for the project proponent to implement for the achievement of sustainable development goals.

The assessments are based on four stages of the project, from planning, construction, operation to decommissioning phase. Based on the various impact assessment and impact rating processes, the following conclusion and recommendations are made about the proposed Medupi FGD, the existing ADF and the proposed railway siding.

Conclusions:

- It is concluded that the significance of positive social impacts generally exceeds the significance of negative social impacts in the implementation of the FGD, the ADF and the railway siding throughout all four stages of the project.
- It is also concluded that implementation of the proposed FGD technology at Medupi will result in reduced levels of SO_2 in the medium and long term in the region and South Africa. It will also contribute to reduction of global SO_2 atmospheric levels. As the result of this, the significance of health risks associated with the SO_2 emissions will be minimized on a long-term basis.
- The results will be an improved biosphere in the region and South Africa, this will translate to improved quality of life for the citizens of Lephalale and the communities located south and southwest of the study area who are also affected by pollutants containing SO_2.
- Based on issues raised by some of the affected communities during the SIA fieldwork, it is concluded that one of the most pressing issues identified during the survey relates to stakeholder relations and project communication.
- The above issue was put forward for the attention of the project proponent; a meeting was scheduled between the project proponent representatives in Lephalale dealing with environmental and social issues on the ground. The aim was to come up with solution on how to best address the communication impasse. Through this meeting and the information made available to the SIA team, it has been determined that Eskom and its stakeholders have done a

significant amount of work in dealing with concerns of the various interested and affected parties on the ground. They have contributed to the establishment structures entrusted with the management of stakeholder relations and communication as part of the Medupi project. A committee has been established to deal with such issues; for example, the Medupi Environmental Monitoring Committee (EMC) as well as the Stakeholder Relations Office in the region. It is therefore concluded that necessary strategies and measures have been put in place to deal with and manage stakeholder relations and communication.

- In terms of ecosystem services, the study assessed how the Medupi FGD, its by-products, the existing AFD and the proposed railway siding would negatively impact on the ecosystems and how such negative impacts will influence ecosystem services that support the health and wellbeing of the affected communities i.e. municipality, other industries, the farmers and households in the regions. In this assessment, the SIA team considered the following (*Table 11 and recommendation section of this report*):
    - **Direct drivers of the ecosystem change**: e.g. change in local land use and cover; resources consumption; pollution; increase in population
    - **Indirect drivers of the ecosystem change**: e.g. demographic change; economic change; socio- political change; cultural and religious change; scientific and technological change.
    - **The wellbeing of ecosystem services beneficiaries**: e.g. these included among others, change in demand for ecosystem service for basic material for good life; change in demand for ecosystem service for health; change in demand for ecosystem service or security; change in demand for ecosystem service for good social relations.
- Taking into consideration of ecosystem services beneficiaries and drivers; we assessed the potential impacts of the proposed railway siding for lime off-taking. The land on which the proposed siding is to be constructed is already reformed or altered. It is therefore, concluded that the railway siding will not have any adverse negative social and economic impacts in terms of increase in traffic volumes and possible road carnage resulting from trucks transporting lime to Medupi.
- In terms of the existing ADF facility (and other infrastructure on site such as slime dams, coal stockpiles etc.), necessary measures have been put in place to mitigate any possible leakage to groundwater resulting in ground water contamination. Approximately 21 boreholes have been

drilled to compile data that would assist the project proponent to assess sulphates levels in the ground water with the aim of mitigating areas where there is groundwater contamination.

- The water issue is concluded to be the biggest threat in the project lifespan, the current allocation to Medupi will be able to operate the six generation units at Medupi. Water for the other 3 of the FGD absorber units are expected to come from MCWAP Phase. The current raw water abstraction from Mokolo Dam of which the Lephalale LM is also dependent on for clear water to support its domestic and farming communities' poses is a biggest socio-economic threat in terms of ecosystems support services.
- From a social impact assessment perspective; it is concluded that the FGD technology retrofit project, the use of the existing ADF to dispose of ash and excess gypsum and the development of the railway siding should proceed as planned provided that the following recommendations are implemented and adhered to:

Recommendations

Below is the list of recommendation proposed to the project proponent to mitigate against any negative impacts and improve the positive benefits of the proposed project:

- Mitigation measures in this report must be included in the Environmental Management Programme (EMPr), which will be approved as condition of environmental authorisation.
- The specialist responsible for compiling the EMPr must consult and consider the findings and the recommendations of the SIA.
- The issue of communication was flagged by some of the communities as a pressing issue. Through engagement with project proponent representatives it has been determined that necessary measures have been put in place to mitigate issues pertaining to stakeholder engagement in the broader Lephalale area.
    - Although Eskom has done a lot to address this concern, it is recommended that the EMC should further strengthen its multi-stakeholder engagement strategy or adopt new forms of communication that resonate with the interests of I & APs in the region.
    - This should be done in a manner that does not polarise relations between existing stakeholders. One way of addressing this issue is to develop a sub-committee for the EMC.

- The sub-committee should include a representative from each of the affected communities. This should be in addition to those communities' representatives already listed in the EMC Terms of Reference (ToR).
- Community representatives from Steenbokpan (Leseding) and the farms (farming community) should form part of the EMC sub-committee due to the fact that they feel excluded in programmes and workshops that deal with issues arising from Medupi construction and the associated infrastructure and technology such as the FGD.
- In addition to EMC public meetings and workshops, the sub-committee will ensure that all community concerns and grievances are deliberated on and addressed directly by the EMC and outside the EMC public meetings. The EMC ToR allows for the election of alternates. Therefore, this recommendation for EMC sub-committee is in line with EMC ToR.

* In projects of similar nature to Medupi, a grievance mechanism committee is often established and communicated to the community in line with best practice. The Medupi EMC is a sufficient structure to handle all issues relating to the environment, monitoring and auditing. However, without increasing bureaucracy, Eskom should consider appointing an independent company/specialist that specialises in the management of Social Risks. The task of the appointee would be to advise and strengthen the following:
    - Working with the Eskom Community Liaison Officer (Stakeholder Engagement Representative) to independently advise on the facilitation of relations between the various project stakeholders such as the appointed contractors, the EMC, the Environmental Control Officer (ECO), the affected community and community organisations such as NGOs, local labourers, local Small Medium Enterprises (SMMEs) as well as big industries.
    - The Social Risk company or specialist should be experienced in multi-stakeholder management, conflict resolution, labour relations, and negotiation of contracts, skills audits, and training and facilitation of skills transfer programmes.
    - If there is already an existing contract for an independent Social Risk company/specialist for the construction of Medupi Power Station – Eskom should consider extending such a contract since the company/specialist will already be familiar with issues on the ground and be well acquainted with community and government structures in Lephalale.

- There will be no need for additional infrastructure for this specialist or company; she/he can use the existing stakeholder relations office and its satellite offices.

This is important because the construction activities at Medupi have on many occasions been subject to disruption due to labour unrest and protest by locals who demand job opportunities. This is something that came out strongly during the public consultation for the proposed FGD project. Some locals who claimed that they were overlooked in the Medupi projects and that they will be overlooked in the current project too disrupted one of the Public Participation (PP) meetings. The inclusion of a social risk company or specialist in the EMC will ensure that the EMC has enough capacity and skills to deal with and address social and socio-economic issues without overly relying on Eskom Communication, CSI and Stakeholder Relations Departments. Furthermore, it will play a key role in reporting, monitoring and auditing of Eskom commitments to addressing social issues in line with ToR of the EMC. The social risk company will work hand in hand with the appointed Environmental Control Officer responsible for the implementation of the EMPr.

Both the SIA impact assessment analysis and stakeholder engagement concluded that the proposed Medupi FGD-RP will result in positive biospheric and social benefits in the receiving environment and the improvement of the quality of life for the affected communities in terms of reduced number of health incidents that result from exposure to high levels of SO_2. There are however disagreements on how the FGD-RP should be implemented; some argue it should be built into the Medupi Units before their synchronisation while the project proponent proposes to retrofit the technology. Those in favour of constructing the FGD with Medupi Units argue that the coming in of Medupi units will results to further increase in SO_2 levels in the region and will compromise the health of citizens who are already suffering from SO_2 health related challenges such as high prevalence of respiratory diseases.

From a SIA perspective, it is recommended that Eskom should prioritise retrofitting and synchronising the FGD technology to Unit 6, 5 and 4 which have been completed and have been operational since 2016 (unit 5) and early in 2017 (Unit 6). These will allay the fears of those in favour of constructing the FGD with the unit stacks and will also increase Eskom compliance levels in terms of reducing SO_2 and increasing atmospheric and air quality. Technically, this will assist them understand the challenges and opportunities of the technology prior to its retrofitting to Units 1, 2 and 3.

In terms of material transport to and from site for the construction of the FGD and to transport gypsum, salts and sludge which are by-products of the FGD; it is recommended that Eskom should speed up the construction of the proposed railway siding and prioritise the railway as the preferred construction material transport mode as well as for the off-take of the FGD by-products to appropriate licensed disposal facilities specially for salts and sludge. This will help mitigate environmental risks associated with the use of public roads to transport these hazardous materials. It will also assist alleviate possible increase in traffic volumes associated with the FGD construction material transportation.

In terms of FGD by-products it is recommended that Eskom should consider tendering the offtake of gypsum for commercial purposes instead of its combined disposal with the ash.

Eskom is highly commended for its zero liquid disposal strategy at Medupi which encourages water recycling and circulation within the footprint. However, this will only assist in meeting the current water demand on site and is not sufficient enough to meet and address the demand with the implementation of the FGD. Water and water allocation however falls outside the statutory mandate of Eskom, but the responsibility of the National Department of Water and Sanitation (DWS). Through the various bargaining platforms available to Eskom and the surrounding industries such as mines and Sasol – it is recommended that Eskom should lobby (together with other industries) DWS to speed up the implementation of Phase 2 MCWAP. This will guarantee Eskom and other industries in Lephalale appropriate water allocation to support the FGD and the growing industries around it such as expanded coal mining due to coal reserves in the Waterberg region. The speeding up of the Phase 2 MCWAP by DWS would also assist mitigate the potential water risk to Lephalale associated with the abstraction of raw water by industries from Mokolo Dam of which the municipality and its constituencies is also directly dependent on for potable water.

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LIST OF ABBREVIATIONS

Acronyms	Description
ALADF	Appropriately Licensed Waste Disposal Facility
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
CPC	Community Participation Consultant
DEAT	Department of Environmental Affairs and Tourism
EIA	Environmental Impact Assessment
FGD	Flue Gas Desulphurisation
IAR	Impact Assessment Report
IDPs	Integrated Development Plans
IEA	Integrated Environmental Assessment
IFC	International Finance Corporation
MW	Megawatts
MCWAP	Mokolo Crocodile (West) Water Argumentation Project
Medupi EMC	Medupi Environmental Monitoring Committee
NO_2	Nitrogen Oxide
O_3	Ozone
PM	Particulate Matter

SDBIPs	Service Delivery and Budget Implementation Plans
SMMEs	Small Medium Enterprises
SIA	Social Impact Assessment
SO_2	Sulphur dioxide
SRMC	Social Risk Management Company
ADF	Waste Disposal Facility
WHO	World Health Organisation
WMA	Water Management Area

1.INTRODUCTION

1.1.Project Description and Background

The current study is a Social Impact Assessment (SIA) for the proposed Medupi Power Station FGD-RP, the operation of the existing Medupi Power Station ADF and the proposed railway siding (south-west of Medupi six units and south of conveyor transport Medupi FGD-RP waste materials). The study also assesses the issue of water usage within Medupi footprint and water demand for current and future operation of Medupi Power Station with the FGD. How these activities positively and negatively impact on the environmental and social fabric of communities of Lephalale and the Waterberg District Municipality is assessed.

The project is located in Lephalale Local Municipality, within Waterberg District, Limpopo Province, South Africa (*Figure 1*). Medupi Power Station (hereafter referred to as Medupi) is one of two South African mega power generation projects under construction, with other being Kusile Power Station in Mpumalanga Province. Medupi, like Kusile Power Station, is a coal fired power station in its completion stages located on an Eskom owned property, Farm Naauw Ontkomen 509 LQ, in Lephalale Local Municipality. The power station (Medupi) consists of six units with a total power generation capacity of 4800 Megawatts (MW) (Eskom, 2006). The first of the six units came online on mid-2015.

Coal fired power stations are known to emit pollutants such as sulphur dioxide (SO_2). SO_2 is one of the most harmful gases produced through combustion of solid fossil fuel such as coal (World Health Organisation, 2014). Coal is the main solid fossil fuel that will be used in Medupi to generate electricity through combustion. Like with combustion of fossil fuel, there are other emissions that are produced throughout the coal life cycle such as nitrogen oxide (NO_2), ozone (O_3) and particulate matter (PM) of various sizes (World Health Organisation, 2014).

Electricity and access to electricity are essential to improved human quality. The South African Bill of Rights puts electricity as one of the three pillars of social service resource, others being water and sanitation (Constitution of the Republic of South Africa, 1996). However, this essential social service comes at a detrimental cost to both human health and the wellbeing the environment affecting biodiversity and aquatic life particularly in the economies that are highly dependent on coal as a source of energy for their power generation. South Africa is one such economy whose energy mix is 80% dependent on coal fired power stations. The legislated government department responsible for energy in South Africa is the Department of Energy. In its website, the department asserts that, "*access to electricity in 1994 was at lower percentage. Since 1994 the Department of Energy (through INEP) make it possible to electrify 6.954 million households using grid technology and over 103 000 households from off-grid technology to connect houses in SA which resemble 90% access to electricity*" (Department of Energy, 2017). The generation, transmission and distribution of power are however the responsibility of Eskom, a State-Owned Enterprise (SOE) which generates approximately 95% of the electricity used in South Africa and approximately 45% of the electricity used in Africa.

Medupi Power Station is built in an area with an existing coal fired power station, Matimba Power Station, located approximately 4.5km north-east of Medupi Power Station and south-west of the town of Marapong (see *Figure 2)*. During the feasibility phase, various impact assessment studies were carried out to determine environmental and social impacts of the project locally, regional and globally. These included air quality studies and the social impacts of Matimba Power Station. Among the gases detected were high levels of SO_2 and exposure to particulate matter (PM) from Matimba and Grootegeluk mine.

One of the planning objectives for the Medupi project is to reduce the high levels of SO_2 in the receiving environment and to comply with South Africa's Air Quality Minimum Emission Standards. In order for the Medupi Power Station to comply with its Air Emissions License targets for SO_2 reduction, it is proposed the Wet FGD technology be retrofitted to the power station. Based on the engineering feasibility studies (please reference the conceptual design report) the proposed FGD technology will reduce SO_2 emission levels by 93% at worst case coal scenario. The social impacts of SO_2 will be discussed at length in the report; the discussion will also include the mechanism by which SO_2 negatively impacts on environmental and public health.

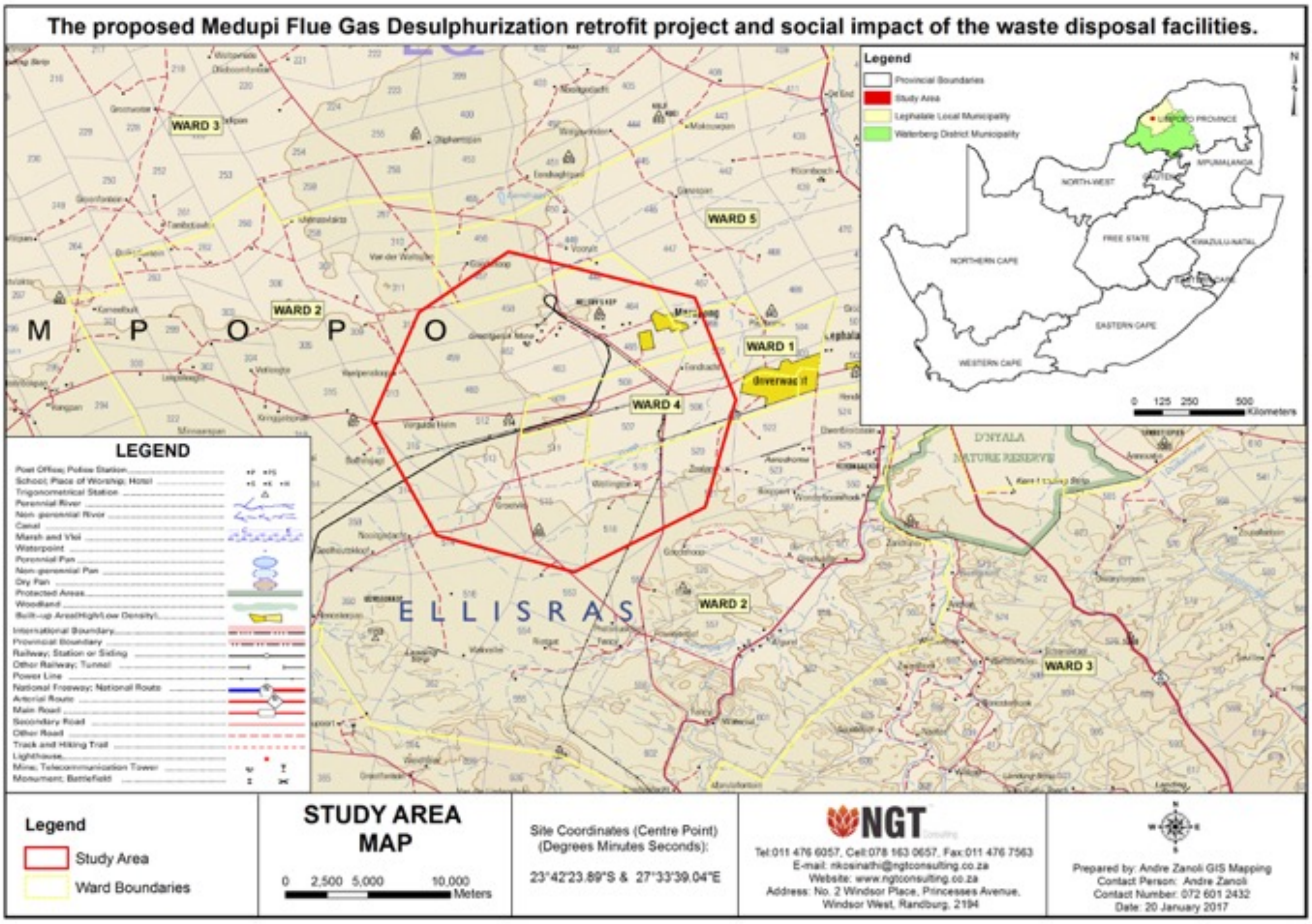

Figure 1– Location of the project area in Lephalale Local Municipality within Waterberg District Municipality, Limpopo Province, South Africa.

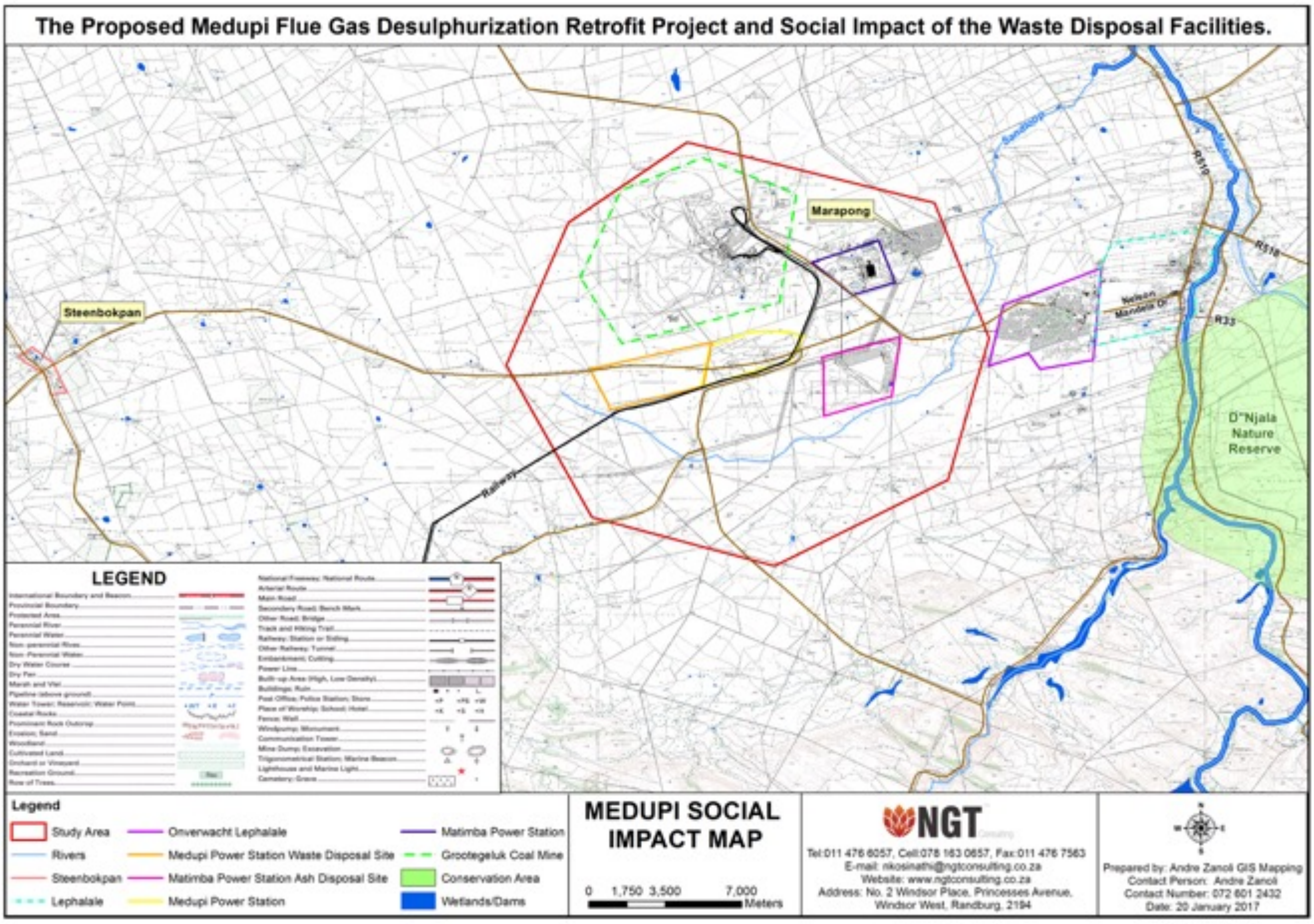

Figure 2- Social Impact Assessment map showing zones of influence for the SIA study

In 2015 Zitholele Consulting commissioned Jones & Wagner, on behalf of Eskom, to undertake waste assessment of ash and FGD waste for Medupi Power Station in order to characterise the different waste streams that will be produced as by-product by the FGD and to advise of the type of required landfill sites to store or dispose of the various wastes. The result of the study was the characterisation of the waste into three waste streams. Medupi and Matimba will both use coal with the same characteristics from Grootegeluk mine (Jones & Wagener 2015). FGD processes result in ash and gypsum, which require disposal as no end market has yet been identified for these by-products.

Based on the assessment of Matimba Power Station ash, Medupi ash was characterised to Type 3 waste requiring disposal on a Class C landfill. Gypsum was also classified as a Type 3 waste requiring disposal on a Class C landfill, showing very similar characteristics to the Medupi ash (Jones & Wagener 2015). Sludge was classified as either Type 1 or 2, which requires disposal "…in a Class A or Class B landfill for material using 96% of calcium carbonate and 85% of calcium carbonate" (Jones & Wagener 2015). The chemical salts will require disposal in a Class A landfill site because they were classified as "…Type 1 waste due to likely leachable TDS concentration as a result of high concentration of sodium chloride in the solid material..." (Jones & Wagener 2015). According to Jones & Wagener (2015), the Class A landfill offers the highest level of environmental protection of landfill barrier in South Africa and [would be the most suitable landfill for both sludge and salts produced at Medupi Power Station].

The ash and gypsum that will be produced from Medupi (retrofitted FGD) will be disposed in the existing Class C facility on an Eskom owned property on Farm Eenzaamheid 687 LQ (*Figure 3 & Figure 4 (3 D model of the ADF)*).

Other by-products of the FGD processes include chemical salts and sludge. The chemical salts and sludge will be disposed at an appropriately licensed waste disposal facility (ALADF). A decision on the ALADF is still to be made by Eskom in consultation with its stakeholders, but the facility should be a Class A facility as per Jones & Wagener (2015) recommendations.

The FGD technology and the operation of the ADF for disposing of Medupi ash and the gypsum require high levels of water usage in a region with scarce water resources. This SIA report, therefore also assesses the social impacts associated with the water requirements of the FGD technology in Medupi and the existing ADF in a region known to be experiencing water constraints.

Zitholele Consulting was appointed by Eskom to manage the Environmental Assessment process (and the associated specialists' impact assessment studies) for the proposed Medupi Flue Gas Desulphurisation (FGD) retrofit project and for the existing waste disposal facility (*Annexure 5*). Zitholele Consulting, in turn, sub-contracted NGT to conduct a Social Impact Assessment (SIA) to inform the impact assessment phase of the IEA for the FGD and the ADF for ash and gypsum.

1.2. Declaration of independence

I, Nkosinathi Godfrey Tomose, confirm that I have no conflicting interests in the undertaking of the proposed activity, that I am independent and conduct my work in an objective manner, that this report complies with the requirements for specialist reports as contained in Appendix 6 of the EIA Regulations published in December 2014, that I have the necessary expertise to conduct studies of this nature and that I will disclose any information I have that I may deem necessary and relevant to the proposed project.

17/February/2018

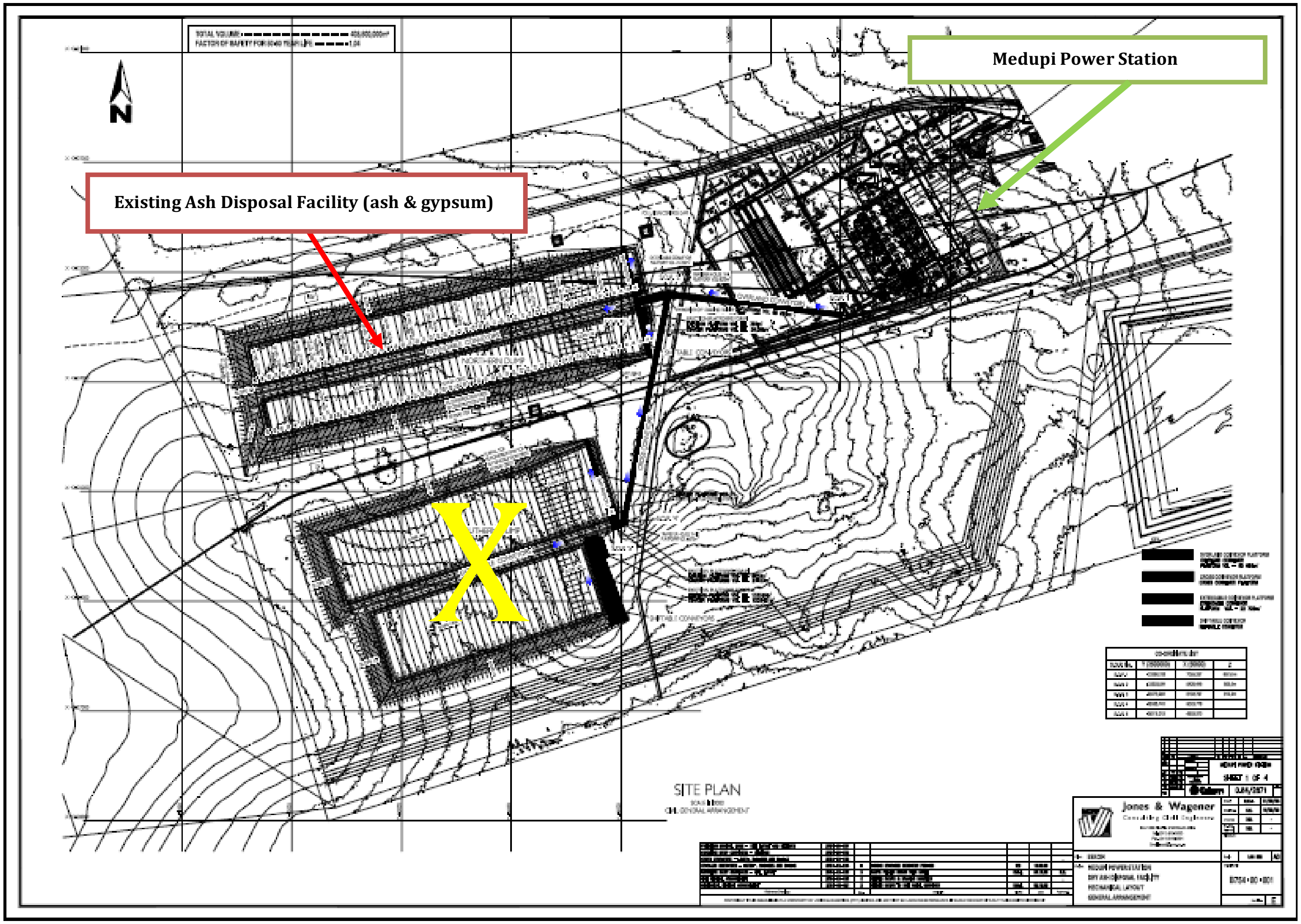

Figure 3- Layout of the Medupi ADF in relation to Medupi Power Station (x is excluded in current study) (Source: Zitholele Consulting, 2015)

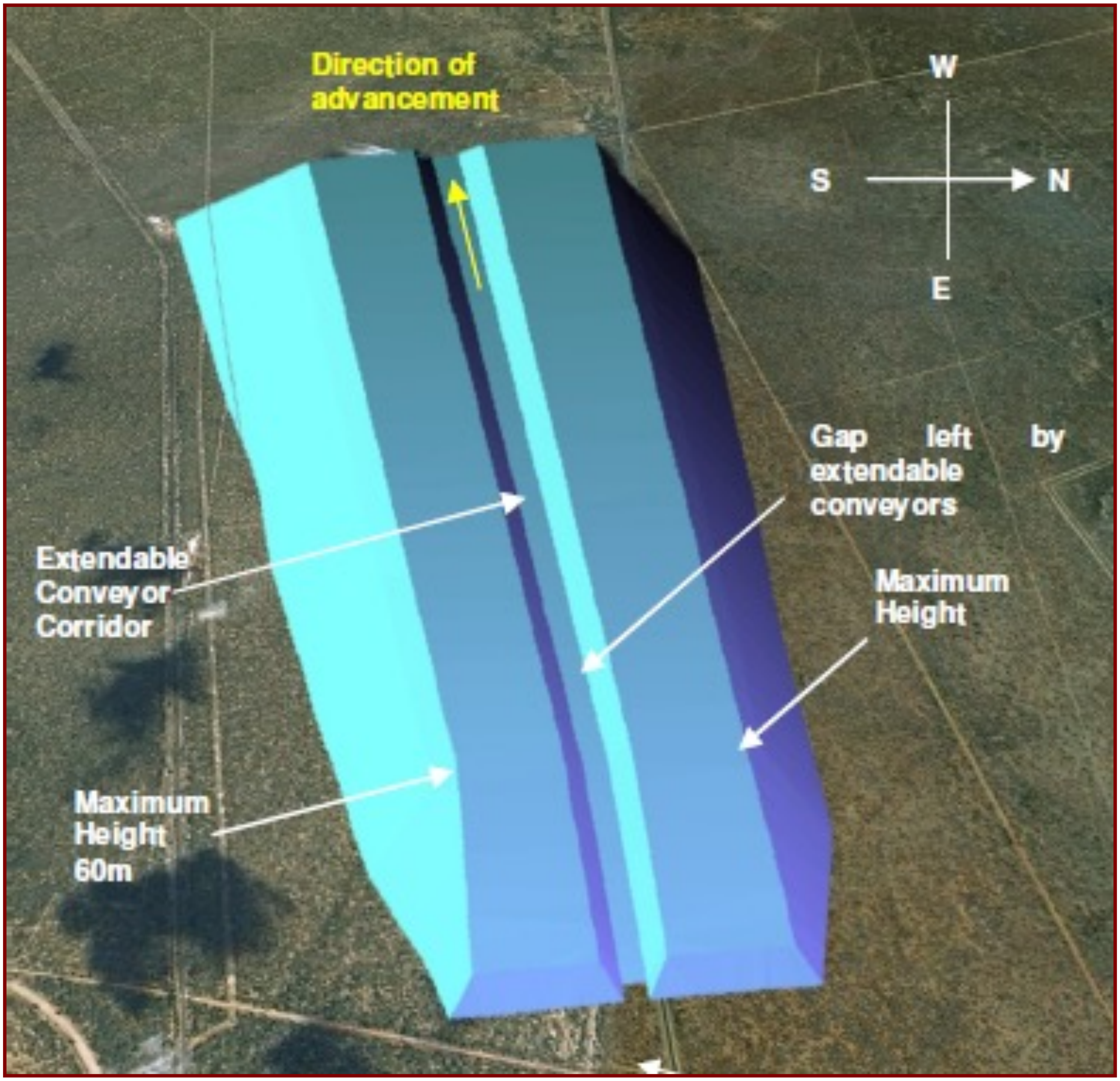

Figure 4- 3D model of the existing ash ADF (Source: Jones & Wagener, 2013)

1.3. Terms of Reference and Scope of Work

This SIA forms part of the project scope deliverables for the study, (EIA) for the proposed Medupi Power Station FGD retrofit project Impact Assessment (IA) Phase (inclusive of waste management licensing and water licensing). This SIA involves:

- The assessment of social impacts of the proposed Medupi Power Station FGD-RP (and the associated infrastructure like the proposed railway yard), with specific focus on how the project will positively or negatively impact on the environment and the social fabric of the Lephalale and the Waterberg District communities and the available ecosystem services.
- Assessment of potential social impacts associated with the operation and decommissioning of the existing and authorised waste multi disposal facility for ash and gypsum disposal.
- Provision of specialist opinion on the potential social impacts for the proposed trucking of sludge and salts to an authorised waste disposal facility outside of the study area. A separate process for the disposal of salt and sludge will be undertaken separately from the current application (Zitholele BID – Annexure 6)
- Discussion of the ratings and integrate the assessment for the purpose of the EIA.
- To compile a Social Impact Assessment (SIA) documenting the findings.
- To make recommendations and conclusions on how the positive social impacts should be enhanced for societal benefits while minimising the project negative social impacts.
- Public participation meetings were held in Lephalale, Limpopo Province as part of the EIA (with Zitholele) and the SIA process (NGT and I & APs including the project proponent); the results of these meetings are utilised to inform the discussions, conclusions and recommendation made about the Medupi FGD-RP.

1.4. Assumptions and Limitations

The following assumptions and limitations are applicable to this study:

- In order to understand the social environment and to predict impacts, complex systems have to be reduced to simple representations of reality (DEAT, 2002a). The experience of impacts is subjective on what one person may see as a negative impact may not be perceived as such by another person.

- The study was based on information available to the author during the assessment process and at the time of compilation of this report.

- In addition to the various drafts of the SIA for the FGD-RP report compiled by NGT, information on stakeholders and comments received during the various public participation meetings for the project was utilised, as is usually the case with SIAs that form part of the Environmental Impact Assessment (EIA) process. SIAs normally draw heavily from information gathered during public participation (identified stakeholders as well as comments received).

- No economic modelling or analysis was done as part of the SIA. Any data relating to the economic profile of the area was obtained from municipal sources, such as municipality/provincial websites, Integrated Development Plans (IDPs), Service Delivery and Budget Implementation Plans (SDBIPs) and census data.

- This report only applies to the Medupi Power Station FGD-RP, the existing authorised ADF, the proposed railway yard with its associated infrastructure and it will not necessarily be accurate for and applicable to similar activities at other sites.

1.5. Study Method and Report Format

The following steps were followed during the process of conducting the SIA:

- Literature review and information gathering;
- Social baseline compilation;
- Sensitivity analysis (scoping);
- Stakeholder identification;
- Field work preparation and arrangements;
- Undertaking of field work;
- Data analysis and interpretation;
- Project, site and route description;
- Impact description and analysis;
- Identification of mitigation measures; and
- Report compilation.

These steps loosely form the basis of the format of the report, which is as follows:

- INTRODUCTION:
    - Project description and background
    - Declaration of independence
    - Terms of reference and scope of work
    - Assumptions and limitations
    - Study method and report format
- LEGAL FRAMEWORK AND GUIDELINES
    - Legal mandate to address social issues in EIA
    - Guideline documents consulted and adhered to
- BASELINE STUDY: Provincial, District and Local Municipal levels
- STAKEHOLDER IDENTIFICATION AND FIELD WORK
- ASSESSMENT METHODOLOGY
- SENSITIVITY ANALYSIS
- IMPACT ASSESSMENT AND RATING
- MITIGATION
- RECOMMENDATIONS
- BIBLIOGRAPHY

Fieldwork for the project was carried out on two occasions:

- Fieldwork that solely focused on the social impacts of the FGD-RP which involved setting up meeting at key zones of influences such as Marapong, Steenbokpan, Onverwacht and Lephalale. This included site meeting with Eskom environmental management team (*Table 1*). The dates for this field work were as follows (*Refer to Annexure 1-4: FGD project notices; notice of proposed public meetings; site notices placed at various venues and photos of the meetings. Results have been summarised in Table 10, Chapter 4 of this SIA)*:

Table 1- Meeting dates, venues and time

Date of issue	Meeting Date	Venue	Time
07 March 2015	18 March 2015	Marapong Library	09:00am to 2:00pm
07 March 2015	19 March 2015	Mogol Club	1:00pm to 3:00pm
07 March 2015	19 March 2015	Steenbokpan Leseding Community Hall	09:00am to 12:00pm
Meeting proposal 12 January 2018	16 January 2018	Eskom Environmental Management Office, Medupi Power Station	11:00am to 3:30pm (meeting inclusive of site walk-about)

- Fieldwork that looked at the waste disposal facility for ash and gypsum which are by-products of Medupi Power Station as well as attendance of the public participation meeting with Zitholele Consulting Public Participation team: in February 2016
- Meeting with farmers and other property owners: in February 2016
- Fieldwork for the waste disposal facility was conducted by Mr Nkosinathi Tomose and Miss Zanele Tomose to verify the site and current conditions: on Friday 25 November 2016.
- The field survey of the proposed railway siding as well as the Medupi construction sites and existing stockpiles and dams was conducted by Nkosinathi Tomose (NGT) and Miss Taryn Aspeling (NGT) in company of Mr Emile Marell (Eskom) and Mr Dovhani Mudzielwana (Eskom) on Tuesday the 16th of January 2018.

SIA is not as seasonal as biodiversity assessments as the human population affected by the project are resident throughout the year/constant throughout the year.

2. LEGAL FRAMEWORK AND GUIDELINES

2.1. Legal Mandate to Address Social Issues in Environmental Imapct Assessment

Constitution of the Republic of South Africa

Aucamp (2009a) writes that there is a clear mandate in the Constitution of the Republic of South Africa (Act 108 of 1996) to include social issues in the EIA process. The Bill of Rights in the Constitution states: Everyone has the right –

(a) to an environment that is not harmful to their health and wellbeing; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –

 (i) prevent pollution;

 (ii) promote conservation; and

 (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

National Environmental Management Act

The National Environmental Management Act (Act 107 of 1998) (NEMA) states that, whereas many inhabitants of South Africa live in an environment that is harmful to their health and well-being, the following (relating to the social environment) are acknowledged.

- Everyone has the right to an environment that is not harmful to his or her health or well-being.
- The State must respect, protect, promote and fulfil the *social*, economic and environmental rights of everyone and strive to meet the basic needs of previously disadvantaged communities.
- Inequality in the distribution of wealth and resources, and the resultant poverty, are among the important causes as well as the results of environmentally harmful practices.

- Sustainable development requires the integration of *social*, economic and environmental factors in the planning, implementation and evaluation of decisions to ensure that development serves present and future generations.

- Everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that -

    - prevent pollution and ecological degradation;

    - promote conservation; and

    - secure ecologically sustainable development and use of natural resources while promoting justifiable economic and *social* development.

Aucamp (2009b) lists environmental principles that must be adhered to in all Acts pertaining to the environment. The following NEMA principles listed refer directly to the human/social environment.

- Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably.

- Development must be socially, environmentally and economically sustainable.

- Environmental justice must be pursued as to not unfairly discriminate unfairly discriminate against any person, particularly vulnerable and disadvantaged persons.

- Equitable access to environmental resources, benefits and services to meet basic human needs and ensure human wellbeing must be pursued.

- Decisions must take into account the interests, needs and values of all interested and affected parties, including all forms of traditional and ordinary knowledge.

- The social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment.

Section 24 of NEMA states that the potential impact on the environment, *socio-economic conditions* and cultural heritage of activities that require authorisation must be considered, investigated and assessed prior to implementation, in order to give effect to the general objectives of integrated environmental management.

<u>Environmental Impact Assessment Regulations</u>

According to Regulation 10 (c) of the Environmental Impact Assessment (EIA) Regulations that were passed in terms of Chapter 5 of NEMA in December 2014 the competent (decision-making) authority is entitled to all information that has or may have the potential of influencing any decision with regard to an application. It can be argued that, since social impacts have the potential of influencing the authority's decision, as much information on potential social impacts as practicably possible should be supplied to the decision-making authority as part of the application (Bezuidenhout, 2009).

The EIA Regulations also prescribe the content of Basic Assessment Reports, Scoping Reports and Environmental Impact Assessment Reports and include features applicable to social impacts, including: A full description of the process followed to reach the proposed preferred alternative (BAR) / activity, site and location (SR) / development footprint (EIR) within the site, including:

- (iv) the environmental attributes associated with the alternatives focusing on the geographical, physical, biological, ***social***, economic, heritage and cultural aspects; and
- (vii) positive and negative impacts that the proposed activity and alternatives will have on the environment ***and on the community that may be affected*** focusing on the geographical, physical, biological, ***social***, economic, heritage and cultural aspects.

(Content of Basic Assessment Reports: Appendix 1(3)(1)(h), Scoping Reports: Appendix 2(2)(h) and Environmental Impact Assessment Reports: Appendix 3(3)(h)).

It is clear from the above that, although there are no explicit requirements for conducting comprehensive SIAs in NEMA or the EIA Regulations, environmental and social interests should be considered equally important.

National Environmental Management Air Quality Act No. 39 of 2004

This Act sets norms and standards for regulating air quality in South Africa in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development while promoting justifiable economic and social development. To also regulate air quality monitoring, management and control, for both specific air quality measures and matters incidental thereof. It promulgation is triggered by the fact that the quality of ambient air in many areas of the country are not conducive to a healthy environment for the people living in those areas let alone promoting their social and economic advancement. This is true in the case of the Waterberg which has been declared as one of South Africa's priority areas in terms of pollution. The application of this Act in terms of the SIA is important considering the fact that the burden of health impacts associated with polluted ambient air falls most heavily on the poor, whereas air pollution carries a high social, economic and environmental cost that is seldom borne by the polluter.

National Environmental Waste Management Act (No.59 of 1998)

In terms of Section 44 of the National Environmental Waste Management Act (NEWMA) No. 59 of 1999 all listed waste management activities must be licensed and in terms of the Act. The Act makes provisions that the licensing procedure must be integrated with the environmental impact assessment (EIA) process. The FGD proposed at Medupi Power Station will result to production of hazardous waste materials such as chemical salts and sludge as well as gypsum and ash. All these by-products of the FGD required application in terms of the NEWMA. The current SIA evaluates the provisions made in the Act for the protection of human health and their ecology through provision of reasonable measures for the prevention of pollution and damage to human environment. This is important in the case of the proposed Medupi FGD which will produce by-products such as chemical salts, sludge, ash and gypsum. All these by-products require special licensing at certified landfill sites. The process of disposing and storing these by-products of the FGD have direct consequence to potential negative or positive impacts of the project to human health and the environment in which they live in.

The Occupational and Safety Act, No. 85 of 1993

The nature of activities associated with the proposed FGD retrofit project have health and safety dimension to them and this triggered provisions of Occupational Health and Safety Act (OHSA), No. 85 of 1993. The objective of this Act is to provide for health and safety of persons at work and for the health and safety of persons in connection with the use of plant and Machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work. It also aims to establish an advisory council for occupational health and safety; and to provide for matters connected therewith. Section 12 of the OHSA is particularly relevant to this SIA because it stipulates that every employer whose employees undertake listed work or are liable to be exposed to the hazards emanating from listed work shall:

- Identify the hazards and evaluate the risks associated with such work constituting a hazard to the health and safety of such employees and take the necessary steps to avoid such risks
- Prevent the exposure of such employees from such hazards as far as reasonably possible.

2.2. Guideline and other documents consulted and adhered to

The following international and local guidelines and standards were adhered to during the process of conducting the SIA:

- Inter-organisational Committee on Guidelines and Principles for SIA (2003);
- Social Impact Assessment: Guidance for assessing and managing the social impacts (Vanclay F. E., 2015);
- EIA Regulations, 2014: Appendix 6 – Specialist reports;
- Department of Environmental Affairs and Tourism, Information Series 4: Specialist studies;
- Department of Environmental Affairs and Tourism, Information Series 22: Socio-Economic Impact Assessment;
- IFC Performance Standards on Environmental and Social Sustainability Effective January 2012
- International Principles for Social Impact Assessment
- International Association for Public Participation (http://www.iap2.org/)

In addition, a PhD thesis titled “Social Impact Assessment as a tool for social development in South Africa: An exploratory study” by Aucamp (2015) was used. This thesis investigated whether SIA can be used effectively as a tool for social development in South Africa; to what extent the SIA methodology currently practiced in South Africa reflects social development, and whether guidelines for SIA can assist SIA practitioners with achieving social development outcomes.

Lastly, two lists of social variables as identified by Vanclay (cited in DEAT, 2006) and the Inter-organisational Committee on Guidelines and Principles for SIA (2003) respectively were used to ensure that all potential social impacts of the development were identified and assessed for all four the project stages. The two table below lists categories of social variable (*Table 2*) and list of social variable (*Table 3*).

Table 2-Categories of social variables

Health and social well-being	Death; nutrition; actual health and fertility; perceived health; mental health; aspirations for future; autonomy; stigmatization; feelings in relation to the project
Quality of the living environment	Physical quality – exposure to noise, dust, risk, odour, etc.; leisure and recreation opportunities; aesthetic quality; availability of housing; quality of housing; physical and social infrastructure; personal safety and hazard exposure; crime and violence
Economic impacts and material well-being	Workload; standard of living; economic prosperity and resilience; income; property values; employment; replacement cost of environmental functions; economic dependency
Cultural impacts	Change in cultural values; violation of culture; experience of being culturally marginalized; commercial exploitation of culture; loss of local language; loss of natural and cultural heritage
Family and community impacts	Alterations in family structure; obligations to family/ancestors; family violence; social networks – interaction with others in community; community connection – sense of belonging; community cohesion; social differentiation and inequity; social tension and violence
Institutional, legal, political and equity impacts	Capacity of government agency to handle workload generated by project; integrity of government agencies – absence of corruption and competence of agency; legal rights; human rights; participation in decision making; access to legal advice; fairness of distribution of impacts across community
Gender relations	Women's physical integrity – can decide about own body; personal autonomy of women – independence in all aspects; gendered division of labour – income, household, childbearing and rearing of children; access to resources and facilities; political emancipation of women

Source: Vanclay, cited in DEAT, 2006

Table 3 -ICGP lists of social variables

Population change	Population size, density and change; influx and outflow of temporary workers; presence of seasonal (leisure) residents; relocation of individuals or families; racial and ethnic composition and distribution
Community/ Institutional arrangements	Voluntary associations; interest group activity; size and structure of local government; industrial/commercial diversification; employment/income characteristics; local/regional/ national linkages; employment equity of disadvantaged groups; historical experience of change
Political and social resources	Distribution of power and authority; inter-organisational cooperation; conflict between newcomers and long term residents; identification of stakeholders; interested and affected parties; leadership capability and characteristics
Individual and family level impacts	Displacement/relocation concerns; trust in political and social institutions; residential stability; family and friendship networks; density of acquaintanceships; perceptions of risk, health and safety; attitudes towards the proposed action; concerns about social well-being
Community resources	Change in community infrastructure; indigenous populations; changing land use patterns; family and friendship networks; effects on known cultural, historical, sacred and archaeological resources

Source: ICGP, 2003

3. BASELINE STUDY

The most common source of quantitative data in SIA is census data, which is used to produce demographic profiles. It is commonly used to provide baseline information. Other sources include Integrated Development Plans (IDPs), Spatial Development Frameworks (SDFs), Service Delivery and Budget Implementation Plans (SDBIPs) and Employment, Growth and Development Plans (EGDPs).

Baseline conditions are the existing conditions and past trends associated with the human environment in which the proposed activity is to take place (DEAT, 2006).

Establishing the baseline conditions is essential for describing the receiving environment, the *status quo* and for identifying and predicting potential impacts. "A prediction of change can only be as effective as the baseline information from which it is derived. It is thus important that the specialist puts the proposed project in perspective by comparing the current state with the potential future state" (DEAT, 2002a).

3.1. Affected Environment and Description

Medupi Power Station is located west of Lephalale in Limpopo Province a little east of the South African border with Botswana, in Lephalale Local Municipality of Waterberg District (*Figure 5*). The SIA covered a 30km radius from Medupi in order to include all the human settlement areas such as Steenbokpan and villages north of Lephalale Town.

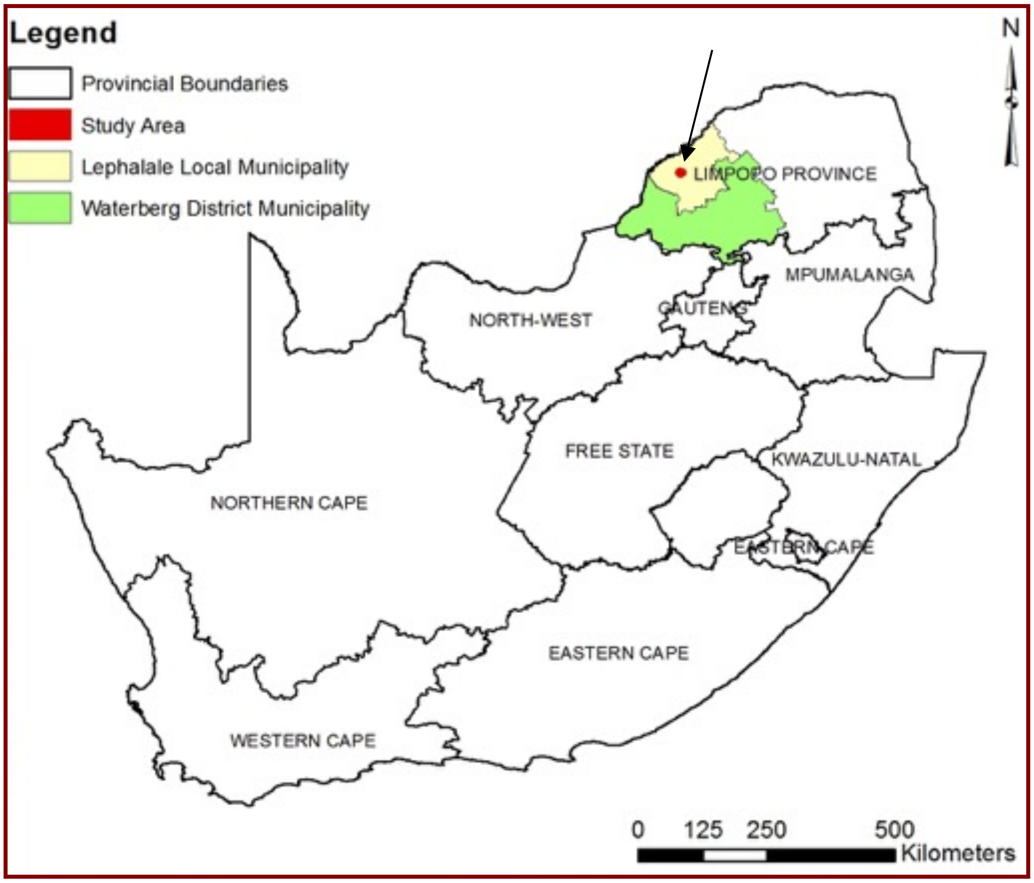

Figure 5- Location of the study area in relation to Lephalale Local Municipality of Waterberg District

Lephalale LM is characterised by a mix of human settlements which vary from formal to informal in townships. A mix of formal and informal dwellings is found in Marapong and the hamlet of Steenbokpan. The suburbs of Onverwacht and Lephalale Town provide formal dwellings in the municipality (*Figure 6*). A number of villages and farms also define the landscape of Lephalale LM. Heavy industries include the newly built Medupi Power Station, the existing Matimba Power Station, Grootegeluk coal mine, Sasol and these are all located west of the town of Lephalale within close proximity to Marapong. A number of new mines are in the planning stages and some have already started operating, mining coal and platinum among other resources. Coal presents the dominant resources currently being mined in Lephalale due to fact that the Waterberg coal reserves represent 40% of South African coal reserves and are mined to support two coal fired power stations in the area and the Sasol coal-to-liquid petrochemical industry. A third power station is planned in the area and is currently undergoing the approval process.

Land uses of Lephalale LM can therefore be described as a mix of agricultural activities, game farming, cattle ranching, industrial activities such as mining, power generation, domestic and industrial water supply. These activities make up 87% of the total land use of Lephalale LM. Lephalale LM and the Waterberg District are characterised by a number of game farms and conservation areas, with the Waterberg Mountains boasting a national conservation status. Within Lephalale LM only one declared conservation area is found and it is situated south-east of the town of Lephalale i.e. D"Njala Nature Reserve (*Figure 6*).

The study area is characterised by a number of secondary roads, with Nelson Mandela Drive cutting across the Town of Lephalale, past Onverwacht towards Medupi Power Station (*Figure 6*). In the east, it joins the R510 (linking Lephalale to Thabazimbi in the south) west of Mokolo River. Other secondary roads that are linked to the R510 which provide access to Lephalale include the R518 and R33. A railway line from Grootegeluk mine passes east and south of Medupi Power Station and extends westwards south of the existing ADF, then south towards Thabazimbi. This is the only documented railway line within the study area.

Marapong is the closest human settlement to Medupi Power Station. It is located approximately 8.6km north-east of the power station and falls within the 10km radius determined as the key priority area/zone of influence. The second closest location is Onverwacht at approximately 10.5km east of the power station. It falls outside the 10km buffer zone defined as the priority area. Lephalale Town is third human settlement situated in close proximity to the power station; it is located approximately 12.6km east of Medupi and east of Onverwacht. It also falls outside the 10km priority area. All these three human settlements are located north and east of Medupi and the existing ADF with prevailing winds blowing north-south and north-east to south-west towards Thabazimbi and the village of Steenbokpan (located some 27km west of Medupi). This means that Marapong, Onverwacht and Lephalale will not be directly significantly affected by emissions from Medupi as determined by the direction of winds and its variables.

The following landmark features can be observed in Figure 6 below:

- Mokolo River is situated east of the Town of Lephalale and adjoin by a small tributary called Sandloop which extends south to west of Medupi Power Station and the ADF.
- A number of pans and wetlands are found throughout Lephalale LM with a large number of wetlands found along Mokolo River and southwest of D"Njala Nature Reserve.
- In close proximity to the study area, three wetlands have been recorded near the Matimba ADF, east of Matimba Power Station and south of Grootegeluk coal mine.

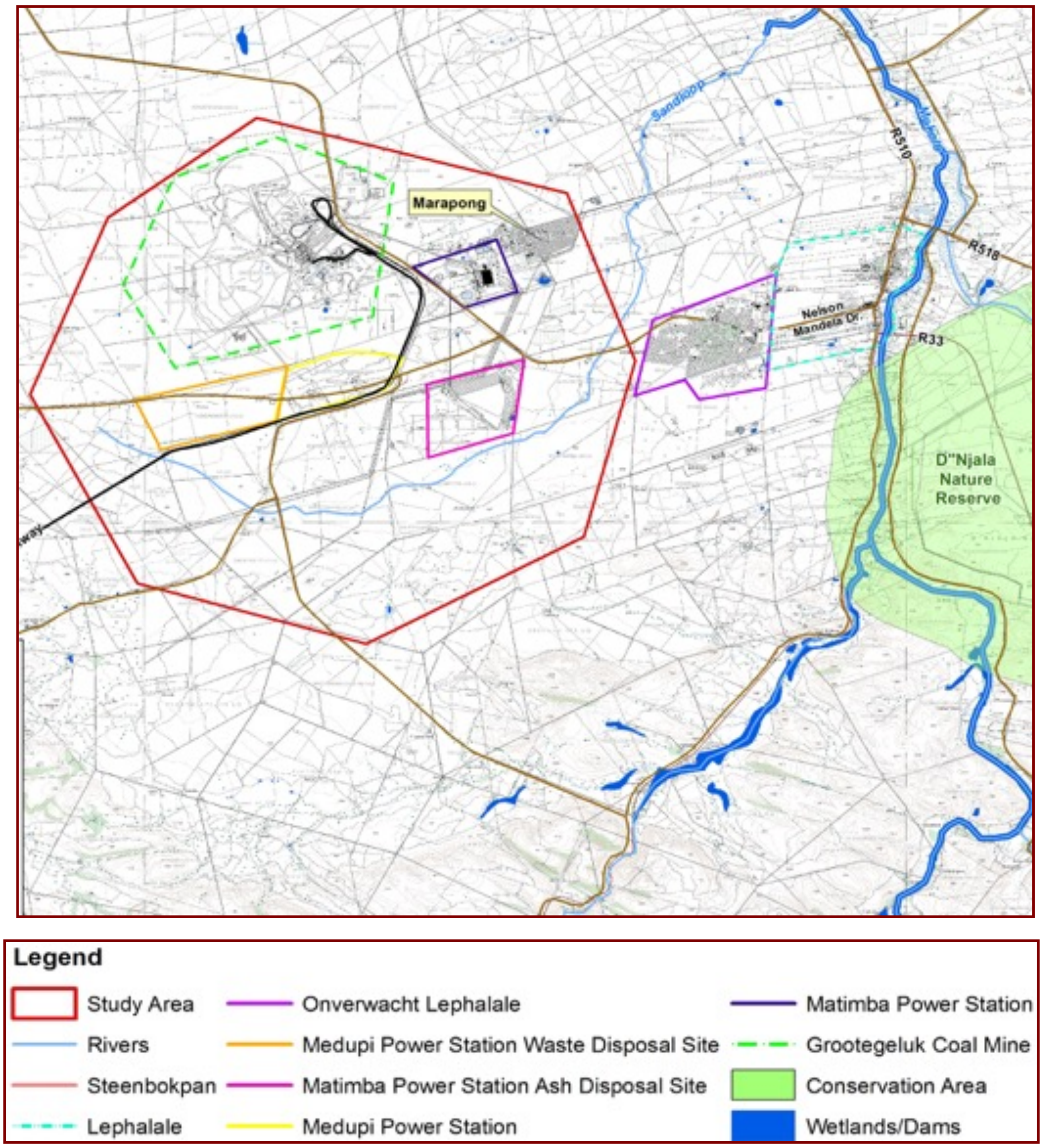

Figure 6- Map showing aspects of Matimba, Grootegeluk, Medupi and settlement areas and water bodies

3.2. Population Dynamics in Lephalale LM

The Local Economic Development Strategy for Lephalale LM show that the population in Lephalale has increased by 45% between 2001 and 2014 (from 85,155 to 123,869) (*Figure 7*) (LM IDP, 2016-2017). Population growth in the Lephalale town node is among the highest in the Limpopo Province. The surge in population is also experienced south of Lephalale LM; for example, Thabazimbi has experienced a population increase of 35%, Mookgopong an increase of 13%, Modimolle an increase of 11%, Bela-Bela an increase of 36% and Mogalakwena recorded an increase 11% in the same period (*Figure 8*). In Lephalale LM the influx can be directly attributed to the construction of the Medupi built coal fired power station project and associated ancillary infrastructure. An assumption was also made that the overall increase in population in the region could be as a result of projected future projects associated with the Waterberg coal fields e.g. the expansion of the mining industry as well as coal-to-liquid petrochemical industry project such as Sasol Mafutha 1 in Lephalale.

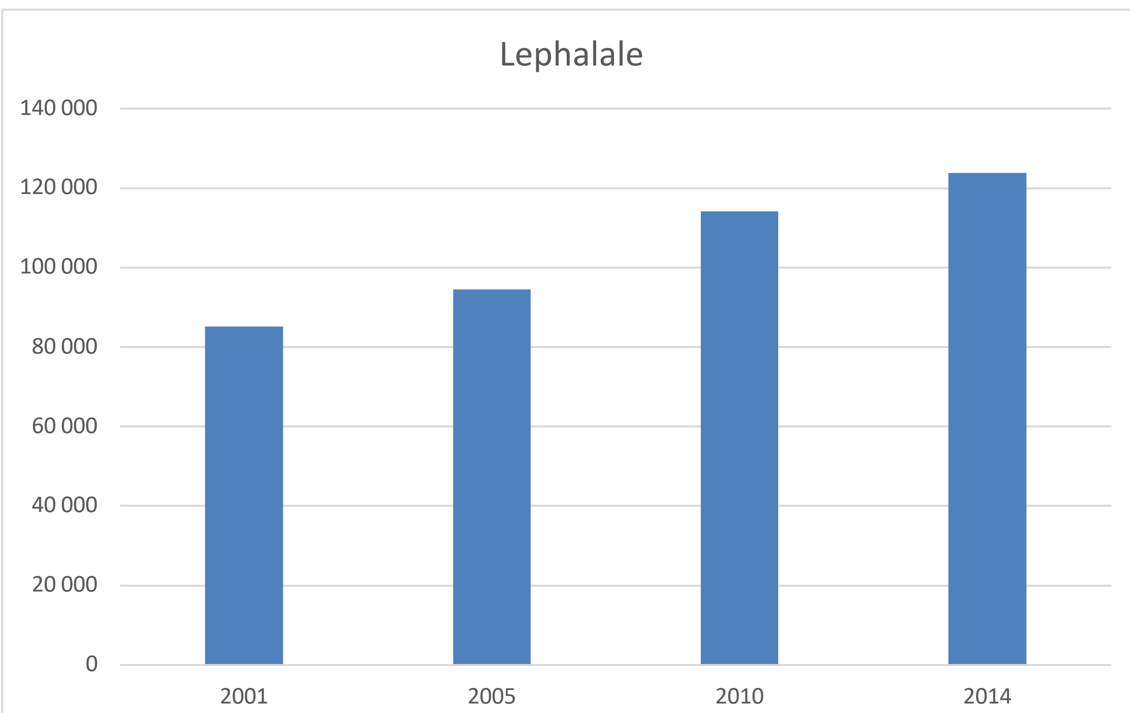

Figure 7 - Total Population of LLM 2001-2014

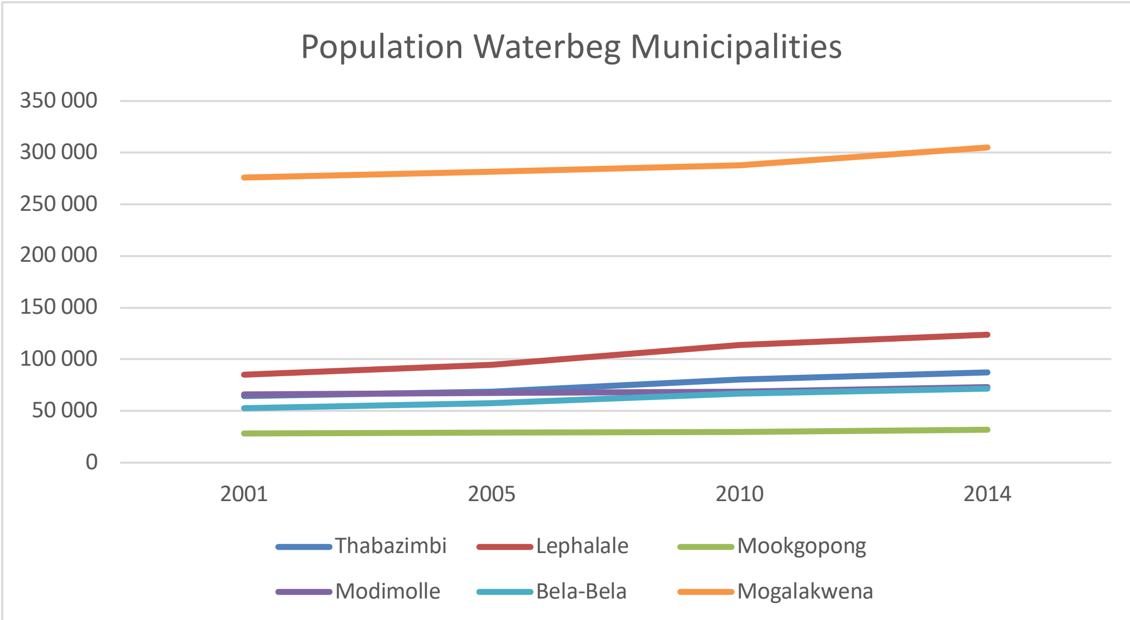

Figure 8 - Total Population of Waterberg Municipalities 2001 – 2014

According to Lephalale LM IDP (2015-2016), 83% of the population migration into Lephalale LM came from within the Limpopo Province, 11% from other South African provinces and 6% from outside South Africa borders (*Figure 9*).

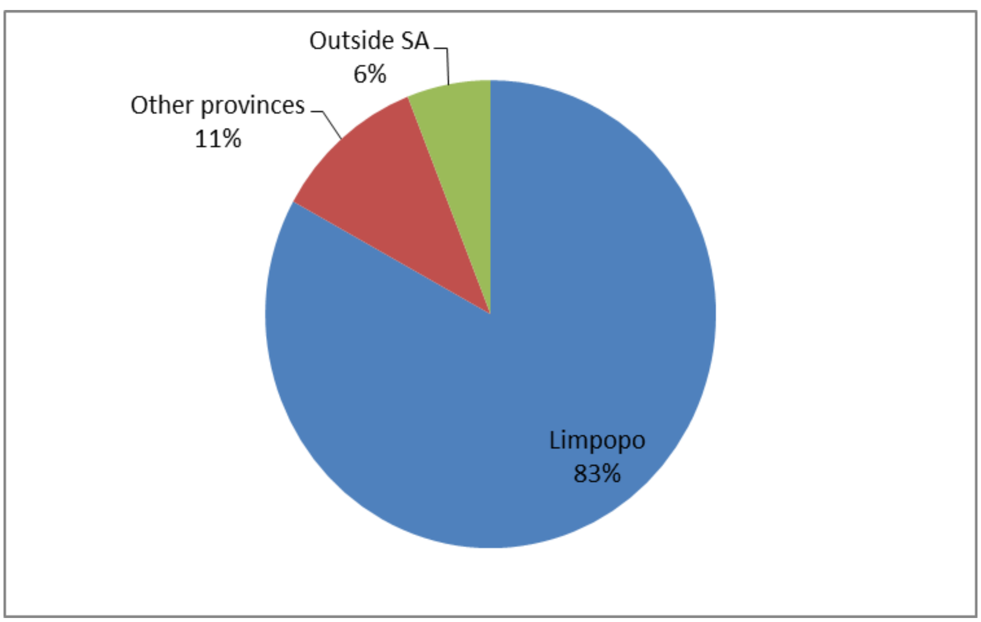

Figure 9 : Source of Migration into Lephalale LM

Based on the above figures, it can be concluded that Lephalale LM is the fastest growing South African LM. Other major influencers are projected projects in the region associated with the Waterberg coal fields such as the expansion of the coal mining industry (new mines), the developing coal to liquid petrochemical industry such as Sasol Mafutha 1, the expansion of Grootegeluk coal mine as well as associated infrastructure built industry such as road construction, water and sanitation built infrastructure, property and housing development.

Section 3.5 below discusses the various economic activities in the LM, it is preceded by the discussion of education and skills levels section (3.3) and health and wellbeing of people in Lephalale LM (section 3.4). Both section 3.3 and 3.4 are seen as important indirect drivers of the economy.

3.3. Education and Skills Levels in Lephalale LM

Lephalale LM has a total of 94 various educational facilities spread throughout the municipality. According to the LM's IDP report (2015-2016), more than 95% of the population is within 30 minutes walking distance to the nearest education facility. Accessibility to schools in the rural areas is relatively good particularly for primary schools. This is not the case with regards to secondary schools as there are still students who stay more than 10km away from the nearest education facility. Access to secondary education has resulted in low numbers of pupils proceeding to tertiary education. The assumption is made that this could be as the result of learners being despondent of traveling long distance to go to school and the cost of public transport resulting in absenteeism and poor learner performance at the end of the year prohibiting them to proceed further with their education.

However, there could be other social and socio-economic influencers to the situation such as the availability of reading materials, qualified teachers and poor school infrastructure. One of the challenges that the municipality has listed is that most of the secondary schools in the rural areas do not have enough teachers to offer mathematics and science subjects, and a lack of technical high schools limits career paths for students.

In terms of overall performance, the LM seems to be slightly higher than the Waterberg and Limpopo in terms of education levels but not sufficient to respond to the needs of the growing economy such as the Lephalale one. Research from Quantec Regional Database and PD Consulting found that 75% of the Lephalale population has schooling below Grade 12 levels (some secondary, complete primary, some primary, and no schooling at all) (*Figure 10*).

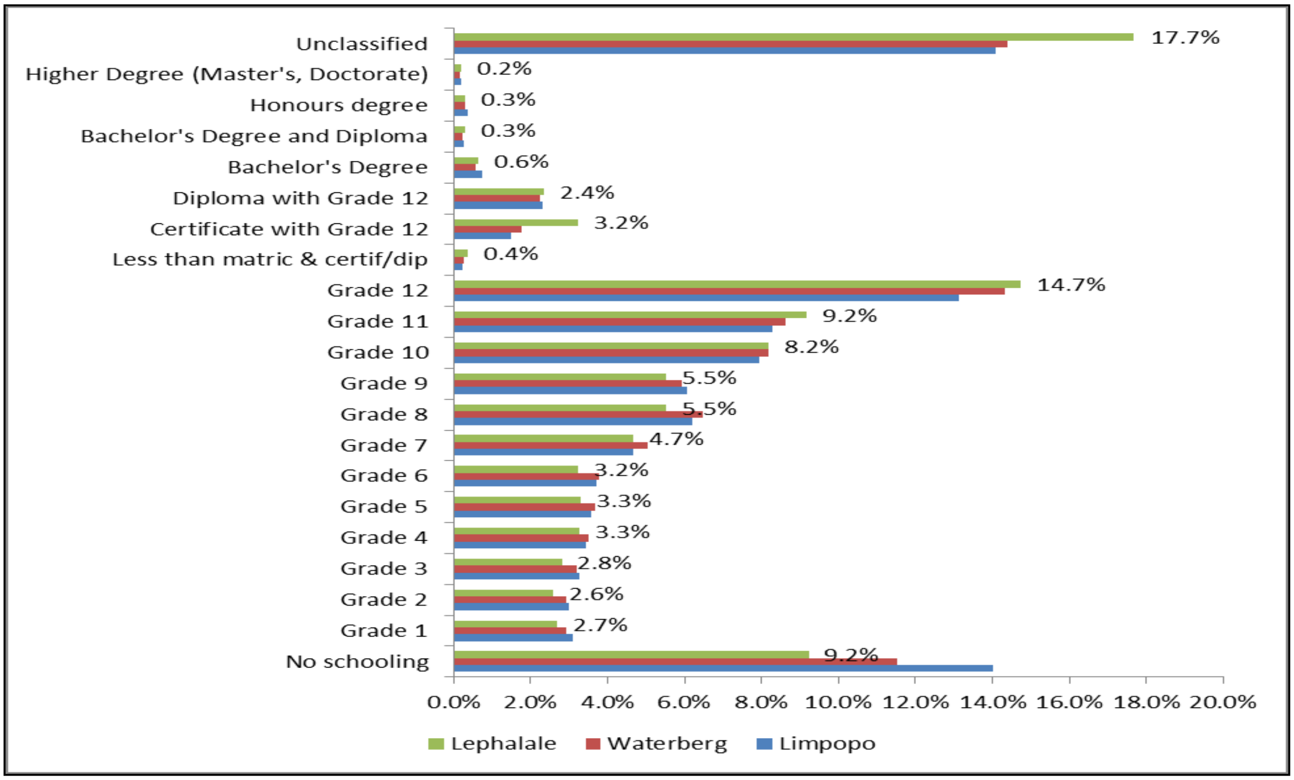

Figure 10 : Education Levels

It has to be noted that not all of Lephalale citizens are below Grade 12 in terms of their educational achievements. There are those who have proceeded beyond Grade 12 and who have obtained post-Grade 12 qualifications such as Diplomas, Degrees and Post-Graduates, but the numbers are very low (*Figure 8*). This fast-growing economic hub only has one FET College, located in Onverwacht with the other campus in Modimolle. The FET College offers a wide range of vocational and diploma courses (http://www.careersportal.co.za/colleges/fet-colleges-public/881-lephalale-fet-college.html /22 January 2017).

Among the listed admission requirements are NSC (Grade 12) or NC (V) level 4 - (NQF Level 4) and this is a challenge in an area with a high number of people without Grade 12. Based on the available data it can be concluded that the average education levels of Lephalale citizens is very low to respond to requirements of the fast-growing economy like that of Lephalale LM. This is evident when one assesses the available skill pool against required skillset in the area to see the variation or gaps that that exist (*Table 4*). Only a few would be able to respond to technologically intense projects such as the FGD and the technical requirements required to work in industries such as heavy chemical processing and recycling industry.

Table 4- Scarce Skills within the Lephalale Municipality

Number of scarce skills				
Sector	Scarce Skill	Baseline	Required	Variance
Mining	Artisan (mining, electricity	79	101	22
	Technician (electrical & Mechanical)	74	98	24
	Machine Operators	106	127	21
	Engineering manager	6	7	1
Tourism	Tourism marketing	2	20	18
	Tour guides	0	200	200
	Tourism information presenters	0	135	135
Agriculture	Agriculture engineering	4	10	6
	Veterinary medicines	6	9	3
	Meat inspectors	1	10	9

3.4. Community Health and Wellness in Lephalale LM

The World Health Organisation (WHO) in 2012 reported that one in eight deaths in the world is due to air pollution. The pollution is either ambient (outdoor) or indoor. WHO further concluded that 88% of premature deaths in middle and low income countries whose economy is coal based to ambient pollution. South Africa is one of such countries whose economy is coal based economy. To understand the community health and wellness in Lephalale and the type of health challenges faced by those affected, one has to understand the various types of polluters and the types of pollutants emitted and how these negatively impact on human health.

Four main polluters have been identified in the study area and they include:

- Eskom through combustion of coal in its Matimba Power Station and the currently built Medupi without the retrofitted FGD technology (Unit 6 was synchronised into the grid in 2015), and disposal of ash from Matimba and Medupi;
- Grootegeluk coal mine through coal extraction and processing, fossil fuel combustion;
- Domestic fossil fuel combustion; and
- Fossil fuel combustion to support the thriving commercial and agricultural industries in the study area.

In South Africa, like in many other parts of the world, there are three main anthropogenic polluters: industrial combustion of fossil fuels, domestic burning of fossil fuels, and exhaust fuel from motor vehicles and trucks. There are also sporadic veld fires, which contribute to the combustion of organic matter and solid fossil fuel materials. Combustion of fossil fuel contributes to pollution of ambient and domestic air. In Lephalale, coal is the main source of pollution throughout its life cycle: from extraction, combustion through to disposal. It contributes to pollution of both ambient and domestic air through a wide range of pollutants such as PM (particulates/dust), SO_2 (Sulphur dioxide), NO_2 (Nitrous oxide), O_3 (Ozone) (Itzkin, 2015). Liquid fossil fuel burnt/used by cars contributes to carbon monoxide (CO), while other known general pollutants include lead and volatile organic compounds.

Exposure to some of the aforementioned pollutants, namely PM (i.e. PM_{10} and PM $_{2.5}$ µm), SO_2, NO_2, O_3 can result to great harm to human health and wellbeing (WHO, 2014). The harm to human health as the result of exposure to these pollutants is directly dependent on their spatial distribution and concentration (McGranaham & Murray 20003). Most of the identified pollutants are a local phenomenon, with concentration at a particular location dependent on the rate of emissions, geography, climate combination and meteorological dispersion factors.

From a human health perspective, a number of illnesses or diseases are associated with the identified pollutants, mostly produced throughout the coal life cycle, and these are mostly respiratory related or cardiovascular in nature or cancer. Abnormal neurological development such as poor fetus growth is known to occur in in children as the result of some of the pollutants, especially those that are coal based.

SO_2 contributes a great deal to respiratory effects as the airways and lungs become damaged by exposure to SO_2 leading to inflammation, cytotoxicity and cell death. PM varies in size between 10 and 2.5 µm and is known to cause asthma, decrease in lung function in children and also causes pulmonary disease. A higher number of patients with lung cancer is often reported in areas with a higher concentration of particular matter (PM) over a long period (Burt, Orris & Buchanon, 2013). SO_2 is known to result in increased severity and incidents of respiratory illnesses in communities that are exposed to high concentrations. The gas is also known to cause inflammation and hyper-responsiveness of airways, aggravate bronchitis and decrease lung function (ibid). There is a strong association between high levels of exposure in a community and hospitalization as the result of SO_2, including those with other respiratory conditions (ibid). According to Burt, Orris and Buchanon, those highly susceptible to health risks associated with high levels concentration of SO_2 include people older than 60 years, children and asthmatic patients. Low concentrations of the gas can also lead to death as the result of heart and lung disease in susceptible patients.

Adel Itzkin (2015) Master of Science Thesis titled “Health in the Waterberg, Up in Smokes?” provides a good insight into amount of pollution experienced by the people in the Waterberg as the result of the combustion of coal. The two graphs below provide a good example of the type of illness and disease associated with some of the above mentioned gases and PM resulting from combustion of coal in power generation efforts (*Figure 11 & 12*). The two graphs show that there is a correlation between illnesses and disease associated with the combustion of coal and disease and illnesses experienced by the people of Lephalale LM.

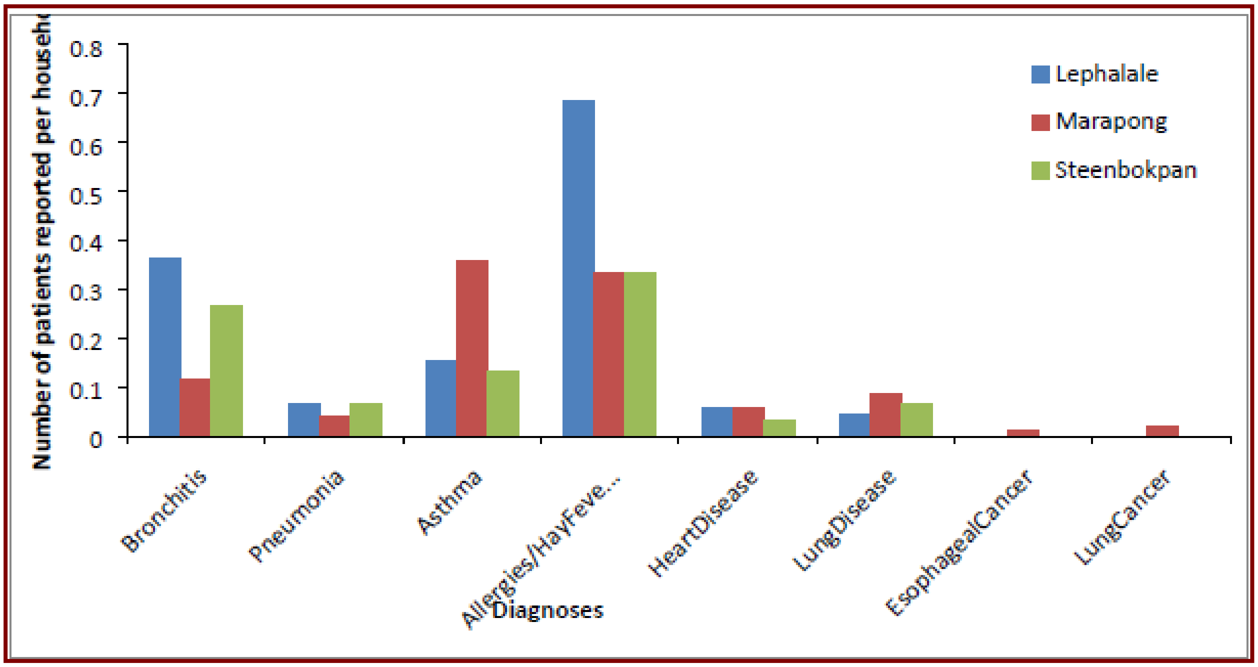

Figure 11- Diagnoses of those who went to seek medical assistance for Lephalale, Marapong and Steenbokpan (represented as average number per household) (Itzkin, 2015)

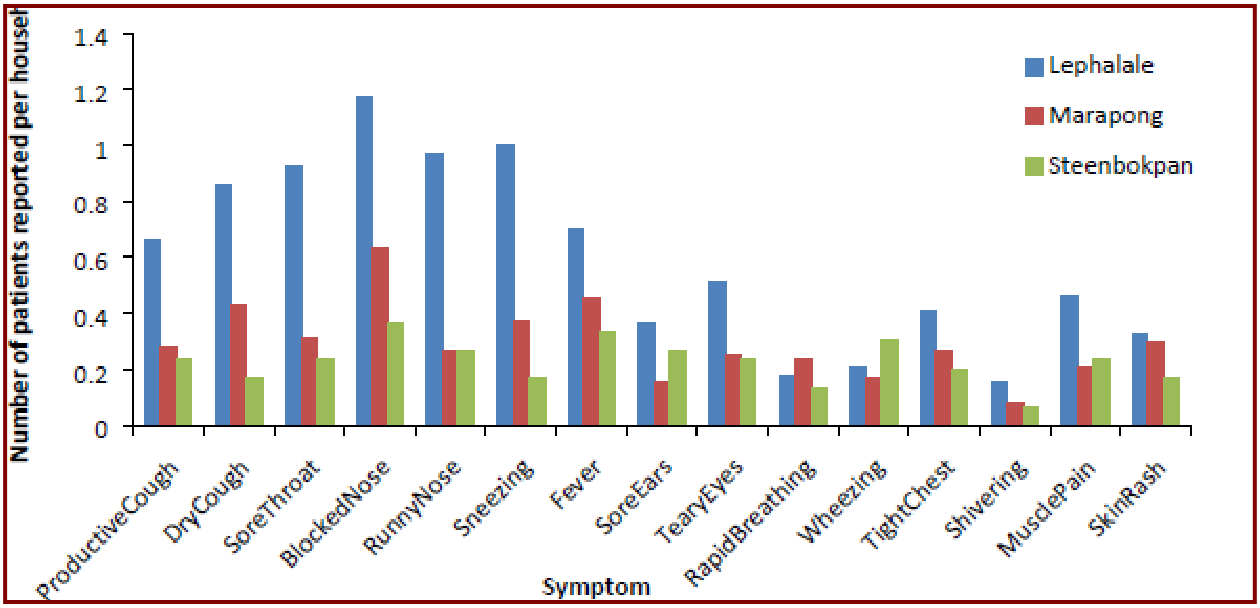

Figure 12- This graph presents the number of people with respiratory problems who experienced each of the symptoms listed. These are measured as average per household for Lephalale, Marapong and Steenbokpan (Itzkin, 2015)

Other diseases and illnesses known in Lephalale are tabled in Table 5 and Table 6 below. Some of these illnesses are accelerated as the result of high exposure to SO_2 and PM. Although not directly linked to emissions, deaths from HIV/AIDS related illness such as pneumonia, tuberculosis and many more may be accelerated due to high levels of exposure to harmful gases such as SO_2 and PM which both contribute to lung disease. As can be seen in Table 6, HIV prevalence in Lephalale is almost double that of the province and the district and AIDS infections are almost 20% higher. Another challenge is that patients seek medical attention when they are at an advanced stage of ailment and this results in high mortality rates amongst children and adults (Lephalale Local Municipality, 2014).

Table 5 : Chronicle of Health Conditions within the Lephalale Municipality

Chronical health condition	***In thousands***	
Tuberculosis	Male	10
	Female	10
	Total	20
Heart attack	Male	5
	Female	8
	Total	13
Stroke	Male	5
	Female	4
	Total	9
Asthma	Male	27
	Female	38
	Total	65
Diabetics	Male	33
	Female	44
	Total	76
Cancer	Male	*
	Female	6
	Total	7

Table 6- HIV Prevalence by District, Municipality and province

Geography	Years	2001	2007	2011	2013	2007 -2013 Percentage Increase
Limpopo	**HIV+ estimates**	211,106	339,034	371,439	379,718	12%
	AIDS estimates	6,433	14,868	19,587	21,559	45%
Waterberg	**HIV + estimates**	28,362	49,114	54,327	55,164	12%
	AIDS estimates	885	2,201	2,921	3,191	45%
Lephalale	**HIV + estimates**	4,335	8,203	9,901	10,309	26%
	AIDS estimates	136	367	529	590	61%

3.5.Economic Activities in Lephalale LM

The 2013 Quantec regional database on economic activities in Lephalale LM shows that mining is the biggest contributor to the municipality GDP, with a total of 34% contribution (*Figure 11*). It is followed by electricity which contributes 23% to the LM GDP. Community services are the next biggest contributor at 16% and Trade at 9% respectively (*Figure 11*).

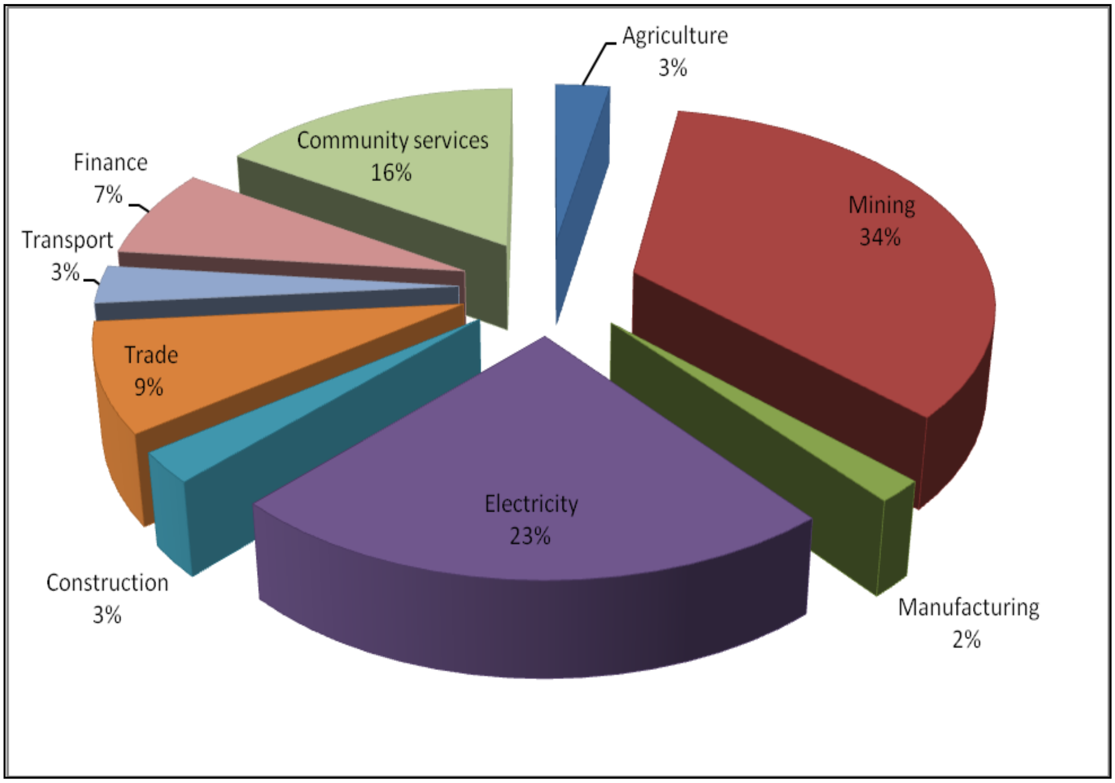

Figure 13- Sector Contribution to GDP

The LM boasts up to 40% of the country's coal reserves. This made the LM the perfect place for the construction of the Medupi power plant, which transformed the face of the Lephalale economy. Based on this and the figures shown in Figure 13 above, the mining and energy sector are the biggest players in the economy of Lephalale LM and that of the Waterberg District. According to an IOL business report article – The town of Lephalale's gross domestic product has increased by about 95 percent a year as a result of the power station's construction (Cox, 2015).

Wayne Derksen, the president of the Lephalale Chamber of Commerce said in a business report article that that in the informal sector; many catering, laundry, transport and labour camp accommodation businesses have boomed (Faku, 2013). He further stated that "Lephalale council's income from revenue including rates and taxes has more than doubled to R212 268 for the 2013/14 financial year from R83 789 in the 2007/8 financial year as a result of Medupi". Eskom has stated that it needs to increase electricity generation from 40 000MW in 2008 to 80 000MW in 2026. Half of this energy supply will be from coal fired power stations, (Lephalale municipality, IDP: 2013-2016). The implication of this is that 20 000MW is needed from coal. Like Kusile power station, Medupi is expected to generate 4, 800MW of electricity. This means that at least another 10 400 MW of generation capacity is required from coal before 2026. With an estimated resource of 50 billion tons of coal, the Waterberg Coal Field is the most likely source of coal for this purpose. The likelihood that the municipality can host three more coal fired power stations is apparent, (Lephalale municipality, IDP: 2013-2016).

The municipality is currently in the second stage of considerable public sector investment which is estimated at R140 billion over six years. With the anticipated Eskom developments, Coal miners are planning developments to meet the increased demand for coal. One such is the Grootegeluk coal mine owned by Exxaro. As part of its mining expansion programme, Exxaro has announced that it will be constructing a new coalmine named Thabametsi. Exxaro is also targeting the development of a 1,200MW independent power plant to be attached to the new mine.

The new coal mines and power stations could lead to a six-fold increase in households in and around Lephalale. This will create a significant demand for building materials and will have positive implications for retail, service and small industry development. Based on all the above, Wayne Derksen, the president of the Lephalale Chamber of Commerce predicts the life expectancy of the economic boom is 30 years due to another power station and all the mining activity. However, Steph Beyers, a director for development at Moolman Group, which built the R170m Lephalale Mall, cautioned that the town's economic "bubble will burst" once the construction of Medupi was complete. He said there would be a "slowdown" once Medupi construction neared completion and the construction workers and consultants left town. He further said "*We, however, believe there are and will be enough other capital projects commissioned in the near future. For example, new mines, the expanding of existing mines, independent power stations, and the upgrade of council infrastructure and so on that will again put and keep the town of Lephalale on a growth path*" (Business Report- Companies, 14 October 2013).

The Limpopo Province is heavily reliant on mining as the major contributor – that a slowdown in this industry even for a few years will have devastating consequences. One way to alleviate the sting of a slowdown is to diversify the economy. Increasingly, the Lephalale development forum is looking to the under-developed tourism industry. The focus is likely to be on hunting and ecotourism industries, but could also be linked to any expansion of the industrial operations and the related business tourism (Lephalale LM IDP, 2016-2017). The Limpopo Province offers a variety of indigenous cultures, game farms, nature reserves, national parks, a biosphere reserve and trans-frontier conservation areas (Limpopo Provincial Government, 2009). As a result, the province has high tourist potential. Similarly, the Waterberg District has a number of cultural, historical and natural resources with tourism potential (IDP, 2010a). Major tourist attractions in the Waterberg District include the Waterberg Biosphere Reserve, the Makapan Caves, the Nylsvley Wetland and Bela-Bela (formerly Warmbaths). The number of tourists visiting Limpopo Province has increased from ~370 000 people in 2002 to ~750 000 in 2007, and the province increased its ranking in terms of its contribution to the national tourism industry from eighth to fifth during the same period (Limpopo Provincial Government, 2009). However, this tourism has largely been as a result of business tourism and will likely mirror the peaks and flows of the petro-chemical industry.

Tourism results in an influx of financial resources into a region (or country) thereby stimulating demand for local goods and services. The contribution of tourism to GDP is expressed as a component of demand for goods and services in the secondary (and to a lesser extent tertiary) sector of the economy; and is comparatively small when compared to the mining and agricultural sectors in Limpopo Province. Nevertheless, tourism is labour intensive and is therefore already a highly strategic and important sector given the socio-economic challenges which face the province. Because of the dominance of the primary sector in the provincial economy and high rates of return on investment in the manufacturing sector in terms of employment creation, promotion of the tourism industry by encouraging the participation of local inhabitants represents an opportunity to diversify the economy and stimulate provincial employment and therefore social development. There exists a tension between the mining and electricity production activities that will drive economic growth but possibly negatively impact the environment and the possible future lucrative tourism revenues.

These industries have also stimulated the growth in other sectors of the economy such as property and property development. For example, over the past three-and-a-half years, new property worth R2 billion has been developed in Lephalale, among them, 25 000 houses and a R170-million shopping mall.

3.6. Employment Rate and Occupation in Lephalale LM

The rate of unemployment in Lephalale is at 22.2%, which is well below the provincial average of 32.4% as per the 2011 national census. Unemployment amongst the youth currently stands at 27%, also below the Limpopo provincial average of 42%. This is due in large measure to local developments associated with Medupi power station and the expansion of coal production from the mines which can be taken to have absorbed a lot of the latent labour force.

Using data from Statistics South Africa that covered Waterberg district municipality, it was found that the municipality of Lephalale' s unemployment rate had been rising steadily in the ten-year period from 2001 to 2011. In 2001 the unemployment rate stood at 18.5 % and in 2011 was at 22.2 %. The Youth unemployment rate stood at 24.0% in 2001 and at 26.9%, (StatsSA, 2011 census). At a District Municipality level, the overall unemployment rate in the Waterberg DM was at 31.7% in 2001 and youth unemployment rate was at 41.1% in the same period. In 2011 the Waterberg DM unemployment rate was at 28.1% and in and youth unemployment rate was at 35.5%. This increase in unemployment in Lephalale but a decrease in the Waterberg DM could be because of an influx of labourers who were unable to secure job opportunities and increased the population and local unemployment rate. For example, Figure 14 below shows that between the years 1996 – 2009 there was a decrease in employment in all skills category. This trend reversed between 2009-2013, which can be attributed to the construction of Medupi power station and also the discovery of coal deposits. The highest increase in employment is with the informal, semi and unskilled employees. Figure 15 shows that the while Agriculture is still the major employer in the municipality, its contribution to employment has decreased from 52% (14631) in 1995 to 25% (7644) in 2013. Wholesale and retail trade is the second largest employer. It has increased from 13% (3676) to 20% (6349). Mining contribution to employment grew from 6% (1663) in 1995 to 17% (5278) in 2013. Community, social and personal services, the fourth largest employer, contributes 13% (4057) to employment (*Figure 15*) (Quantec Regional Economic Database, 2013).

The rate of employment or employability of the people of Lephalale is directly linked to their education and skills levels. The health and wellbeing of a society also influences to response of its citizens to available employment opportunities as these are some of the social dynamics that should also be considered in the assessment of employment rate at a given society (*Figure 14*).

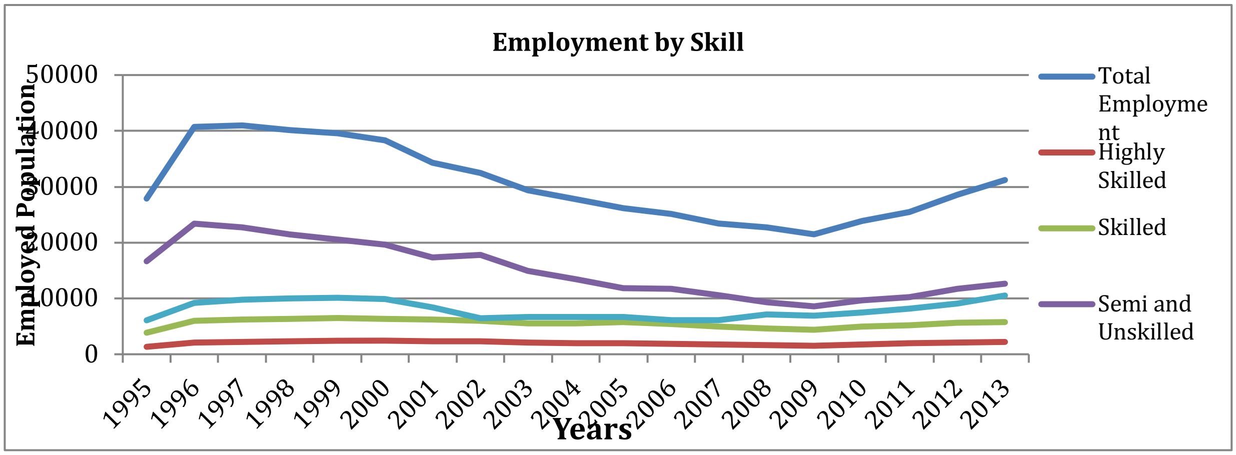

Figure 14 -Employment by Skill Level

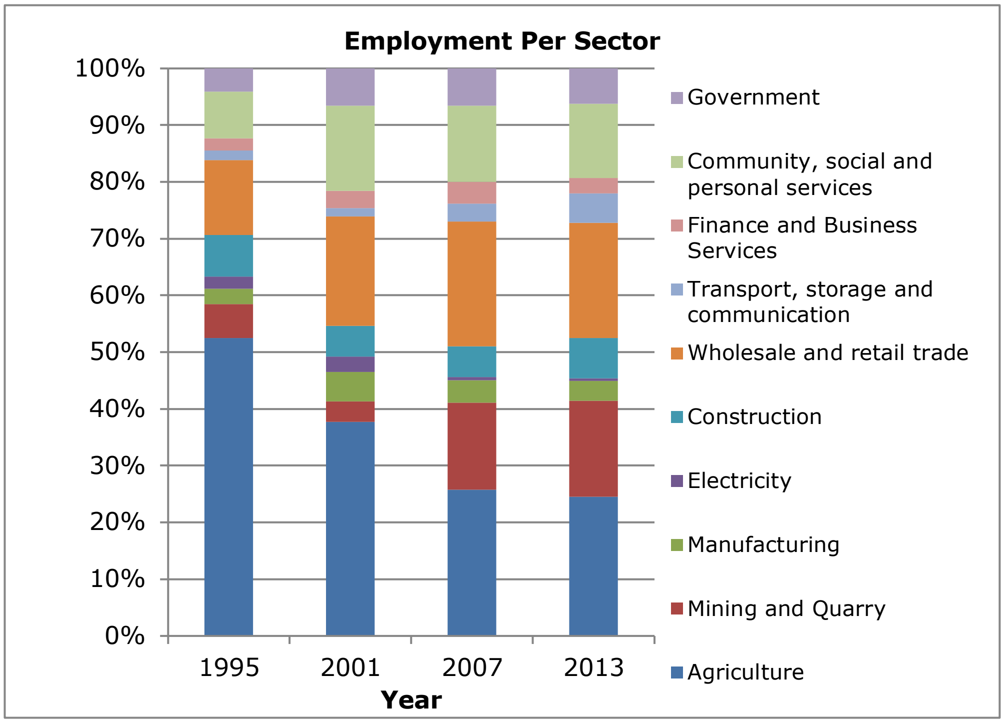

Figure 15 : Sector Employment within LLM

3.7. Income Distribution in Lephalale LM

This income section looks at how Lephalale LM total income is distributed amongst its citizens. Income in Lephalale varies between state contribution through social grants, to income earned through employment opportunities. There is currently approximately 45% of the *economically active* [1] population who are not earning an income through employment opportunities and are dependent on state grants, ie almost half of the population of Lephalale LM is dependent on social grants. The low income earners make up the second group and mostly earn betweeen R500.00 and R3,500.00 per month and the third category is of middle income earners between R3,500.00 and R12,800.00 per month (*Figure 16*). Based on the education levels of Lephalale LM citizens, it is more likely that people who fall within R3,500.00 and R12,800.00 income bracket per month are those who are skilled and semiskilled employees and the almost 45% being those with no higher education who cannot be absorbed in the job market. Due to the technical skills requirements from industries such as the Medupi build there has been a increase people

[1] These are people between ages 16 and 65 and should form part of the labour force.

earning between R 3,500.00 and R 12,800.00 per month in the period 2001 to 2011 and this by grew at 17.42% per annum. This could also be attributed to inward migration of people with higher skills levels. During the same period there has been a steady decline in those earning less than R3, 500.00 per month of 0.69% per annum. The disparities in income distribution is evident when one assesses access to social services such as housing, health, electricity among other social service resources. For income earned to translate to the affordability rate of citizens, the more income earned by individuals per households the more disposable money available per household to afford basic social services such as better housing, electric connection, etc.

For example, a 2013 Financial Mail article asserts that there is very little flow of money to Marapong Township. The article goes further to describe the bad environmental situation in Marapong which when compared to Lephalale Town paints a bad picture about the socio-economic conditions of those who live in townships such as Marapong. For example, four shopping malls have been built in Lephalale Town and are tenanted by large chain stores like Mr Price, Checkers and Game.

The disparities in income distribution have resulted in some labour representatives complaining that the township and the workers are not getting a good deal from the new money that flows into Lephalale. However, there seems be a misunderstanding of what causes these disparities such as low levels of available skills and qualifications. This has on many occasions resulted in volatile labour relations in the area. The assessment also shows low levels of saving by the locals with high consumption rate (*Figure 16*).

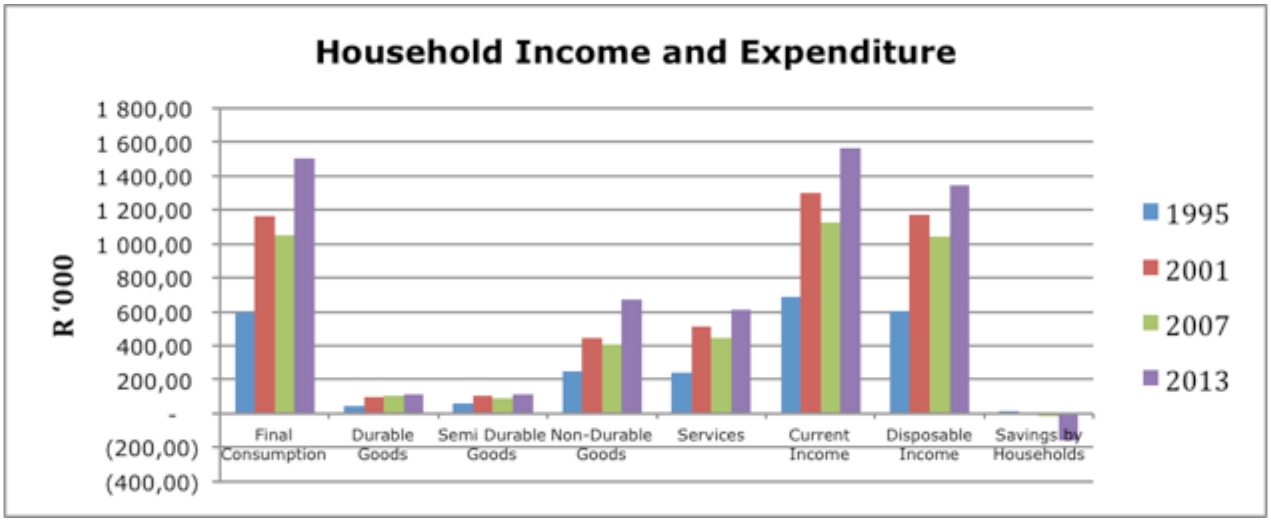

Figure 16 - Household Income and Expenditure in Lephalale

3.8. Housing and Human Settlements in Lephalale LM

Lephalale LM is a host to a number of current and future coal mines and coal fired power station with one nearing completion (Medupi Power Station). A number of human settlements are located in close proximity to some of the known industries (such as coal fired power stations) and the mines. The close proximity of human settlements to heavy industries such as mines and power station is important when evaluating and assessing the social impacts of the FGD technology at Medupi and the impacts of the existing ADF. The various types of human settlements and their conditions also play an important role in understanding the social dynamics of the kind of communities that will be positively and negatively affected by the proposed Medupi Power Station FGD technology retrofit project and operations of the existing ADF for ash and gypsum.

The discovery of coal and its subsequent mining at Grootegeluk coal mine resulted in the establishment of Lephalale (previously known as Ellisras) (Itzkin, 2015). Most of the published literature still refers to Ellisras as a mining town in the Waterberg region. The town of Lephalale has also grown significantly accommodating an influx of job seekers in the LM. There are four main human settlements considered in the current SIA study, namely Marapong Township, Onverwacht Township (suburb), Lephalale Town and

Steenbokpan village (with rapidly growing informal settlements) (*Figure 17*). The location and the social dynamic of each of the four human settlement areas are briefly described below:

Figure 17- Location of Medupi in relation to Steenbokpan, Marapong, Onverwacht and Lephalale

- **Marapong Township:**
    - The township is very close to Matimba Power Station and north-east of Medupi Power Station and ADF.
    - It is situated east of Grootegeluk coal mine, south-west of the newly planned coal mine in the region and north of Matimba ADF (ash disposal facility).
    - It is characterised by a mix of formal, semi-formal and informal housing.
    - With construction of Medupi, Marapong became home to a number of semi-skilled and unskilled labourers working at Medupi, some of whom have found permanent residence in the township.

- The formal houses include Eskom compound for Eskom employees and houses which accommodated Grootegeluk mine and Eskom employees.
- Semi-formal houses include extensions to old houses and recently built backrooms to house either extended members of the family or for rental purpose triggered by the development of Medupi Power Station and associated ancillary infrastructure.
- Shacks have been built within the formalized stands (for rental purposes) and some have encroached informally on public space (most likely from those who do not want to rent).

- **Steenbokpan Village:**
  - A former village located south-west of Grootegeluk coal mine, Matimba Power Station and Matimba AFD.
  - It is situated south-west of newly Medupi Power Station and the associated the ADF for ash and gypsum.
  - Currently, a host to a number of informal settlements with dwellings predominately characterised by shacks and crudely built houses without access to electricity, water and sanitation.
  - People still use a combination of pit latrines and bucket system.

- **Onverwacht Township:**
  - A suburb located immediate west of the Town of Lephalale characterised by a formal housing scheme with all the social services required.
  - It is for the middle and upper income earning citizens of Lephalale Town.
- **Lephalale Town:**
  - The main business hub of Lephalale LM.
  - Characterised by formal houses occupied by middle to upper income earning citizens of Lephalale.
  - Has the necessary town or central business district support infrastructure.
  - Together with Onverwacht, the town is situated further east of Matimba Power Station, Medupi Power Station and the associated ADF.

- These two suburbs (Onverwacht and Lephalale town) are far (approx. 10km) from the mining area of Grootegeluk coal mine and other heavy industries (approx. 5-10km) located in the west.
- They are further north of Matimba AFD.
- Like Marapong and Steenbokpan, Lephalale Town and Onverwacht are also growing at a rapid rate mostly triggered by the construction of Medupi and projected future projects within Lephalale LM.

Current and projected future projects in Lephalale LM have resulted in a population increase and housing shortage and demand. According to a January 2015 Mail and Guardian article – property prices in formal suburbs/ areas in Lephalale have increased significantly. According to a 2014 Q3 Pay Prop Rental Index Mail and Guardian article, "*Residential properties in Lephalale formal suburbs command some of the highest rental prices in South Africa. The average monthly house rental in the suburbs was R19, 986.00. By comparison, the weighted average rental in the up-market Johannesburg suburb of Bryanston was R19, 016. The demand for living space far outstrips supply because there are numerous obstacles to the construction of new homes: there is not enough water, the sewerage system is inadequate and there is a power shortage*" (GEDYE, 2015). This has led to a boom in guest houses and B&B's particularly in the suburbs. Before 2007, there were only a handful of guesthouses and bed-and-breakfasts; now there are more than 3 000. According to Wayne Derksen, the president of the local chamber of commerce, 2 500 new houses were built between 2009 and 2010, and more than 1000 new flats were constructed in the past two years. However, this is not enough to support the massive increase in population. Figure 18 shows the number of households by dwelling type in the Lephalale region (Quantec Regional Economic Database, 2013). The biggest percentage increase in dwelling type is in Informal dwelling/shack in backyard which increased by 381%. This is followed by apartments in a block of flats that increased by 292% and Informal dwelling not in backyard e.g. informal settlement which increased by 142%. House or brick structure on a separate stand or yard grew by a significant 127%, while town and cluster houses grew by 75%. In total, informal dwellings increased by 214% whereas formal housing grew by 99% in total. The growth in informal housing demonstrates that demand for housing far outstrips supply. Another telling statistic is the decrease in traditional huts which speaks to the growing urbanization of Lephalale and the decline of rural development.

Human Settlements	1995	2013	Percentage Increase
House or brick structure on a separate stand or yard (out of graph as the high number compared to the rest of the data it throws out scale of graph.	10328	23410	127%

	Traditional dwelling/made of traditional materials	Flat in a block of flats	Town/cluster/house	House/flat/backroom in backyard	Informal dwelling/shack in backyard	Informal dwelling not in backyard eg informal settlem...	Total informal dwelling/shack	Room/flatlet not in backyard but on a shared property	Other/unspecified/NA
1995	4428	225	153	1552	450	1060	1510	426	775
2013	416	882	267	344	2165	2570	4735	340	343
Percentage Increase	-91%	292%	75%	-78%	381%	142%	214%	-20%	-56%

1995 2013 Percentage Increase

Figure 18-Human Settlements in LLM 1995 – 2013

The housing shortage is so severe, that even the informal dwellings do not come cheap. In Marapong, the township that houses mainly employees of Medupi and the Grootegeluk mine, the price for accommodation is steep. A back room could cost up to R1 200 per month, while a shack costs R600/month to rent according to Lephalale municipality executive director for strategy, Khoroshi Motebele. The Lephalale municipality had been inundated with requests from residents to transform their homes into guest houses. Margie Geyser, from the property company Remax, said demand for accommodation in Lephalale peaked in 2012 and 2013, when there was a zero percent vacancy rate. But 2014 had seen the demand drop off. She said there was a 5% vacancy rate in 2015 and demand was expected to drop off significantly in 2016. Abrie van Vuuren, who provides accommodation to Medupi contractors, said a 100% occupancy rate in 2012 and 2013 had dropped to 70% for 2014.

Substantial areas have been cleared for new residential development which may impact on the sense of place older inhabitants have of the area. The provincial government has also allocated 1.2 billion on a three-year basis for the establishment of 500 Erven in Altoodstyd Farm; Altoostyd 506-LQ is located west of Onverwacht and east of Medupi power station. The project is expected to provide housing for middle income and other designated groups, which forms natural extension of the existing housing scheme. The scattered nature of the township development area has prompted the local municipality to follow an infill approach for integrated human settlement (Lephalale Municipality, IDP 2013/16). As regards to the area on the urban periphery, it is noted that development tends to take on a minimum intervention mode. This is due to the fact that rural areas have low growth potential. Challenges around housing are focused on questions about the lack of well located, developed land for housing, as most of the land which is well located and well suited is privately owned and insufficient for housing subsidies. There is also a question of a high number of people with RDP housing needs. Other issues include the fact that the municipality does not own the land around provincial growth point areas, illegal occupation of land (informal settlers) and traditional leaders allocating residential sites without consultation with the municipality, (Lephalale Municipality, IDP 2013/16).

3.9.Water and Sanitation

3.9.1. Water Availability and Water Allocation in Lephalale LM

Water is one the scarce resources in the Waterberg DM and South Africa. Its availability plays a critical role in the planning and the implementation of mega infrastructure projects such as the current construction of Medupi Power Station FGD retrofit project and the associated ancillary infrastructure like the ADF for ash and gypsum. The availability of water is also important in stimulating investment in some sectors of the economy such as the mining sector which uses significant amounts of water. The success of the agricultural and food sector is directly linked to water and useable water availability. Water is also an essential resource for various domestic uses in our daily lives and the most critical one is the availability of drinkable water for both human and animal consumption.

South Africa, like most developing economies, is on a fast industrialization and urbanization trajectory and this requires access to energy to support such growth which has both positive and negative impacts to human and natural environment. Water is an essential resource to support both industrialization and urbanization. In Lephalale LM key water users include Eskom (for power generation), independent power producers (IPPs), coal mining (for power), other mining activities, fuel-liquid gas industry and for domestic and commercial uses by the municipality (Nemai Consulting, 2010). The question is where do all these water stakeholders receive their water from and whether it is sufficient to meet their future water demands?

A Department of Water Affairs (2009) (now Department of Water & Sanitation) report (P RSA A000/00/9209) states that Lephalale receives its water from the Mokolo Dam constructed on the Mokolo River catchment which forms part of the Limpopo Management Area. The river flows from Modimolle, south-east of Lephalale, to the Limpopo River in the north. Mokolo Dam is a large dam that was constructed in the late 1970s and completed in July 1980 (DWS, 2009). The aim of the dam was to supply water to Matimba Power Station, Grootegeluk coal mine, Lephalale LM for irrigation purposes downstream of the dam (agricultural activities) (DWS, 2009). Therefore, it can be argued that before 2008 Lephalale LM solely depended on the Mokolo Dam for its water.

On the question of future water demand by the various stakeholders with interest in water, in 2008 the South African custodian of water, the Department of Water and Sanitation (DWS) (previously referred to as Department of Water Affair or Department of Water Affair and Forestry), commissioned a number of due diligence studies to look at future water options for the Waterberg and the growing industries as well as rapid urbanizing Lephalale. One of known catalysts of such growth are the Waterberg coal field known to contain approximately 40% of South Africa's mineable coal that can be used to support future energy needs of the country such as power generation and extraction of other fossil fuel such as coal to liquid and coal for domestic international needs. Based on this premised growth trajectory of the area and the available water infrastructure, DWS determined that the water availability and water use in Lephalale allowed for limited spare yield but could not support the future allocations (DWA, 2009). In summary, what this says is that between 2008 and 2009 Mokolo Dam alone could not support the industrialisation and growth of Lephalale. The future development associated with the Waterberg coal fields meant that there would be additional requirements of water in Lephalale LM.

Due to limited water availability in Lephalale, mostly triggered by the need to achieve developmental goals such as the establishment of industries that would support South African Economy; more water infrastructure was required. In 2008 the DWS (then DWA) commissioned the Mokolo Crocodile (West) Water Argumentation Project (MCWAP) to meet future water demands in Lephalale LM. The options included augmentation of existing water supplies from Mokolo Dam and Mokolo River catchment within Limpopo WMA in Lephalale LM. This is high quality water suitable for domestic consumption. This included transferring the surplus effluent[2] return flow from the Crocodile River (West) / Marico WMA to Lephalale and the area around Steenbokpan (DWA, 2009). This is low quality water that is suitable for industries and not for domestic use - a positive strategic position by the DWS. This undertaking by the DWA to plan and lead the implementation of such a mega water augmentation project was a positive one by the Department which is the primary custodian of water in South Africa. MCWAP was staged into two phases, namely Phase 1 and Phase 2.

Phase 1 (augmentation of existing water supplies) aimed at providing drinking quality water to industries and municipality and Phase 2 (transferring the surplus effluent return flow from the Crocodile River (West) / Marico WMA) aimed at providing low quality water to industries. Among the known stakeholders who participated in the project and who require water in the area for current and future needs are (also see *Table 7*):

- The Lephalale LM;
- Eskom;
- IPPs;

[2] "Liquid waste that is sent out from factories or places where sewage is dealt with, usually flowing into rivers, lakes, or the sea" (http://dictionary.cambridge.org/dictionary/english/effluent/2017/Januray/20)

- Grootegeluk Mine (coal mining);
- Exxaro Projects;
- Sasol (Mafutha 1).

Table 7 – List of companies that participated in the water argumentation projection process (then DWA, 2009)

No.	Proponent	Details
1	Eskom	Matimba, Medupi + 4 coal fired power stations power stations
2	Independent Power Producers (IPPs)	Equivalent of 1 Eskom power station
3	Exxaro	Matimba coal supply + further projects
4	Coal mining	Allowance for 4 additional coal mines each supplying a power station
5	Sasol	Mafutha 1 Coal to Liquid Fuel (CTL) plant and associated coal mine
6	Municipality	Estimate based on projected growth in households for construction and permanent workforce

The projected volumes and rate of requirements per use based on Scenario 9 planning in 2010 show that the municipality required more water from the MCWAP in the period 2009 and 2014 than most of the other water users, while in the projected period 2015 to 2030 Sasol required more water that most industries and the municipality (*Table 8*). The projected water requirements for the local municipality were derived using the existing number of households in Lephalale and adding the projected growth in households as a result of the establishment of new mines, power stations and coal-to-liquid fuel facilities (Nemai, 2010). A planning horizon for the period 2009 to 2030 was considered.

Table 8- Projection of required water by key water users in Lephalale LM based on Scenario 9 of the DWS (then DWA, 2009)

Year	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030
Eskom	4.3	4.3	4.9	6.8	9.3	10.9	14.3	50.9	77.6	77.6
IPP's	-	0.4	0.9	0.9	1.5	4.4	13.2	15.6	15.6	15.6
Coal Mining (Power)	-	-	1.1	2.7	4.4	5.3	6.8	14.1	20.0	20
Exxaro Projects	3.0	3.2	3.7	4.7	6.6	9.2	10.8	16.9	16.2	19.2
Sasol (Mafutha 1)	-	-	0.4	6.1	6.6	9.9	25.2	43.5	43.5	44.0
Municipality	5.6	5.9	7.7	10.4	12.0	13.6	14.5	20.4	21.2	21.6
Total	12.9	13.8	18.7	31.7	40.4	53.4	84.8	161.4	194.1	198.0
Irrigation + Mokolo River	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Total + Irrigation	23.3	24.2	29.1	42.1	50.8	63.8	95.2	171.8	204.5	208.4

Other than the MCWAP project as the predominant source of water in Lephalale LM, Lephalale is known to contain good ground water which has the potential for exploitation particularly for domestic and agricultural consumption. The area is known to contain good aquifers although retention of surface water due to sandy nature of geomorphology is not very good.

A total of 8 main dams, 138 boreholes and 15 wetlands have been recorded in Lephalale LM. The LM also plays an important role in managing and conserving its water resources. Lephalale LM is known to be the best performing municipality in the Waterberg DM in terms of providing quality drinking water to its citizens. Its Blue drop status is at 92.84% and better than that of the Waterberg DM which is at 64.38% (Lephalale LM, 2014).

Based on the available data on water in the LM, it seems that the existing Mokolo Dam water scheme mostly services the needs of the urban area and the nearby industries. The rural areas in Lephalale LM are highly dependent on borehole water for sustenance. According to the Municipality IDP (2014) 85% of Lephalale LM water comes from boreholes and only 15% from well-field-type boreholes in the riverbed alluvium which are all owned and operated by the Municipality (Lephalale LM, 2014). The rural areas include farms, conservation areas and rural villages.

In terms of water allocation and water distribution within Lephalale LM, the Municipality is designated as both the Water Service Authority and Water Service Provider in Lephalale, but the primary water custodian is the DWA. Exxaro and Eskom play an important role in the provision of the water service through their investments in Water Treatment Plants. For example,

- Exxaro's Zeeland Water Treatment Works, situated south of the town of Lephalale, has a total capacity of 3Ml/d (1.095 Million m/a)
- Matimba Power Station supplies water to Marapong via the Marapong Treatment Works which has a capacity of 6.0 Ml/d (2.19 Million m3/a).

According to Nemai (2010), both Exxaro and Eskom are the main suppliers of quality water to the municipality.

It should be noted, though, that ninety two (92%) percent of water infrastructure in the Municipality is over 20 years old. Sixteen percent (16%) of the water service system has been identified as being in poor to very poor condition. These are some of the challenges that are faced around water infrastructure (Lephalale Municipality, IDP 2013/14):

- Poor borehole yields in rural areas.
- Bulk water services in urban areas have reached full utilization.
- Illegal connections in rural areas.
- Lack of accountability to water losses.
- Limited availability of ground water in rural areas.
- Low quality of drinking water in rural areas.

These issues provide challenges in terms of social impacts in the receiving environment with the planned FGD technology to be retrofitted at Medupi and the existing ADF which both require large volumes of water for their operations and sustenance.

In meeting these challenges, some of the envisaged water supply projects include:

- Booster pump station for Onverwacht 10ML reservoir.
- Witpoort water treatment plant Relocation.
- Determination of suitable pipelines for water allocation depending of the various stakeholder water requirements. Currently these are the envisaged pipelines based on current and immediate water requirements:
    - New 6ML reservoir for HangKlip industrial area;
    - New 400mm diameter pipe taking treated effluent;
    - New 300mm diameter bulk pipeline to supply Altoostyd reservoir.
- There is also an analysis of capacity of existing reservoirs to handle upgrading of existing water supply from standpipe (ongoing).

3.9.2. Sanitation

Sanitation[3] is another social service that is directly linked to the availability of water resources. Therefore, the availability of water infrastructure such as water treatment plants directly talks to sanitation. Equally important is the use of effluent water derived from sanitary programmes for industrial stimulation and other initiatives such as farming. The question is what is the state of Lephalale LM sanitary infrastructure and how is it integrated to Phase 2 MCWAP to supplement the available water for industrial use in the Municipality?

[3] "The systems for taking dirty water and other waste products away from buildings in order to protect people's health" (http://dictionary.cambridge.org/dictionary/english/sanitation?q=Sanitation+/January/20/2017)

The assessment of this infrastructure within the project area around Medupi power station has found that 94% of waterborne sanitation infrastructure in the municipality is over 20 years old. About 15% of the sanitation network had been identified as being in very poor condition. The assets have experienced significant deterioration and may be experience impairment in functionality and will require renewal and upgrading (Lephalale Local Municipality, 2014). Problems noted around the question of sanitation are that there is a need to redesign the existing sewer networks in Lephalale Town and Onverwacht to reduce the number of pump stations. Further, the area does not have sufficient water resources and infrastructure to accommodate a waterborne sanitation system for all households. More than 50% of households in the municipality are without hygienic toilets (*Table 9*). Sanitation backlog is estimated to be 14,250 units, mostly in the farms and rural village. Other than what will be distributed by the Phase 2 MCWAP, there is no clear indication on what percentage of low quality (effluent) water will be derived from the existing Lephalale LM sanitary infrastructure.

Table 9-Sanitation within the LLM

Type of Toilet	**1995**		**2001**		**2007**		**2013**	
	No of household	%	No of household	%	No of household	%	No of household	%
Flush or chemical toilet	6,367	33%	9,190	45%	12,119	44%	13,784	45%
Pit latrine	9,647	50%	11,240	54%	12,723	46%	14,435	47%
Below RDP	3,384	17%	207	1%	2,835	10%	2,518	8%
Total	**19,397**	**100%**	**20,638**	**100%**	**27,677**	**100%**	**30,737**	**100%**

3.10. Access to electricity

This section of the SIA looks at the current accessibility to electricity within Lephalale LM as an essential social service resource as enshrined in the South African Bill of Rights (1996). According to Stats SA, out of the total number of households in Lephalale LM which is standing at 27 950, only 21 846 households have access to electricity (*e.g. Figure 19*). Matimba has not been able to meet the need for electricity in Lephalale. It is assumed that Medupi will relieve the constraints on the supply of electricity to the area and assist supply an adequate reliable supply of electricity to the country

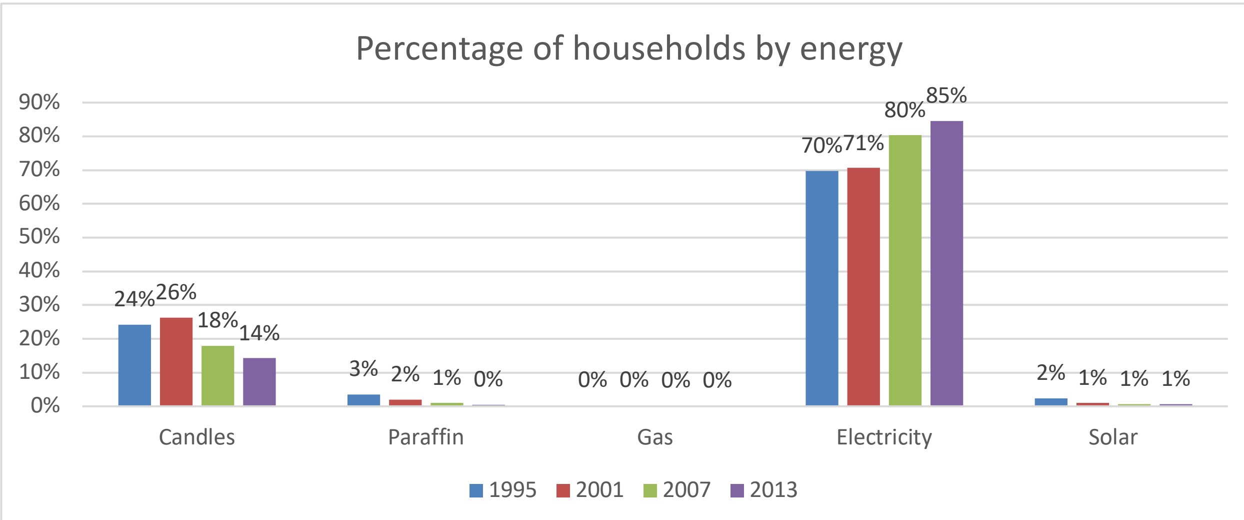

Figure 19 : Access to electricity within LLM

3.11. Road Infrastructure and Access to Transportion

Lephalale LM is situated in an area with no national roads passing through it. There are two major national roads some distance away, viz the N1 linking Tshwane and Polokwane in the east, and the N4 linking Tshwane and Rustenburg in the south. From these two national roads, three provincial arterial roads can be used to access Lephalale and these include the R518 and the R517 that both adjoin the N1 in the east and the R510 to the south. The N11 is another national road that could be used to access Lephalale via provincial arterial road R572, especially by those coming from the northern Highveld coal fields. Within Lephalale the Nelson Mandela Drive is the main road linking Lephalale and the power stations and coal mines.

According to the 2012 Integrated Transport plan the majority of people in Lephalale walk to work (37%) and hitchhikers make up a total 11% (*Figure 20*). Vehicle drivers make up 8% and those who use public transport to work such as mini bus taxis make up 11% and buses make up 6% (Waterberg District Municipality, 2012). The high incidence of people commuting as passengers in private vehicles could be evidence of hitch-hiking because the number of people who own cars is very low in Lephalale LM. Most commuters depend on public transport, and taxis emerged as the most used public transport service in the Waterberg District Municipality.

According to the 2014 – 2016 IDP, the current economic development in Lephalale has brought about an increase in demand for public transport. There is a total of seven taxi ranks in Lephalale to date of which:

- Four are formal
- Three are informal.
- Four of the seven ranks have no ablution facilities.
- There is one bus rank and bus shelters provided by the Lephalale LM at some of the villages can only accommodate 5 people.

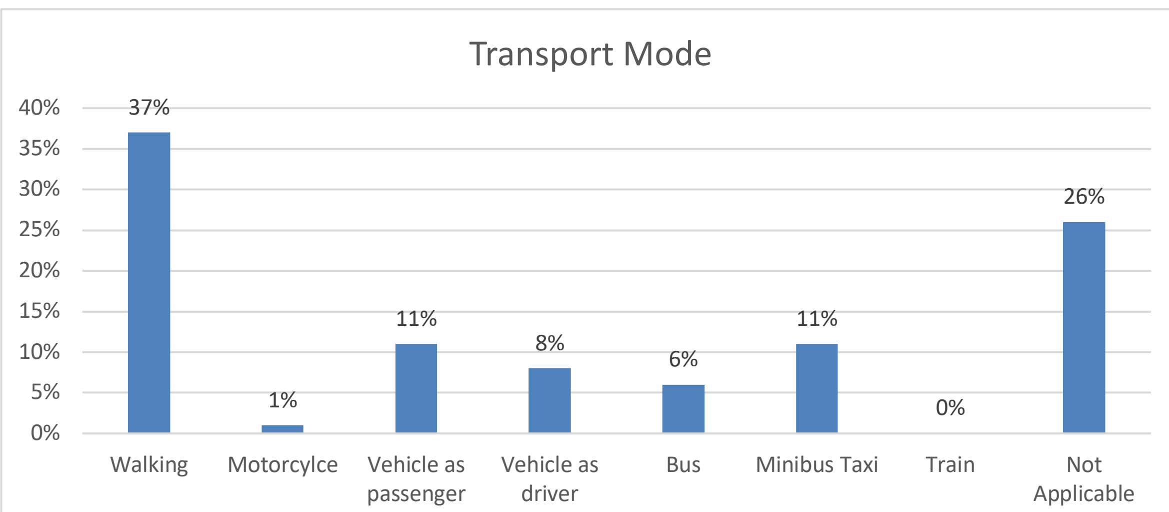

Figure 20 - Transport services LLM

There are several factors determining the nature, distance and utilisation of routes for transportation in Lephalale. Lephalale Economic Development Forum (LEDF) shows influencers as:

- There are 38 rural villages in Lephalale LM, many of them located 40 km or more from the CBD of Lephalale.
- The geographical location of the villages and work opportunities in Lephalale are the determining factors in transport demand, specifically.
- Relatively short distances between Marapong, Town, the mine and power stations – commuters in these areas typically cover distances of less than 25 km, and taxis operating on these routes are able to make 2 to 3 trips per peak time period
- The CBD and town are located close to the coal mines and power stations, whereas the villages developed historically along Lephalale River.

The above factors contribute to the following transport challenges

- Public transport has a poor level of service as a result of distance between the economic activities, the location of towns, villages and area of employment.
- Bus stop shelters do not provide enough under-roof protection against rain; and long queues of passengers are exposed to the sun or rain.
- No ablution facilities are provided at taxi ranks. Commuters must pay R2 for the service at some locations (close to filing stations).
- Road safety conditions along Nelson Mandela and other Municipal roads have deteriorated, mainly because there are inadequate road shoulders and/or pedestrian walkways and taxi layby areas.
- Increased number of abnormal load vehicles creating bottlenecks on the main access routes through town to the mine and power station.

3.12. Conclusions of the Baseline Assessment

The study area is characterized by the following:

- Low levels of education
- Few opportunities for skills development

- Inadequate water and sanitation infrastructure
- Road network in reasonable condition but challenges with public transport
- Settlement areas within prevailing winds from power stations and coal mine/s

4. STAKEHOLDER IDENTIFICATION AND FIELD WORK

This chapter describes the various processes followed in discussion the project with interested and affected parties (I &APs) and summarises the findings of such engagements.

4.1. Legal requirements for Public Participation in this SIA

Section 24 of the National Environmental Management Act, No 107 of 1998 sets prescripts for the management of the cultural environment. This section of the Act puts emphasis on integrated management of the environment and encourages a multi-stakeholder engagement from social aspects such as Public Participation or engagement to the management of heritage resources. The public participation process is defined in terms of the environmental impact assessment application for environmental authorisation, as a "process by which potential interested and affected parties are given the opportunity to comment on, or raise issues relevant to, the application of the environmental process" (Section 4 (1), 2014 EIA Regulation). The objective of this process is to ensure adequate and appropriate opportunity for public participation in decisions that may affect the environment. The NGT (Department: NGT Socio-Economic Studies) team followed prescripts of Section 24 of the NEMA in conducting its public participation process for the Socio-Economic Impact Assessment (SEIA) and this process involved:

- The identification of key stakeholders;
- Development of a stakeholders or Interested and Affected Parties (I&APs) database;
- Communicating with I&APs – telephonic, e-mails, and legal notices;
- Setting up meetings and stakeholder interface forums or public meetings (*e.g. Annexures 1 to 4*);
- Requesting comments and submissions from I&APs
- Holding public meetings for stakeholder engagement.

4.2.The meetings were held with the following stakeholders between February and May 2015 (*Annexures 1 -4, see also Annexure 5*).

- Zitholele Consulting –Zitholele Consulting, Waterfall Business Park, Midrand, Gauteng Province;
- The Waterberg Environmental Justice – Mokolo Hall, Lephalale, Waterberg District, Limpopo Province;
- Lephalale Development Forum – Mokolo Hall, Lephalale, Waterberg District, Limpopo Province;
- Eskom in Eskom Megawatt Park, Sunninghill, Gauteng Province;
- Marapong community in Marapong Library, Marapong Township, Lephalale, Waterberg District, Limpopo Province;
- Leseding Community in Leseding Hall, Lesedi (Steenbokpan), Lephalale, Waterberg District, Limpopo Province;
- Mokolo Hall, Onverwacht, Lephalale, Waterberg District, Limpopo Province
- Medupi Power Station with Eskom environmental management team on site. Location Lephalale, Waterberg District, Limpopo Province.

4.3. Summary of Key Issues Raised in the Meetings and Public Participation Forum Relating to the Proposed Medupi FGD Technology

The interested and affected parties (I&APs) were predominantly well informed about the proposed Medupi FGD technology proposed at Medupi. In total four meetings were held in Lephalale, two meetings in Mokolo Hall in Onverwacht, one meeting in Marapong Library and one meeting in Leseding Community.

Below are issues and concerns raised by communities of Marapong and other interested and affected parties such as the Waterberg Environmental Justice, SANCO and the Lephalale Development Forum. It excluded comments and inputs given by the Leseding community which will be attached as an annexure to the report. Key issues of interest were raised in all the public forums and these included among others:

- Gas and particulate emissions – resulting in risk to health.
- Water Allocation.
- Waste Management.
- Increased population size, service delivery and land allocation.
- Disturbance in the pattern of life.
- Economy: employment and labour relations.
- Cultural Heritage- burial grounds and graves.

- Communication: Public Participation and Consultation.

In recommendations made in the public forums it is concluded that the most fundamental recommendation made to the developer (Eskom) regarding the FGD technology in Medupi is that it should not be retrofitted but included in the actual construction of the remaining 4 Units since Medupi lost an opportunity to include the FGD technology in the construction of Unit 6 (completed) and Unit 5 which is on the verge of being completed.

Table 10 – Identified Social Parameters during Stakeholder Engagement Forums for the Social Impact Assessment in Lephalale in 2015

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
1. SO_2– resulting to risk to human health.	**Issues Relating to Health:** • According to the community, the developer is adding more coal fired stations in Lephalale – Medupi Power Station is just one of the few stations planned in the area. There is also a third coal fired station planned in the area called Coal 3 Power Station. • The concern is that the proposed Medupi Flue Gas Desulphurisation (FGD) technology is retrofitted instead of being built in with the units. This means that during the retrofitting there will be significant additions to the already high levels of pollutants in the atmosphere within Lephalale (incl. Marapong) resulting from Matimba Power Station another Eskom coal fired station. • Gases emitted from Matimba Power Station are argued to have had a great negative impact to the community of Marapong. It is argued that many members of the community are suffering from respiratory related illnesses such as: Tuberculosis (TB), Asthma. Some have been diagnosed with unknown disease such as continuous dry eyes and headaches etc. • A major concern is that, regarding Matimba the developer of Medupi Power Station has mostly focus educating the community about Carbon Dioxide (CO_2) as the most dangerous gas emission hiding the effects of Sulphur Dioxide (SO_2). They have filtered Matimba with electrostatic precipitators or pulse jet fabric filters to remove particulate matter and to reduce the amounts of particulates and CO_2 in the atmosphere. The community would like to know why is that only Medupi Power Station is retrofitted with the FGD and not Matimba too since they both use the same fossil fuel which is coal?	**Proposed Mitigations:** • To mitigate emissions from Medupi Power Station, particularly SO_2, the community is proposing that the proposed Medupi FGD technology should be built in with the 6 Units instead of being retrofitted later. • They argue that the developer has missed the opportunity with 2 of the 6 Units, with Unit 6 already completed and synchronised the 2 March 2015. Unit 5 is about to be completed soon too. • Therefore, the argument is that the remaining 4 Units should be built with the FGD technology to curb the levels of SO_2 in the atmosphere while Unit 6 and 5 are operational. • To curb emissions at Matimba which is not directly related to the current study but has socio-economic implication to the health and wellbeing of the people of Marapong, the community argues that the developer should also consider retrofitting Matimba with the FGD technology.

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
SO_2– resulting to risk to human health (Continue).	• Based on the known prevailing winds direction in the Lephalale, most winds flow north-south meaning that many of the emissions will flow south affected more the communities that are in the south. The community of Marapong felt strong that the brothers and sisters in Lesedi formally known as Steenbokpan should also be considered as they are mostly likely to be affected by Medupi emission during the retrofitting process and are more likely to suffer from health related problems resulting from SO_2 and other gases. • Based on the existing documents published by the developer and its consultants, the Marapong community argues that the pollutants or emissions from Medupi Power Station will cross the South African border to the neighbouring country of Botswana – there is therefore an interest on whether or not has the Socio-Economic Impact Assessment (SEIA) and Environmental Impact Assessment (EIA) Public Participation Process (PPP) been extended to Botswana since the Medupi emissions will also affect the health of the people in Botswana particularly those who are neighbouring South Africa? **Other questions relating to the project included:** The World Bank and the Development Bank of Southern Africa (DBSA), investors in the project, approved Medupi on the premise that it will have an FGD technology with it; what is their take on it.	The community make an assertion that the developer of Medupi argues that to retrofit FGD technology at Matimba will be expensive and the community argues that should not be at the "expenses of the life and health".

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
SO_2– resulting to risk to human health (Continue).	**Issues Relating to Health:**	
	• FGD being retrofitted? • What measures are going to be implemented to protect communities while the FGD technology is being retrofitted yet some of the Units like Unit 6 have been synchronized?	
	Summary: • The Medupi Power Station is seen as a threat to health by Marapong Community, the Waterberg Environmental Justice, SANCO and the Lephalale Development Forum. • These interested and affected parties (I&APs) are arguing that if the FGD technology is retrofitted it might contribute negatively to highly levels of emissions in the areas since the retrofitted technology will only start operating 6 years from the completion of Medupi Power Station. • They argue that by the time the retrofitted technology becomes operational many communities will have already been affected by SO_2 and gases such as CO_2 as is in the case of Matimba and surrounding Exxaro and the newly established Boikarabelo Coal Mine.	**Summary:** • There is a general feeling that the FGD technology at Medupi should be built with each of the remaining units since Eskom has missed the opportunity with Units 6 and 5.

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
2.Water Allocation.	**Issues Relating to Water:** • According to the community of Marapong Community, sections of Marapong and the township as a whole are already experiencing water outages. They have also heard of water outages in areas such as Onverwacht. When water comes back it is argued that it is often dirty, contaminated and not pleasant for consumption. • One of the challenges is that Lephalale does not have sufficient water and this is seen as a major challenge for the community and the surrounding industries such as farms, Eskom and the mines. With the proposed FGD technology at Medupi future water outages are predicted and it is asserted that they will be the norm of the day. • According to Marapong Community, the Waterberg Environmental Justice, SANCO and the Lephalale Development Forum there is a number of newly proposed mines in the area and some are being built and this will lead to even more water stress in Lephalale. Among the newly built mines is Boikarabelo Mine in the west of Medupi power station and south-west of Grootegeluk Mine. • The question that the above-mentioned I&APs have is what plans are put in place to ensure that there will be adequate water allocation to Marapong and the surrounding communities (incl. Farming communities), Medupi, Boikarabelo Mine, Grootegeluk Mine and the proposed Coal 3 Eskom Power Station in the future? <u>[Response from NGT Socio-Economic Solutions: the Medupi power station has a number of offset projects in the area and these include the Mokolo-Crocodile Water Argumentation Project</u>). • The I&APs argue that the Mokolo-Crocodile Water Argumentation Project will not be sufficient to address the water allocation in Lephalale supplying the existing and growing industries, the farming community and for domestic usage.	**Proposed Mitigations:** • According to community and other I&APs the Mokolo-Crocodile Water Argumentation Project phase 1 is not sufficient for water allocation in Lephalale with the FGD coming up. To mitigate the water challenge these stakeholders, argue that phase 2 of the project urgently needs to be implemented. • The first phase included the construction of dams at Mokolo River and transporting the water to Lephalale. However, some of the water is being transferred/distributed to mines such Boikarabelo Mine in the area west of Medupi. • The Crocodile River dams are still under construction and these dams and pipelines should be completed prior the construction of the FGD technology at Medupi to mitigate the water shortages and outages in Lephalale and surrounding communities. •

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
Water Allocation (continues)	The other contributing factor to the implementation of phase 2 of this water argumentation scheme is that companies or stakeholders steering the project do not even agree on what needs to happen to effectively implement the scheme.	• Even so, this water argumentation scheme is not seen sufficient enough to cater for the needs of the ever growing Lephalale and the community argues that more efforts should be considered to address the water shortage in the future and there is a proposition that other water scheme projects should be considered in the near future.
	Summary: • There is a growing concern about future water shortages in the area and that the current Mokolo-Crocodile Water Argumentation Scheme is not sufficient to accommodate the ever growing municipality and associated industries. • Secondly, the current water shortages/cuts are associated with unclean and contaminated water in Lephalale.	**Summary:** • It is proposed that the developer and associated stakeholders such as the local, district, provincial and national government as well as companies involved in the Mokolo-Crocodile Water Argumentation Project should first implement phase 2 of the scheme before considering the implementation of the FGD or its operation.

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
3. Waste Management.	**Issues Relating to Waste Management:** • There is a major concern regarding the management of by-products of the proposed FGD technology and these are some of the by-products considered as high on the agenda: gypsum and effluent water. • According to the community, from the discussions about the FGD technology that they have attended at Medupi there has been limited discussion around the issues of waste disposal of the FGD technology by-products. There is therefore a strong demand to know the location of the treatment plants for the effluent water and storage sites for the gypsum.	**Proposed Mitigations:** • The community suggested that they will need to be consulted during the site selection process for the gypsum storage and effluent water treatment plants.
	Summary: • There is concern that the by-products of the FGD technology will also have negative impact in the community and they need to know where they will be located.	**Summary:** • Community and other I&APs feel the need to be consulted during site selection process.

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
4. Increased population size, service deliver and land allocation.	**Issues Relating to Growing Population Size and Land Demand:** • According to the community since the inception of Medupi power project there has been an increase in population size in Marapong and surrounding communities. There is a high demand for housing to accommodate Medupi labourers. • Eskom contractor village has not been able to accommodate all its contractors and many of these contractors have had to find accommodation in Marapong. As a result, there is now an increase in the number of squatter dwellers. • It is argued that the number of squatters and insufficient provision of services to the people of Marapong mean that the local government does not have enough resources to cater for all its people and the new comers providing them with housing, water, electricity among others. As such it is deemed important that Eskom devise a plan to accommodate its contractors. • The proposed FGD technology construction phase is seen as having a potential to threaten the already insufficient resources in Lephalale and Marapong specifically such as housing, water, available land to the local communities and electricity. • The community is concerned about most of the land in and around Marapong and Lephalale at large being owned by the two entities: Eskom and Exxaro whom they define as major polluters in the area.	**Proposed Mitigations:** • They argue that if Eskom and Exxaro (whom they define as major polluters) own so much land in and around Lephalale, they should consider allocating more land to the community of Marapong to accommodate their employees and allow for the growth of Marapong Township. • They further argue that if Eskom, Exxaro and the Municipality plan to expand more industries near Marapong in the near future which will threaten their health and social structure maybe the three parties should consider allocating land for the establishment of new township elsewhere where they will accommodate the people of Marapong.
	Issues Relating to Growing Population Size and Land Demand: • Another concern for the community of Marapong is that not only do they have to share their resources with Eskom labourers coming from other province and areas within Limpopo Province; Eskom has in the past deliberately excluded them in the provision of its resources by establishing its contractors camp with all the necessary resources such as clean water and electricity. For the Medupi plant there is a dedicated village that has been developed to house Medupi employees and contractors.	

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
Increased population size service deliver and land allocation (continues)	• Therefore, the community feels that the influx of labourer for the construction of the FGD technology at Medupi will further lead to threat to the already stretched resources within their community. The community seek a plan from the developer on how the developer will protect the land of the Locals because currently the developer is only taking care of its workers from the villages it built for Medupi i.e. the Medupi contractor's village?	
	Summary: • The increase in population size in the area as a result of Medupi construction is seen as a challenge by the community and threat to their already limited resources. • The community also feel strong about the fact that they will eventual be absorbed in an industrial zone of Lephalale where their health and social structure/wellbeing will be compromised.	**Summary:** • Some community members are considering relocation from their current location more towards Lephalale central business district (CBD) or past Onverwacht where they argue they will be less susceptible to pollutions

SOCIO-ECONOMIC PARAMETE IDENTIFIED BY INTERESTE AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
5. Disturbance in the pattern of life	**Issues to Population Growth and Change in the Local Pattern of Life**: • The community of Marapong argue that since the establishment of Medupi there the community has experienced a significant growth and this has brought about many changes in the pattern of life in the community, surrounding communities and Lephalale as a whole. Among issues that are of concern to them is the increase in number of liquor outlets, increase number of accidents and deaths. • A new economic phenomenon or culture that many male community members raised is the introduction of prostitution in the community which they feel is something not endemic to the province and Lephalale. • Some of the members argued that Medupi has hired more male figures than females and now their women are being poached by the Medupi labourers who have more resources at their disposal to afford the newly acquired lifestyle by women in the townships and they are also taking their wives.	**Proposed Mitigations:** • The issue seems contentious and some community members recommended that all male Eskom construction workers should be accommodated in camps away from the township of Marapong. • Others recommended that Eskom should be more vocal on HIV/Aids on its new contractors for the FGD technology installation.
	Issues to Population Growth and Change in the Local Pattern of Life: **Summary:** • The increase in population is seen as a catalyst to the change in the pattern of life in Marapong and the surrounding communities, resulting to social ills such as prostitution, alcohol abuses (alcohol is readily available), high accidents rates, murder etc.	**Summary:** • The recommendation is that more HIV/Aids related campaigns should be developed by the developer educating its contractors and these should be extending to Marapong.
	Issues to Population Growth and Change in the Local Pattern of Life: Prostitution and the newly developed intimate relationships between what is called Medupi labourers or contractor is linked by some of the community members to HIV/Aids scourge that is current facing Marapong and Lephalale Local Municipality. This, however, seem to be gender biased as more blame for prostitution and promiscuity is linked to women in the township.	

SOCIO-ECONOMIC PARAMETE IDENTIFIED BY INTERESTED ANI AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
Disturbance in the pattern of life (continues)	**Summary:** • There is a strong sentiment that in many occasions consultants working in Lephalale do not properly engage and consult inclusively in their PPP and consultation process. The result is the elimination of community views and concerns regarding projects. There is also a strong belief that community inputs are often regarded as anti-developmental in nature and not important – which are particularly when addressing issues that affect or have the potential to directly affect them.	**Summary:** • More inclusive public engagement is recommended.
6. Economy: employment and labour relations.	**Issues Relating to Employment and Labour Relations:** • According to the community during the Medupi power station EIA and its associated SEIA and PPP the developer made a number of promises to communities about the socio-economic benefits of the project to the local economy and direct benefits to the people of Marapong. • They, however, share a strong sentiment that these benefits have not been derived by the people of Marapong. The benefits are derived by those with political connection to the Local Municipality and Medupi. Secondly the benefits of Medupi are derived by labourers from outside Lephalale and Limpopo Province. There is a strong shared sentiment that provinces such as the Eastern Cape and KwaZulu-Natal are the beneficiaries of the Medupi plant and they will continue to benefit from the construction of the FGD technology at Medupi. For example, they argue that "almost everyone in Medupi, new residents of Marapong and the Eskom contractor's village speaks IsiZulu or IsiXhosa. We have also seen streets dominated by these culture groups – yards that are like eMzini Wezinsizwa - a local sitcom]". • The community requires more commitment by the developer to grow the Economic of Locals and benefit local people in its development of the FGD technology at Medupi.	**Proposed Mitigations:** • Community members are arguing that the developer should apart the community of Marapong with necessary skills so that they can be able to compete with outside job seekers and be readily available skilled when the construction phase commences

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
employment and labour relations (continues)	**Issues Relating to Employment and Labour Relations:** **Summary:** Outsiders or migrant job seekers are seen as a threat to the local labourers and people from two of South African provinces are seen as being given preferential retreatment when it comes to job opportunities by the local industries operating in and around Marapong.	**Summary:** • Skills transfer is seen as the most basic and fundamental tool of empowering the people of Marapong in order to participate in the economy and Eskom plants.
7. Cultural Heritage- burial grounds and graves.	**Issues Relating to Cultural Heritage:** • The community feels that their ancestral graves were not properly handled during the construction of Medupi and they are not pleased with how the process has been dealt with. They argue that some of the community graves were relocated without any of the community concerns and some of the graves were fenced off from the construction without them being consulted. Furthermore, they are restricted from visiting their ancestral graves within Medupi precinct – "Eskom is refusing us access to visit our ancestral graves located within its property". • One of the resident knows only four of Molwantwa graves were removed and few of Mokoena were taken to Pretoria without their consent and they require a way forward on how to deal with the issue.	**Proposed Mitigations:** • The developer should send its newly appointed heritage consultant to consult with the people of Marapong and this should be in a public platform rather than individual families
	Summary: • There is general sense of disquiet around the issue of graves and their handling as well as access to graves located within Eskom precinct.	**Summary:** The community want the issue of graves addressed and require a consultative process so that they can give inputs in the process.

SOCIO-ECONOMIC PARAMETER IDENTIFIED BY INTERESTED AND AFFECTED PARTIES	ISSUES AND QUESTIONS RAISED REGARDING THE IDENTIFIED SOCIO-ECONOMIC PARAMTERS	MITIGATORY MEASURES PROPOSED BY AFFECTED COMMUNITIES/STAKEHOLDERS/I&APS
8. Communication: Public Participation and Consultation	**Issues Relating to The Public Participation Process & Consultation**: • There is consensus among members of the Marapong Community, the Waterberg Environmental Justice, SANCO and the Lephalale Development Forum that Lephalale and Waterberg people and associated organisations are not against development taking place in their district and municipality. The challenge is eminent with many development taking place within their region is that stakeholder are not always consulted and public participation processes are not always inclusive; they are often limited to communities such as Lephalale (CBD) and Onverwacht. • This, they suggest, poses a great challenge to many developments that are now taking place within Lephalale because local communities often feel excluded from process.	**Proposed Mitigations:** • It is recommended that consultants should not only limit their notices to site notices and newspaper notice, but should also engage community leaders such as councillors, tribal and traditional leaders.
	Summary: • There is a strong sentiment that in many occasions consultants working in Lephalale do not properly engage and consult inclusively in their PPP and consultation process. The result is the elimination of community views and concerns regard projects. There is also a strong belief that community inputs are often regarded as anti-developmental in nature and not important – which are particularly when addressing issues that affect or have the potential to directly affect them.	**Summary:** • More inclusive public engagement is recommended.

Summary of Eskom Interview and site survey

Table 11- Key Issues Discussed with Eskom EMC representatives

Issues	Comment on Issues
Water use and water allocation as part of the Medupi project	**1.Water Supply** • The current water source in Lephalale to support industry and municipal needs is Mokolo Dam. Industries such as Eskom (Medupi and Matimba Power Station) and the mines such as Grootegeluk abstract raw water from this dam. • The raw water is supplied to the new water reservoir from the existing pipeline from Wolvenfontein Reservoir which is supplied from the Mokolo dam. • This pipeline currently supplies Matimba Power Station, the Grootegeluk Mine and local Municipality – this supply forms part of the Phase 1 Mokolo Crocodile Water Augmentation Project (MCWAP) • Provision for future supply of raw water from Crocodile West will also be made available once the DWS has completed the Phase 2 MCWAP. Two pipelines are proposed to be constructed in parallel to the new raw water reservoir and pipeline within a 12m servitude. • The current supply is based on the water allocation that Eskom has been granted following its Water Use License Application (WULA). • The allocated water is sufficient enough to operate Medupi units 1 to 6. For other auxiliary programmes on site such as dust suppression Eskom uses water that has been captured within the Eskom water catchment. It cleans and circulates this water to complement the water that it receives from Mokolo Dam on approximately 80% (Mokolo raw water)/ 20% (captured and circulated water)

	2. Water Demand
	• With the construction of the FGD, there will be not enough water to operate both the Medupi Units and the FGD and as such the Phase 2 MCWAP would need to be urgently implemented by the DWS.
	• Eskom would continue to use raw water from this scheme with clean water allocated to municipality and the farming communities.
	• Even if Eskom captures, clean and circulate its storm water within the Water Catchment it will not be enough to aid the current raw water supply from Mokolo Dam.
	
	3. Water Pollution
	• Eskom has design and implement a storm water management systems and a created water catchment for the that will ensure that it lives up to water philosophy of Zero Liquid Discharge (e.g. **Annexure 8**).
	    o It collects, clean and circulate surface and dirty water. Effluent water is collected and directed to Waste Water Treatment Plant and recirculated to complement the raw water from Mokolo Dam. This assist mitigates any pollution to nearby waterbodies such as the wetland west of Medupi Precinct.
	    o East of Medupi Power Station clean and dirty water dams have been constructed.
	    o The coal stock piles, **the existing ADF** have all been designed with a liner to ensure that they do not contaminate ground water which some of the farmers are reliant on. Furthermore, a storm water management plan has been designed around the existing ADF (**Annexure 7**).
	    o In terms of the assessment of potential pollution/contamination of ground water, Eskom has drilled approximately 21 boreholes to collect baseline data that will assist analyse the levels of phosphates and other contaminants in the ground water.

Stakeholder Engagement	• According to the Eskom environmental team, the Eskom Medupi stakeholders include: Non-Governmental Organizations (NGO's), Non-Profit Organizations (NPO's), Lephalale Local Municipality and local communities (Marapong and Ga-Seleka,).
	• With regard to the issue of consultation which was flagged by some communities during the SIA public meetings, Eskom argues that it has conducted stakeholder meetings throughout the project life of Medupi. The aim has been to listen to peoples interests in the project and has given platform to all I & APs to give inputs on the project. However, it also believes that the interest in the project have been mostly limited to issues relating to jobs and job opportunity. With limited interest in the environment wellbeing which also have direct effect on the health and social wellbeing of the affected communities – the Waterberg Environment Justice Forum (WEJF) has been complemented as a very assisting stakeholder giving constructive inputs.
	• In terms of Stakeholder database, all stakeholders are said to be kept on Environmental Control Officers (ECO's) list and attend meetings that inform on the project process of the Medupi Power Station. Among other organisations that Eskom EMC consider to be I & APs in the project are:
	  ○ Greenpeace
	  ○ Earth350.org
	  ○ Earth Africa
	  ○ WEJF

Social and Economic Impacts	**1.Employment Created** In total, the Medupi Power Station project has created over 14 000 jobs and has contributed to vast infrastructure development. Eskom Procurement Centre ensured that preference be given to local persons and businesses, whereby 30%

	of the workforce is allocated to local people only. Local builders, cleaners, caterers and general workers have been hired. Alongside, Eskom partnered with the local taxi association to provide shuttle services for on-site purposes. Local persons and local business (small-to-medium-enterprises) were trained through the Skill Development Programme (SDP) set up by Eskom to provide local communities with the required skills and training needed for the project. In addition, Eskom SDP also ensured that a vast percentage of females are trained in the year programme and employed by the Medupi Power Station project. Through partnership with Department of Water and Sanitation (DWS), Department of Environmental Affairs (DEA), Department of Public Works (DPW) and Department of Agriculture and Rural Development (DARD), Eskom has aided in the establishment of local farmers providing goods and services through to the local workforce. This also ensure that there is direct procurements of products from local farmers to support among other things food products to catering companies that provide meals to contractors on site. **2. Layoff of Labour post Medupi Construction Phase** Eskom has made provision for an exit plan at the end of the Medupi Power Station project construction phase. This exist plan makes use of both an internal and external plan. In term of the stability of the project, Eskom has introduced upskilling initiative. This initiative is set up to train current employees of the Medupi project in other relevant fields so that they can maintain the level of employment in the area of Lephalale. Another initiative called the Medupi Leadership Initiative(MLI) forms part of this exit plan whereby a local entrepreneurship programme has been created to provide locals and local businesses, specifically Black youth and women; the training focuses on business and financial training in order to educate and expand local businesses capabilities beyond the Medupi project and ensure that they become self-sustainable. In addition to MLI, Eskom has invested R14 million to construction of a facility for training electrical engineers and welders to develop skilled staff for future employment opportunities within the Medupi project and beyond.

Environmental and Social Awareness	Awareness programmes amongst current employees (mainly contractors) and local community have been constructed to create environmental and sustainability awareness. The EMC currently used as a platform to inform and educate local populations. EMC members are sent out to communities to conduct environmental and social awareness programmes through public meetings and workshops with the aim of educating the locals on environmental issues, such as water quality, air quality, land degradation, waste management and monitoring and reporting on environmental impacts. The EMC has also developed outreach programmes aimed at local schools and the FET Colleges (Further Education and Training Colleges). The objective of all these awareness, education and outreach programmes is to educate and provide a direct link between the public and the environment. It is also asserted that I&APs such as Greenpeace, Earth3050.org and Earth Africa are invited to these community programmes (or forums) to give inputs on key environmental and social issues. Other milestone that Eskom prides itself on achieving is the development of a contractor village which took a different approach from the old/historic hostel dwelling associated with the old South Africa mining and industry approach top housing labours. It is asserted that the Eskom village is more inclusive and more family based or family oriented: "In order to ensure the safety of our contractors, we did not build a contractor village that is typical of the old hostel dwelling. We created a village that encourages closeness between workers and their families, preventing families being broken up, alcoholism, depression, Sexually Transmitted Diseases (STD's), potential spread of HIV/AIDS. Workers are transported to and from their homes and families, on a daily basis. Specialised personnel have been contracted to provide medical services, laundry services, a bar, and a soccer pitch to sub-contractors" (Emile Marell, pers.com, 16 January, 2018).

Table 12- Ecosystems change drivers associated with the project

Type of ecosystem change drivers		**Ecosystem change drivers likely to be associated with the project: Yes; No; Not sure**	**Supporting information**
Direct drivers of ecosystem change	Change in local land use and cover	Yes	• The project has and will continue to impact on the land use and cover.
	Harvest and resources consumption	Yes	• The abstraction of water from Mokolo Dam which the municipality, the farmers and the domestic use is also reliant on will also result to change in the ecosystem change. • Medupi currently abstracts its water from Mokolo Dam to support its facility functionality.
	Pollution	Yes	• For the first 5 years of Medupi Power Station operation and before the implementation of the FGD the project will contribute to air quality pollution and degradation • Within the Medupi precinct there is various machinery and plant that is fuel based operated, some of it which may result to oil leakage and spills.

Indirect drivers of ecosystem change	Demographic change	Yes	• Due to job expectations there has been an increase in population in Lephalale and the surround since the commencement of the Medupi Construction Programme (MCP). • Furthermore, the infrastructure that has been developed to offset the MCP such as upgraded and newly constructed roads has also resulted to accessibility of Lephalale thus the increase in population size.
	Economic change	Yes	• On the positive side, the municipality and local businesses have benefited significantly from increase in economic activities related to the MCP and will continue to benefit with the construction of the FGD.
	Socio-political change	Yes	• There has also, however, been a downside of increase in political stakes in the region where different stakeholders have different expectation and bargaining powers on who should benefit and who should not.
	Cultural change	Not sure	• The Medupi Power Station has contributed to cultural change through the destruction of burial grounds and graves; however, the current project will not result to cultural change. • This being said there is a separate heritage management process underway to identify and map cultural areas that were previous impacted. • Therefore, there is no certainty that the area where the FGD technology is proposed will not form part of the map.

	Scientific and technological change	Yes	The FGD will result to an improvement to science and technology for the reduction of SO2 levels in the atmosphere. The data collected post the introduction of the FGD will also inform future technology developments for the coal fired power stations in the country.
Wellbeing of ecosystem services beneficiaries	Change in demand for ecosystem service for basic material for good life	No	• The FGD technology and the associated proposed infrastructure are highly technical and there will be very few jobs for the locals in the implementation of the FGD. • The FGD is a technology that will require highly skilled labour, thus the limited jobs for the locals in the implementation of the FGD.
	Change in demand for ecosystem service for health	Yes	• The implementation of the FGD will result to improved atmosphere and reduced pollution levels that will result to improved quality of life for the locals.
	Change in demand for ecosystem service or security	No	• The FGD will not result to large number of labour polls in Lephalale like it has been the case with the construction of Medupi six units. As such, there will be no demand for ecosystem services for security.
	Change in demand for ecosystem service for good social relations	Not sure	• There high technical nature of the project and the fact that the project will absorb less of local labour in its implementation may result to contestation for job opportunities and challenges of social relations between the developer.

5. SIGNIFICANCE ASSESSMENT METHODOLOGY

The assessment methodology used was taken from Zitholele Consulting recommended methodology for the EIA and it has been adapted to suit the needs of the current SIA study. A number of criteria are used to determine the significance of an impact. These criteria and their ratings are listed below.

5.1. Nature of the impact

Each impact should be described in terms of the features and qualities of the impact. A detailed description of the impact will allow for contextualisation of the assessment.

5.2. Extent of the impact

Extent intends to assess the footprint of the impact. The larger the footprint, the higher the impact rating will be. The table below provides the descriptors and criteria for assessment (*Table 13*).

Table 13- Criteria for the assessment of the extent of the impact.

Extent Descriptor	Definition	Rating
Site	Impact footprint remains within the boundary of the site.	1
Local	Impact footprint extends beyond the boundary of the site to the adjacent surrounding areas.	2
Regional	Impact footprint includes the greater surrounds and may include an entire municipal or provincial jurisdiction.	3
National	The scale of the impact is applicable to the Republic of South Africa.	4
Global	The impact has global implications	5

5.3. Duration of the impact

The duration of the impact is the period of time that the impact will manifest on the receiving environment. Importantly, the concept of reversibility is reflected in the duration rating. The longer the impact endures, the less likely it is to be reversible. Refer to Table 14 for criteria for rating duration of impacts.

Table 14- Criteria for the rating of the duration of an impact.

Duration Descriptor	Definition	Rating
Construction / Decommissioning phase only	The impact endures for only as long as the construction or the decommissioning period of the project activity. This implies that the impact is fully reversible.	1
Short term	The impact continues to manifest for a period of between 3 and 5 years beyond construction or decommissioning. The impact is still reversible.	2
Medium term	The impact continues between 6 and 15 years beyond the construction or decommissioning phase. The impact is still reversible with relevant and applicable mitigation and management actions.	3
Long term	The impact continues for a period in excess of 15 years beyond construction or decommissioning. The impact is only reversible with considerable effort in implementation of rigorous mitigation actions.	4
Permanent	The impact will continue indefinitely and is not reversible.	5

5.4. Potential intensity of the impact

The concept of the potential intensity of an impact is the acknowledgement at the outset of the project of the potential significance of the impact on the receiving environment. For example, SO_2 emissions have the potential to result in significant adverse human health effects, and this potential intensity must be accommodated within the significance rating. The importance of the potential intensity must be emphasised within the rating methodology to indicate that, for an adverse impact to human health, even a limited extent and duration will still yield a significant impact.

Within potential intensity, the concept of irreplaceable loss is taken into account. Irreplaceable loss may relate to losses of entire faunal or floral species at an extent greater than regional, or the permanent loss of significant environmental resources. Potential intensity provides a measure for comparing significance across different specialist assessments. This is possible by aligning specialist ratings with the potential intensity rating provided here. This allows for better integration of specialist studies into the environmental impact assessment. See Table 15 and Table 16 below.

Table 15- Criteria for impact rating of potential intensity of a negative impact.

Potential Intensity Descriptor	**Definition of negative impact**	**Rating**
High	Significant impact to human health linked to mortality/loss of a species/endemic habitat.	16
Moderate-High	Significant impact to faunal or floral populations/loss of livelihoods/individual economic loss.	8
Moderate	Reduction in environmental quality/loss of habitat/loss of heritage/loss of welfare amenity	4
Moderate-Low	Nuisance impact	2
Low	Negative change with no associated consequences.	1

Table 16-Criteria for the impact rating of potential intensity of a positive impact.

Potential Intensity Descriptor	**Definition of positive impact**	**Rating**
Moderate-High	Net improvement in human welfare	8
Moderate	Improved environmental quality/improved individual livelihoods.	4
Moderate-Low	Economic development	2
Low	Positive change with no other consequences.	1

It must be noted that there is no HIGH rating for positive impacts under potential intensity, as it must be understood that no positive spinoff of an activity can possibly raise a similar significance rating to a negative impact that affects human health or causes the irreplaceable loss of a species.

5.5. Likelihood of the impact

This is the likelihood of the impact potential intensity manifesting. This is not the likelihood of the activity occurring. If an impact is unlikely to manifest, then the likelihood rating will reduce the overall significance. Table 17 provides the rating methodology for likelihood.

The rating for likelihood is provided in fractions in order to provide an indication of percentage probability, although it is noted that mathematical connotation cannot be implied to numbers utilised for ratings.

Table 17- Criteria for the rating of the likelihood of the impact occurring

Likelihood Descriptor	**Definition**	**Rating**
Improbable	The possibility of the impact occurring is negligible and only under exceptional circumstances.	0.1
Unlikely	The possibility of the impact occurring is low with a less than 10% chance of occurring. The impact has not occurred before.	0.2
Probable	The impact has a 10% to 40% chance of occurring. Only likely to happen once in every 3 years or more.	0.5
Highly Probable	It is most likely that the impact will occur and there is a 41% to 75% chance of occurrence.	0.75
Definite	More than a 75% chance of occurrence. The impact will occur regularly.	1

5.6. Cumulative Impacts

Cumulative impacts are reflected in the in the potential intensity of the rating system. In order to assess any impact on the environment, cumulative impacts must be considered in order to determine an accurate significance. Impacts cannot be assessed in isolation. An integrated approach requires that cumulative impacts be included in the assessment of individual impacts. The nature of the impact should be described in such a way as to detail the potential cumulative impact of the activity.

5.7. Significance Assessment

The significance assessment assigns numbers to rate impacts in order to provide a more quantitative description of impacts for purposes of decision making. Significance is an expression of the risk of damage to the environment, should the proposed activity be authorised.

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, which takes cognisance of extent, duration, potential intensity and likelihood.

Impact Significance = (extent + duration + potential intensity) x likelihood

Table 18 provides the resulting significance rating of the impact as defined by the equation as above.

Table 18- Significance rating formulas.

Score	Rating	Implications for Decision-making
< 3	Low	Project can be authorised with low risk of environmental degradation
3 – 9	Moderate	Project can be authorised but with conditions and routine inspections. Mitigation measures must be implemented.
10 – 20	High	Project can be authorised but with strict conditions and high levels of compliance and enforcement. Monitoring and mitigation are essential.
21 – 26	Fatally Flawed	Project cannot be authorized

An example of how this rating scale is applied is shown below in Table 19.

Table 19- Example of Rating Scale based on impacts associated with preconstruction of the FGD

Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Publication of FGD project	<u>Direct Impact:</u>	Existing	3	2	2	0.75	5 - MOD	Advertise the type of available jobs and the required skillset	Lephalale has high rate of unemployment
	Employment expectations and influx of migrant labour.	Cumulative	4	3	8	0.75	11 - HIGH		Job seekers will increase levels of unemployment in the area if not employed in the FGD.
		Residual	1	2	1	0.5	2 - LOW		With mitigation the number of job seekers will be reduced to those with necessary skills and qualifications to take up advertised job opportunities.

6. IMPACT IDENTIFICATION AND DESCRIPTION

As per the EIA Regulations, 2014 – Appendix 6 (adapted to be applicable to SIA), the anticipated impacts of the proposed Medupi Ash Disposal Facility (MADF) on the social environment are described. These include initial impacts, cumulative impacts and residual impacts, both positive and negative, during all the phases of the project. The two lists of variables described in Table 2 (Categories of social variables) and Table 3 (ICGP list of social variables) were used during the impact identification process. It is important to consider that the goal of all projects should be sustainable social development and that no development should hamper that. Human Rights should also under no circumstances be compromised or infringed upon.

IMPACT ASSESSMENT AND RATING

Two positive impacts were identified and rated for the preconstruction phase of the FGD. These were both positive impacts associated with the project.

6.1. Impact Rating: Project Planning /Pre-Construction Phase

PRE-CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Publication of the FGD project	Indirect Impact: Developing spin off businesses to support FGD construction phase (B&Bs). (PI)	Existing	2	3	8	1	13 – HIGH	Two mitigation measures are proposed: – There could be initiatives developed to contribute towards educating and developing necessary skills for the locals to take advantage of opportunities associated with the FGD construction and operation. – Local businesses could be incubated and developed to be able to take opportunities in the FGD BID.	The area is in need of employment opportunities
		Cumulative	2	3	8	1	13 – HIGH		There will be increase in economic development.
		Residual	2	2	8	1	12 – HIGH		There will be growth in the Lephalale LM GDP.
	Indirect Impact: Employment expectations and influx of migrant labour. (NI)	Existing	3	2	2	0.75	5 – MOD	Re-employ existing workforce who are currently working at the station.	Lephalale has high rate of unemployment
		Cumulative	4	3	8	0.75	11 – HIGH		Unqualified job seekers will increase levels of unemployment in the area if not all employed in the FGD.
		Residual	1	2	1	0.5	2 – LOW		With mitigation the number of job seekers will be reduced to those with necessary skills and qualifications to take up advertised job opportunities.

6.2. Impact Rating: Project Construction Phase

CONSTRUCTION PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Construction of the FGD.	Direct Impact:	Existing	1	1	1	1	3 - MOD	Skills development initiative to prepare locals to have necessary skills to take up employment opportunities with the FGD.	Lephalale currently has low levels of education and high number of unskilled people who are unemployed.
	Employment of skilled, semi-skilled and unskilled labours in the construction of the FGD. (PI)	Cumulative	2	1	4	1	7 - MOD		The number of unskilled and unemployed is likely to remain high without mitigation.
		Residual	2	1	1	0.5	2 - LOW		With mitigation more locals will be employable in the construction of the FGD.
	Direct Impact:	Existing	2	1	1	1	4 - MOD	Local businesses should be incubated and developed to be able to take opportunities in the FGD BID.	Lephalale local businesses
	Development of tenders and contract opportunities for local businesses in construction of the FGD and ancillary infrastructure (PI)	Cumulative	2	1	2	1	5 - MOD		Current local business involvement is limited mostly to unskilled labour services which are short term based.
		Residual	2	1	1	1	4 - MOD		Without mitigation local businesses involvement/participation will remain low in construction of the FGD and ancillary infrastructure.

CONSTRUCTION PHASE									
Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
Construction of the FGD.	Indirect Impact:	Existing	2	4	1	1	7 - MOD	Mitigation for FGD will benefit other road users.	There are high volumes of traffic and limited traffic control mechanism put in place to control traffic in the area of Medupi.
	Improvement in local road conditions with the construction of the FGD, such as the development urban type road infrastructure with traffic lights and speed humps aimed at mitigating risk of uncontrolled traffic during and off peak hours of the construction phase. (PI). The traffic impact assessment shows that the road infrastructure is already stressed.	Cumulative	2	1	1	1	4 - MOD		With increase in traffic volumes as a result of prolonged construction at Medupi will result to further congestion.
		Residual	2	2	1	0.5	3 - MOD		With mitigation there will be improved traffic management and easy flow of traffic.
	Direct Impact:	Existing	1	5	1	1	7 - MOD	Construction activities for the FGD should be restricted within the existing Medupi footprint	Construction activities at Medupi have already altered the receiving environment.
	Change in local land use in the affected area for the development of the FGD and operations of the ADF. (NI)	Cumulative	1	5	1	0.75	5 - MOD		Construction activities of the FGD, the railway siding will be limited within the existing footprint.
		Residual	1	1	1	0.5	2 - LOW		With mitigation construction activities will be restricted to the Medupi footprint. There is therefore no change in landuse as the development is taking place within the already disturbed area.

CONSTRUCTION PHASE									
Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
	Direct Impact:	Existing	1	1	1	1	3 - MOD	Prioritising local business or contractors in some of the contracts associated with the construction of the FGD.	The Medupi built project construction activities are benefit Lephalale LM economy.
	Extension of the construction phase currently underway in Medupi resulting to prolonged contractor activity in Lephalale which benefit local businesses (PI).	Cumulative	2	1	2	1	5 - MOD		There will be extension of economic benefits to the municipality with extension of construction activities at Medupi.
		Residual	1	1	2	0.5	2 - LOW		With mitigation and prioritisation of local business positive spinoff of the extended construction at Medupi can be increased
	Indirect Impact:	Existing	2	1	1	1	4 - MOD	Traffic management systems should be developed to manage traffic during pick hours and off pick hours especially for construction trucks during the construction phase of the FGD retrofit project. This should include installation of traffic lights and traffic circles at major intersections such as D1675, Afguns and Nelson Mandela Drive near Medupi and Matimba Power Station (Hatch Goba, 2016).	The area of Medupi current does not have traffic management systems in place causing congestion.
	Increase in traffic volumes resulting from a combination of existing road users such as mine trucks, buses and mini bus/taxis, private car owners, Matimba trucks and an increase in construction vehicles/trucks transporting materials to and from Medupi for the construction of the FGD. (NI)	Cumulative	2	1	1	0.75	3 - MOD		There will be increased in traffic volumes with the construction of the FGD.
		Residual	2	1	1	0.5	2 - LOW		Traffic volume will remain high but with controlled management system there will be flow in traffic.

CONSTRUCTION PHASE									
Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
	Indirect Impact:	Existing	2	1	1	0.5	2 - LOW	Installation of traffic lights and traffic circles at major intersections such as D1675, Afguns and Nelson Mandela Drive near Medupi and Matimba Power Station (Hatch Goba, 2016). The other proposition is that a four way stop should be considered as an alternative to traffic lights at the above mentioned intersections. Appropriate traffic calming devices should be implemented	The absence of traffic management systems near Medupi are causing health and safety risk for drivers to and from Medupi.
	Increase in occupation health and safety risks resulting from increase in traffic volumes associated with construction vehicles/trucks working on the FGD as well risks associated with the actual prolonged construction phase at Medupi. (NI)	Cumulative	2	1	1	0.75	3 - MOD		With construction of the FGD and increase in traffic volumes the risk will increase.
		Residual	2	1	1	0.2	1 - LOW		Installation of traffic lights, speed humps and circles will reduce the risk. Appropriate traffic calming devices should be implemented
	Indirect Impact:	Existing	2	2	2	0.5	3 - MOD	The Department of Water and Sanitation (DWS), the custodian of water in the country, should ensure that implements both Phase 1 and Phase 2 of MCWAP with coming live of Medupi and FGD. Eskom should explore other alternatives water sources in its water use licenses to minimise the risk of overly depending to MCWAP Phase 2 for the implementation of the FGD. Both Eskom and DWS should align their project schedule and ensure that there are no delays in implementing the MCWAP Phase 2	Lephalale is currently under a lot of water constraint
	Increase in pressure for water demand and allocation to support the construction of the FGD, the ADF, and existing industries and for domestic uses. (NI)	Cumulative	3	2	4	0.75	7 - MOD		Construction of the FGD will increase water demand in the area.
		Residual	3	3	8	1	14 - HIGH		With mitigation more water allocation alternatives will be considered and water demand met.

CONSTRUCTION PHASE									
Activity	Nature of Impact	Impact type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
	Indirect Impact:	Existing	2	4	1	0.5	4 - MOD	With FGD and ancillary infrastructure there will be net improvements in infrastructure in the receiving environment.	The Medupi built project has contributed to improved infrastructure.
	Improvement in local road conditions with the construction of the FGD and ADF, such as the development urban type road infrastructure with traffic lights and speed humps aimed at mitigating risk of uncontrolled traffic during and off peak hours of the construction phase. (PI)	Cumulative	2	4	1	0.75	5 - MOD		There will be further improved infrastructure as the result of the FGD and ADF.
		Residual	2	4	1	0.75	5 - MOD		With mitigation there will be improved infrastructure and improved economic development and investment as the result FGD and the ADF.
	Indirect Impact:	Existing	2	1	1	0.75	3 - MOD	To improve project public participation and communication strategies in order to strengthen multi-stakeholder engagement and participation in the planning and implementation of the FGD retrofit project and associated ancillary infrastructure such as the ADF ash and gypsum. The environmental Affairs also need to grant Eskom to implement the FGD	The Medupi built project has contributed to economic growth in Lephalale LM.
	Increase in negative public sentiments about the project FGD if the FGD is delayed and not implemented urgently (NI)	Cumulative	2	1	1	0.75	3 - MOD		There will be increase in economic development in Lephalale LM.
		Residual	2	1	1	0.5	2 - LOW		With right intervention there will be more sustainable economic growth and positive net growth of its GDP. There will also be improved health in the region with the implementation of the technology.

6.3. Impact Rating: Project Operational Phase

OPERATIONAL PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Synchronisation and operation of the FGD technology to Medupi PS six units.	<u>Direct Impact:</u>	Existing	2	4	8	1	14 - HIGH	Eskom should prioritize the tender for construction of the FGD and prioritize retrofitting the FGD within time and budget to ensure compliance with AEL timeframes for SO2 reduction targets.	There are currently high levels of SO2 gas in the atmosphere
	Synchronisation and operation of the FGD technology at Medupi will result to reduction in SO2 levels in the atmosphere resulting to improved ambient air quality and improved human health as the result of the FGD.(PI)	Cumulative	4	4	8	1	16 - HIGH		The FGD will contribute to reduction of the SO2
		Residual	5	4	8	0.1	2 - LOW		There will be 93% reduction in the SO2 levels in Lephalale and reduction in global stats of SO2 levels
	<u>Direct Impact:</u>	Existing	2	2	8	1	12 - HIGH	Urgent implementation of the FGD technology in Medupi	There is existence of illnesses that are resulting from high levels of SO2.
	Reduction is respiratory related diseases such as asthma, bronchitis, lung cancer, eye irritations, pneumonia and cardiovascular disease resulting from emission such as SO2. The result is overall improvements to human health and quality of life for the locals and labourers through improved ambient air quality in the receiving environment as the result of implementing the FGD. (PI)	Cumulative	2	2	4	0.75	6 - MOD		The implementation of the FGD will reduce respiratory diseases
		Residual	2	1	8	0.1	1 – LOW		There will be net improvement in health and quality of life by human in Lephalale.

OPERATIONAL PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
	Indirect Impact:	Existing	4	2	2	1	8 - MOD	Implementing the FGD on time will result to avoidance of potential labour unrest which may hamper the supply of power.	Medupi construction has often resulted to labour unrest.
	Stabilization of the National Grid and improved electric supply to support the growing economy and achievement of social imperative such as provision of power for domestic use throughout the country. (PI)	Cumulative	4	2	2	0.75	6 - MOD		The FGD will contribute to success full implementation operation of the power station
		Residual	4	4	2	0.1	1 - LOW		With mitigation the FGD will contribute to positive supply in power grid
	Direct Impact:	Existing	1	1	2	1	4 - MOD	Local businesses should be incubated and equipped with necessary skills to be able to develop the secondary industry associated with commercial viable gypsum industry. A programme can be initiated to assist local users to obtain the necessary waste management licenses for utilization of gypsum.	The area has low skills and education to allow for the development of secondary gypsum industry.
	Development of the secondary industries as the result of implementation of the FGD through sales of its commercial suitable gypsum to the farming industry- locally, regional, nationally and possibly internationally (if well packaged). Or secondary industry such as manufacturing of construction materials like the gypsum boards for ceilings and partitions. (PI)	Cumulative	1	1	2	0.75	3 - MOD		With implementation of the FGD
		Residual	1	1	2	0.5	2 - LOW		With mitigation the locals will be able to develop the secondary industry.

6.4. Impact Rating: Project Decommissioning Phase

DECCOMMISSIONING PHASE									
Activity	**Nature of Impact**	**Impact type**	**Extent**	**Duration**	**Potential Intensity**	**Likelihood**	**Rating**	**Mitigation**	**Interpretation**
Decommission of the FGD technology and the ADF in 50 years	Indirect Impact:	Existing	1	3	1	0.5	3 – MOD	With interventions in skills development, there will be will be necessary skills and employment opportunities for the locals. Eskom	The area has low education and skills levels among the locals and this had negatively impacted on them in the Medupi built project.
	Employment opportunities in disassembling and recycling of recyclable materials from the FGD and the ADF. (PI)	Cumulative	2	1	2	1	5 – MOD		Unemployment by the locals will remain high with decommissioning of the FGD and ADF (highly technical projects) without mitigating the situation.
		Residual	2	1	8	1	11 – HIGH		With mitigation there will be improved employment opportunities for the locals in the decommissioning of the FGD and the ADF.

7. CONCLUSIONS

Conclusions:

- It is concluded that the significance of positive social impacts generally exceeds the significance of negative social impacts in the implementation of the FGD, the ADF and the railway siding throughout all four stages of the project.
- It is also concluded that implementation of the proposed FGD technology at Medupi will result in reduced levels of SO_2 in the medium and long term in the region and South Africa. It will also contribute to reduction of global SO_2 atmospheric levels. As the result of this, the significance of health risks associated with the SO_2 emissions will be minimized on a long-term basis.
- The results will be an improved biosphere in the region and South Africa, this will translate to improved quality of life for the citizens of Lephalale and the communities located south and southwest of the study area who are also affected by pollutants containing SO_2.
- Based on issues raised by some of the affected communities during the SIA fieldwork, it is concluded that one of the most pressing issues identified during the survey relates to stakeholder relations and project communication.
- The above issue was put forward for the attention of the project proponent; a meeting was scheduled between the project proponent representatives in Lephalale dealing with environmental and social issues on the ground. The aim was to come up with solution on how to best address the communication impasse. Through this meeting and the information made available to the SIA team, it has been determined that Eskom and its stakeholders have done a significant amount of work in dealing with concerns of the various interested and affected parties on the ground. They have contributed to the establishment structures entrusted with the management of stakeholder relations and communication as part of the Medupi project. A committee has been established to deal with such issues; for example, the Medupi Environmental Monitoring Committee (EMC) as well as the Stakeholder Relations Office in the region. It is therefore concluded that necessary strategies and measures have been put in place to deal with and manage stakeholder relations and communication.
- In terms of ecosystem services, the study assessed how the Medupi FGD, its by-products, the existing AFD and the proposed railway siding would negatively impact on the ecosystems and how such negative impacts will influence ecosystem services that support the health and wellbeing of

the affected communities i.e. municipality, other industries, the farmers and households in the regions. In this assessment, the SIA team considered the following (*Table 11 and recommendation section of this report*):

- **Direct drivers of the ecosystem change**: e.g. change in local land use and cover; resources consumption; pollution; increase in population
- **Indirect drivers of the ecosystem change**: e.g. demographic change; economic change; socio- political change; cultural and religious change; scientific and technological change.
- **The wellbeing of ecosystem services beneficiaries**: e.g. these included among others, change in demand for ecosystem service for basic material for good life; change in demand for ecosystem service for health; change in demand for ecosystem service or security; change in demand for ecosystem service for good social relations.

- Taking into consideration of ecosystem services beneficiaries and drivers; we assessed the potential impacts of the proposed railway siding for lime off-taking. The land on which the proposed siding is to be constructed is already reformed or altered. It is therefore, concluded that the railway siding will not have any adverse negative social and economic impacts in terms of increase in traffic volumes and possible road carnage resulting from trucks transporting lime to Medupi.
- In terms of the existing ADF facility (and other infrastructure on site such as slime dams, coal stockpiles etc.), necessary measures have been put in place to mitigate any possible leakage to groundwater resulting in ground water contamination. Approximately 21 boreholes have been drilled to compile data that would assist the project proponent to assess sulphates levels in the ground water with the aim of mitigating areas where there is groundwater contamination.
- The water issue is concluded to be the biggest threat in the project lifespan, the current allocation to Medupi will be able to operate the six generation units at Medupi. Water for the other 3 of the FGD absorber units are expected to come from MCWAP Phase. The current raw water abstraction from Mokolo Dam of which the Lephalale LM is also dependent on for clear water to support its domestic and farming communities' poses is a biggest socio-economic threat in terms of ecosystems support services.
- From a social impact assessment perspective; it is concluded that the FGD technology retrofit project, the use of the existing ADF to dispose of ash and excess gypsum and the development of

the railway siding should proceed as planned provided that the following recommendations are implemented and adhered to:

8. RECOMMENDATIONS

Below is the list of recommendation proposed to the project proponent to mitigate against any negative impacts and improve the positive benefits of the proposed project:

- Mitigation measures in this report must be included in the Environmental Management Programme (EMPr), which will be approved as condition of environmental authorisation.
- The specialist responsible for compiling the EMPr must consult and consider the findings and the recommendations of the SIA.
- The issue of communication was flagged by some of the communities as a pressing issue. Through engagement with project proponent representatives it has been determined that necessary measures have been put in place to mitigate issues pertaining to stakeholder engagement in the broader Lephalale area.
    - Although Eskom has done a lot to address this concern, it is recommended that the EMC should further strengthen its multi-stakeholder engagement strategy or adopt new forms of communication that resonate with the interests of I & APs in the region.
    - This should be done in a manner that does not polarise relations between existing stakeholders. One way of addressing this issue is to develop a sub-committee for the EMC.
    - The sub-committee should include a representative from each of the affected communities. This should be in addition to those communities' representatives already listed in the EMC Terms of Reference (ToR).
    - Community representatives from Steenbokpan (Leseding) and the farms (farming community) should form part of the EMC sub-committee due to the fact that they feel excluded in programmes and workshops that deal with issues arising from Medupi construction and the associated infrastructure and technology such as the FGD.
    - In addition to EMC public meetings and workshops, the sub-committee will ensure that all community concerns and grievances are deliberated on and addressed directly by the EMC and outside the EMC public meetings. The EMC ToR allows for the election of alternates. Therefore, this recommendation for EMC sub-committee is in line with EMC ToR.

- In projects of similar nature to Medupi, a grievance mechanism committee is often established and communicated to the community in line with best practice. The Medupi EMC is a sufficient structure to handle all issues relating to the environment, monitoring and auditing. However, without increasing bureaucracy, Eskom should consider appointing an independent company/specialist that specialises in the management of Social Risks. The task of the appointee would be to advise and strengthen the following:
    - Working with the Eskom Community Liaison Officer (Stakeholder Engagement Representative) to independently advise on the facilitation of relations between the various project stakeholders such as the appointed contractors, the EMC, the Environmental Control Officer (ECO), the affected community and community organisations such as NGOs, local labourers, local Small Medium Enterprises (SMMEs) as well as big industries.
    - The Social Risk company or specialist should be experienced in multi-stakeholder management, conflict resolution, labour relations, and negotiation of contracts, skills audits, and training and facilitation of skills transfer programmes.
    - If there is already an existing contract for an independent Social Risk company/specialist for the construction of Medupi Power Station – Eskom should consider extending such a contract since the company/specialist will already be familiar with issues on the ground and be well acquainted with community and government structures in Lephalale.
    - There will be no need for additional infrastructure for this specialist or company; she/he can use the existing stakeholder relations office and its satellite offices.

This is important because the construction activities at Medupi have on many occasions been subject to disruption due to labour unrest and protest by locals who demand job opportunities. This is something that came out strongly during the public consultation for the proposed FGD project. Some locals who claimed that they were overlooked in the Medupi projects and that they will be overlooked in the current project too disrupted one of the Public Participation (PP) meetings. The inclusion of a social risk company or specialist in the EMC will ensure that the EMC has enough capacity and skills to deal with and address social and socio-economic issues without overly relying on Eskom Communication, CSI and Stakeholder Relations Departments. Furthermore, it will play a key role in reporting, monitoring and auditing of Eskom commitments to addressing social issues in line with ToR of the EMC. The social risk company will work hand in hand with the appointed Environmental Control Officer responsible for the implementation of the EMPr.

Both the SIA impact assessment analysis and stakeholder engagement concluded that the proposed Medupi FGD-RP will result in positive biospheric and social benefits in the receiving environment and the improvement of the quality of life for the affected communities in terms of reduced number of health incidents that result from exposure to high levels of SO_2. There are however disagreements on how the FGD-RP should be implemented; some argue it should be built into the Medupi Units before their synchronisation while the project proponent proposes to retrofit the technology. Those in favour of constructing the FGD with Medupi Units argue that the coming in of Medupi units will results to further increase in SO_2 levels in the region and will compromise the health of citizens who are already suffering from SO_2 health related challenges such as high prevalence of respiratory diseases.

From a SIA perspective, it is recommended that Eskom should prioritise retrofitting and synchronising the FGD technology to Unit 6, 5 and 4 which have been completed and have been operational since 2016 (unit 5) and early in 2017 (Unit 6). These will allay the fears of those in favour of constructing the FGD with the unit stacks and will also increase Eskom compliance levels in terms of reducing SO_2 and increasing atmospheric and air quality. Technically, this will assist them understand the challenges and opportunities of the technology prior to its retrofitting to Units 1, 2 and 3.

In terms of material transport to and from site for the construction of the FGD and to transport gypsum, salts and sludge which are by-products of the FGD; it is recommended that Eskom should speed up the construction of the proposed railway siding and prioritise the railway as the preferred construction material transport mode as well as for the off-take of the FGD by-products to appropriate licensed disposal facilities specially for salts and sludge. This will help mitigate environmental risks associated with the use of public roads to transport these hazardous materials. It will also assist alleviate possible increase in traffic volumes associated with the FGD construction material transportation.

In terms of FGD by-products it is recommended that Eskom should consider tendering the offtake of gypsum for commercial purposes instead of its combined disposal with the ash.

Eskom is highly commended for its zero liquid disposal strategy at Medupi which encourages water recycling and circulation within the footprint. However, this will only assist in meeting the current water demand on site and is not sufficient enough to meet and address the demand with the implementation of the FGD. Water and water allocation however falls outside the statutory mandate of Eskom, but the responsibility of the National Department of Water and Sanitation (DWS). Through the various bargaining platforms available to Eskom and the surrounding industries such as mines and Sasol – it is recommended that Eskom should lobby (together with other industries) DWS to speed up the implementation of Phase 2 MCWAP. This will guarantee Eskom and other industries in Lephalale appropriate water allocation to support the FGD and the growing industries around it such as expanded coal mining due to coal reserves in the Waterberg region. The speeding up of the Phase 2 MCWAP by DWS would also assist mitigate the potential water risk to Lephalale associated with the abstraction of raw water by industries from Mokolo Dam of which the municipality and its constituencies is also directly dependent on for potable water.

9. REFERENCES

Aucamp, I. (2009a). Social Impact Assessments. In P. Aucamp, *Environmental Impact Assessment: A Practical Guide for the Discerning Practitioner* (pp. 109-120). Pretoria: Van Schaik Publishers.

Aucamp, I. (2015, April). Social Impact Assessment as a tool for Social Development in South Africa: An exploratory study. *A thesis submitted in partial fulfilment of the requirements for the degree Doctor Philosophiae*. University of Pretoria.

Aucamp, P. (2009b). *Environmental Impact Assessment: A Practical Guide for the Discerning Practitioner.* Pretoria: Van Schaik Publishers.

Bezuidenhout, H. (2009). *An improved social impact evaluation framework for the completion of SIA sections during the environmental impact assessment process for residential developments in South Africa.* Pretoria: MA dissertation, University of Pretoria.

Burt, E., Orris, P., & S. Buchanan. (2013). Scientific Evidence of Health Effects from Coal Use in Energy Generation. Healthcare Research Collaborative

Burdge, R.J. and Vanclay, F. (1996). Social Impact Assessment: a contribution to the state of the art series. *Impact Assessment, 14*, 59-86.

Bussiness Day Live. (2015). *Bussiness Day Live*. Retrieved March 28, 2016, from http://www.bdlive.co.za/national/2015/05/26/sas-urban-population-growing-larger-and-younger

Constitution of the Republic of South Africa, 1996 (Act no. 108 of 1996). (n.d.).

DEAT. (2002a). Specialist Studies. *Information Series 4*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT. (2002b). Impact Significance, Integrated Environmental Management. *Information Series 5*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

DEAT. (2006). Socio-Economic Impact Assessment. *Integrated Environmental Management Series 22*. Pretoria: Department of Environmental Affairs and Tourism (DEAT).

Eskom Holdings Limited. (2011). *The Eskom Factor .*

Gibson, R. (2006). Sustainability assessment: basic compounds of a practical approach. *Impact Assessment and Project Appraisal, 24(3)*, 170-182.

Interorganizational Committee on Guidelines and Principles. (1994). *Guidelines and Principles for Social Impact Assessment.* Washington DC: Department of Commerce.

Interorganizational Committee on Guidelines and Principles for SIA (ICGP). (2003). Principles and Guidelines for Social Impact Assessment. *Impact Assessment and Project Appraisal, 21(3)*, 231-250.

Itzkin, A. (2015). Health in Waterberg,Up in Smoke? Unpublished MSc. University of the Witwatersrand, Johannesburg

McGranahan, G. & Murray, F. (2003). Air Pollution and Health in Rapidly Developing Countries. Management of Environmental Quality: An International Journal, 14(4), 542 - 543.

National Environmental Management Act, 1998 (Act no. 107 of 1998). (n.d.).

Regulations in terms of Chapter 5 of the National Environmental Management Act, 1998 (Environmental Impact Assessment Regulations) of 4 December 2014. (n.d.).

South Africa. (2014). South African National Environmental Management Laws Amendment Act (NEMLA) of 2014.

Statistics South Africa. (2011). *Statistics by place*. Retrieved March 22, 2016, from http://www.statssa.gov.za/?page_id=964

The International Bank for Reconstruction and Development / THE WORLD BANK. (1998). Participation and Social Assessment: Tools and Techniques. Compiled by J. Rietbergen-McCracken and D. Narayan.

Vanclay, F. E. (2015). Guidance for assessing and managing the social impacts of projects. Fargo ND: International Association for Impact Assessment.

World Bank. (1995). Social Assessment. *Environmental Department Dissemination Notes Number 36*. Washington DC: World Bank.

Internet Sources:

http://www.miningweekly.com/article/high-court-rules-in-favour-of-earthlife-africa-in-south-africas-first-climate-change-case-2017-03-08 (15/05/2017)

http://cer.org.za/news/eskom-flouts-air-pollution-laws-and-world-bank-loan-conditions (15/05/2017)

http://www.eskom.co.za/OurCompany/CSI/AboutUs/Pages/default.aspx (18/05/2017)

Business Report- Companies Section, 14 October 2013. http://www.iol.co.za/business-report/companies/eskom-plant-brings-boom-to-lephalale-1591263 (18/05/2017)

8. ANNEXURES

ANNEXURE 1- NOTICE OF THE FGD PROJECT TO INTERESTED AND AFFECTED PARTIES

No. 2 Windsor Place
Princesses Avenue
Windsor West
Randburg
2194

Department:
NGT Socio-Economic Solutions

Tel: 011 476 0657
Fax: 086 273 6562
Cell: 078 163 0657
www.ngtgroup.co.za

NOTICE FOR SOCIO-ECONOMIC PUBLIC PARTICIPATION

ATTENTION: INTERESTED & AFFECTED PARTIES

RE: PROPOSED ESKOM MEDUPI POWER PLANT FLUE GAS DESULPHURISATION RETROFIT PROJECT

Dear Interested and Affected Party

This letter serves as a notice for a Consultative Process for a Socio-Economic Study for the proposed Medupi Flue Gas Desulphurisation (FGD) Plan proposed within the Medupi Power Development Precinct (MPDP) to mitigate gas emissions (e.g. Sulphur Dioxide) that will result from combustion of the Medupi coal powered station. This consultative process is hereby conducted according to the National Environmental Management Laws Amendment Act No. 25 of 2014; National Water Amendment Act No.27 of 2014; National Environmental Management: Waste Amendment Act No. 26 of 2014 and; Policies that govern the Socio-Economy of South Africa.

NGT Projects & Heritage Consultants is appointed by Zitholele Consulting as independent Socio-Economic consultant to conduct a Socio-Economic Impact Assessment study for the proposed Medupi Power Station FGD technology retrofitting.

The coal that Medupi Power Station burns to generate electricity results in ash and flue gases generated as the main by-products. The purpose of the FGD is to remove the sulphur dioxide from the exhaust flue gases. The proposed project entails the following:

- Storage, handling and disposal of wastes
- Treatment of waste water within a Zero Liquid Discharge (ZLD) system;
- A conveyor belt for the transportation of waste to the ash disposal site;
- Services including electricity and water supply in the form of power lines, pipelines, and associated infrastructure; and
- Access and maintenance roads to the ash disposal facility (ADF).

Based on the used socio-economic receptors at a Desktop level, we have determined that the affected communities include: Ward 2 (Marapong), 3, 4 (Overwacht) and Ward 5 (Lephalale) due to their close proximity with the Medupi power station. Ward 1 & 5 may also be affected on the spatial extent of the impact. Ward 2, located just south of the Farm Zongezien and north east of existing Matimba Power Station. Ward 4 and 5, are located to the southeast and east of the existing Matimba power station. There are also farm homesteads scattered around the area with livestock farming (mainly game and cattle ranching).

Among the determined social services canters we have considered the following: schools and clinics include Ellisras School, Clinic and Hospital located in Ward 4; Lekhureng primary School in Ward 1 and Weltevrede Montoma School in Ward 5 (Census 2001).

As such, I&APs are invited to contact us if they have any queries or inputs regarding the project (i.e. Socio-Economic component). A public meeting can be arranged upon request. Interested candidates are urged to make contact within 40 days upon receipt of this letter to the undersigned:

Carli Terreblanche	carli@ngtgroup.co.za	**Tel:** 011 476 6057 **Fax:** 011 476 7563
Themba Nyauza	themba@ngtgroup.co.za	No. 02 Windsor Place, Princesses Avenue, Windsor West, Randburg, 2194

Yours Sincerely

Carli Terreblanche

Socio-Economic Consultant

ANNEXURE 2- NOTICES FOR PUBLIC MEETING TO DISCUSS THE PROPOSED MEDUPI FGD RETROFIT PROJECT IN LEPHALALE LOCAL MUNICIPALITY

NGT Projects & Heritage Consultants (Pty) Ltd

Division: NGT Socio-Economic Solutions

Site Notice: Proposed Environmental Impact Assessment and Waste Management License Application for the proposed Medupi Power Station Flue Gas Desulphurisation

Date of issue: 07 March 2015
Proposed Date of the Meetings: 18/03/2015
Venue: Morapong Library
Times: 09:00am to 2:00pm

The following project is conducted according to the National Environmental Management Act (NEMA), No 107 of 1998 and the EIA Regulations, 2010; National Environmental Management Waste Act (NEM: WA), No 59 of 2008 as amended; National Water Act, No 36 of 1998 as amended and; Policies that govern the Socio-economy of South Africa.

Eskom have appointed Zitholele Consulting to undertake and Environmental Impact Assessment for the proposed Medupi Power Station Flue Gas Desulphurisation Retrofit Project. The coal that Medupi Power Station burns to generate electricity results in ash and flue gases generated as the main by-products. The purpose of the FGD is to remove the sulphur dioxide from the exhaust flue gases.

The project entails:

- Storage, handling and disposal of wastes
- Treatment of waste water within a Zero Liquid Discharge (ZLD) system;
- A conveyor belt for the transportation of waste to the ash disposal site;
- Services including electricity and water supply in the form of power lines, pipelines, and associated infrastructure; and
- Access and maintenance roads to the ash disposal facility (ADF).

Locality:
Medupi Power Station is located approximately 13 km west of the town of Lephalale in the Limpopo Province, Waterberg District Municipality.

Any Interested and Affected Party who wishes to comment on the socio-economic aspect of the project are invited to do so in writing to:

NGT Projects and Heritage Consultants

Division: NGT Socio-Economic Solutions

No. 02 Windsor Place, Princesses Avenue, Windsor West, Randburg, 2194;

Fax: 011 476 7563; E-mail: nkosinathi@ngtgroup.co.za

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NGT Projects & Heritage Consultants (Pty) Ltd

Division: NGT Socio-Economic Solutions

Site Notice: Proposed Environmental Impact Assessment and Waste Management License Application for the proposed Medupi Power Station Flue Gas Desulphurisation

Date of issue: 07 March 2015
Proposed Date of the Meetings: 19/03/2015
Venue: Steenbokpan Leseding Community Hall
Times: 09:00am to 12:00pm

The following project is conducted according to the National Environmental Management Act (NEMA), No 107 of 1998 and the EIA Regulations, 2010; National Environmental Management Waste Act (NEM: WA), No 59 of 2008 as amended; National Water Act, No 36 of 1998 as amended and; Policies that govern the Socio-economy of South Africa.

Eskom have appointed Zitholele Consulting to undertake and Environmental Impact Assessment for the proposed Medupi Power Station Flue Gas Desulphurisation Retrofit Project. The coal that Medupi Power Station burns to generate electricity results in ash and flue gases generated as the main by-products. The purpose of the FGD is to remove the sulphur dioxide from the exhaust flue gases.

The project entails:

- Storage, handling and disposal of wastes
- Treatment of waste water within a Zero Liquid Discharge (ZLD) system;
- A conveyor belt for the transportation of waste to the ash disposal site;
- Services including electricity and water supply in the form of power lines, pipelines, and associated infrastructure; and
- Access and maintenance roads to the ash disposal facility (ADF).

Locality:
Medupi Power Station is located approximately 13 km west of the town of Lephalale in the Limpopo Province, Waterberg District Municipality.

Any Interested and Affected Party who wishes to comment on the socio-economic aspect of the project are invited to do so in writing to:

NGT Projects and Heritage Consultants

Division: NGT Socio-Economic Solutions

No. 02 Windsor Place, Princesses Avenue, Windsor West, Randburg, 2194;

Fax: 011 476 7563; E-mail: nkosinathi@ngtgroup.co.za

NGT Projects & Heritage Consultants (Pty) Ltd

Division: NGT Socio-Economic Solutions

Site Notice: Proposed Environmental Impact Assessment and Waste Management License Application for the proposed Medupi Power Station Flue Gas Desulphurisation

Date of issue: 07 March 2015
Proposed Date of the Meetings: 19/03/2015
Venue: Mogol Club
Times: 1:00pm to 3:00pm

The following project is conducted according to the National Environmental Management Act (NEMA), No 107 of 1998 and the EIA Regulations, 2010; National Environmental Management Waste Act (NEM: WA), No 59 of 2008 as amended; National Water Act, No 36 of 1998 as amended and; Policies that govern the Socio-economy of South Africa.

Eskom have appointed Zitholele Consulting to undertake and Environmental Impact Assessment for the proposed Medupi Power Station Flue Gas Desulphurisation Retrofit Project. The coal that Medupi Power Station burns to generate electricity results in ash and flue gases generated as the main by-products. The purpose of the FGD is to remove the sulphur dioxide from the exhaust flue gases.

The project entails:

- Storage, handling and disposal of wastes
- Treatment of waste water within a Zero Liquid Discharge (ZLD) system;
- A conveyor belt for the transportation of waste to the ash disposal site;
- Services including electricity and water supply in the form of power lines, pipelines, and associated infrastructure; and
- Access and maintenance roads to the ash disposal facility (ADF).

Locality:
Medupi Power Station is located approximately 13 km west of the town of Lephalale in the Limpopo Province, Waterberg District Municipality.

Any interested and Affected Party who wishes to comment on the socio-economic aspect of the project are invited to do so in writing to:

NGT Projects and Heritage Consultants

Division: NGT Socio-Economic Solutions

No. 02 Windsor Place, Princesses Avenue, Windsor West, Randburg, 2194;

Fax: 011 476 7563; E-mail: nkosinathi@ngtgroup.co.za

NGT Projects & Heritage Consultants (Pty) Ltd

Division: NGT Socio-Economic Solutions

Kennisgewing: Voorgestelde Omgewingsimpakstudie en Afvalbestuurslisensie Aansoek vir die Voorgestelde Medupi Kragstasie Rookgas Ontswawelings Projek

Datum van Uitreiking: 05 Maart 2015

Voorgestelde Datum van Vergadering: 07/03/2015

Voorgestelde Plek: Mogol Club (Corner Nelson Mandela and George Wells)

Tyd: Vanaf 10:00 tot 12:00

Die volgende project is onderneem volgens die Wet op Nasionale Omgewingsbestuur, Wet 107 van 1998 en die Oliereguiasies van 2010; Die Nasionale Omgewingsbestuur: Afvalbestuur Wet, 59 van 2008, soos gewysig; Die Nasionale Waterwet, Wet 36 van 1998, soos gewysig; Sosio-Ekonomiese Beleid van Suid-Afrika.

Eskom het Zitholele Consulting aangwys om die Omgewings Impakstudie vir die voorgestelde Eskom Medupi Kragstasie Rookgas Ontswawelings Projek te ondemeem. Die steenkool wat deur die Medupi Kragstasie verbrand word om elektrisiteit te genereer, ontaard in as en rookgas as die hoof by-produkte. Die doel van die projek is om die swaweldioksied te te verwyder van die uitgelate rookgas.

Die projek behels:

- berging, hantering en verwydering van afval;
- behandeling van afvalwater binne 'n Zero Liquid Discharge (ZLD) stelsel;
- 'n vervoerband vir die vervoer van afval na die storting terrein;
- dienste wat elektrisiteit en watertoevoer in die vorm van kraglyne , pypleidings en verwante infrastruktuur insluit; en
- toegang en instandhouding van paaie na die storting fasiliteit

Ligging

Die Medupi Kragstasie is ongeveer 13 km wes van die dorp Lephalale in die Limpopo Provinsie, Waterberg-distriksmunisipaliteit geleë.

Enige belanghebbende en geaffekteerde partye wat kommentaar wil lewer op die sosio-ekonomiese aspek van die projek word uitgenooi om 'n skrywe te rig aan:

NGT Projects and Heritage Consultants

Division: NGT Socio-Economic Solutions

No. 02 Windsor Place, Princesses Avenue, Windsor West, Randburg, 2194;

Fax: 011 476 7563; E-pos: nkosinathi@ngtgroup.co.za

ANNEXURE 3 – EXAMPLE OF SITE NOTICES PLACED AT VARIOUS VENUES AND PHOTOS TAKEN DURING PUBLIC MEETINGS THAT TOOK PLACE AS PART OF THE SIA CONSULTATIVE PROCESS

Figure 21- Site notice at Lephalale FM

Figure 22- Site notice at the entrance of one of the local Zion church

Figure 23-Site Notice at a local Spaza Shop Marapong

Figure 24- Site notice at Marapong Clinic

Figure 25- Site notice near one of the Spaza Shops in Marapong

Figure 26- Site notice at Marapong Library

Figure 27- Site notice at Spar Onverwacht

Figure 28- Notice at Steenbokpan community hall (first row) and local Spaza shop (second row)

Figure 29- Site notice at a Sasol donated facility in Steenbokpan

Figure 30- Site notice at Lephalale FET and Ellisras District Hospital

Figure 31 – Picture showing attendents and the meeting proceeding at Marpong Library on the 16 April 2015

Figure 32 – Meeting proceeding at Leseding Community (Steenbokpan)

ANNEXURE 4- GENERAL SITE CONDITION OF THE EXISTING MEDUPI ADF

Figure 33-Signage at the Medupi Ash Disposal Facility entrance point

Figure 34- Available land that has been cleared for the growth of the Ash Disposal Facility (AFD). Image taken from the west facing east

Figure 35- The width of the facility facing Medupi from the west end of the ADF

Figure 36 – The western end on the AFD

Figure 37- Northern end of the AFD

Figure 38- Northern dam associated with the AFD

Figure 39- Current ash heap at the facility

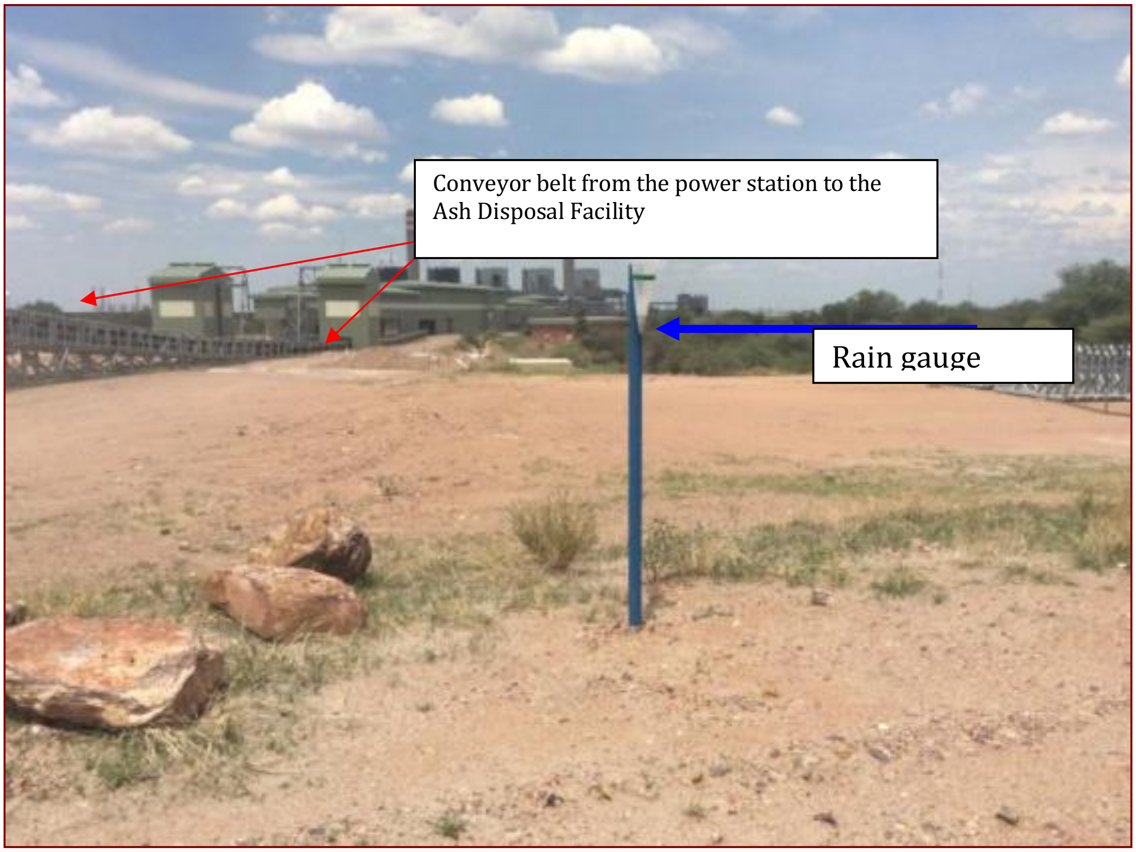


Figure 40- Conveyor belt system associated with the AFD

Figure 41- Land dedicated to the facility. Taken south of the facility facing north

Figure 42- Image of the land dedicated to the facility and ash heap from Medupi power station. Taken from the south facing north-east

Figure 43- Two dams associated with the facility located south-west of the current ash heap

Figure 44- Fence line demarcating the facility with the southern property and the railway line

Figure 45- Machine that loads ash onto the facility from conveyor belt

Figure 46- Sprinkler system developed to suppress dust

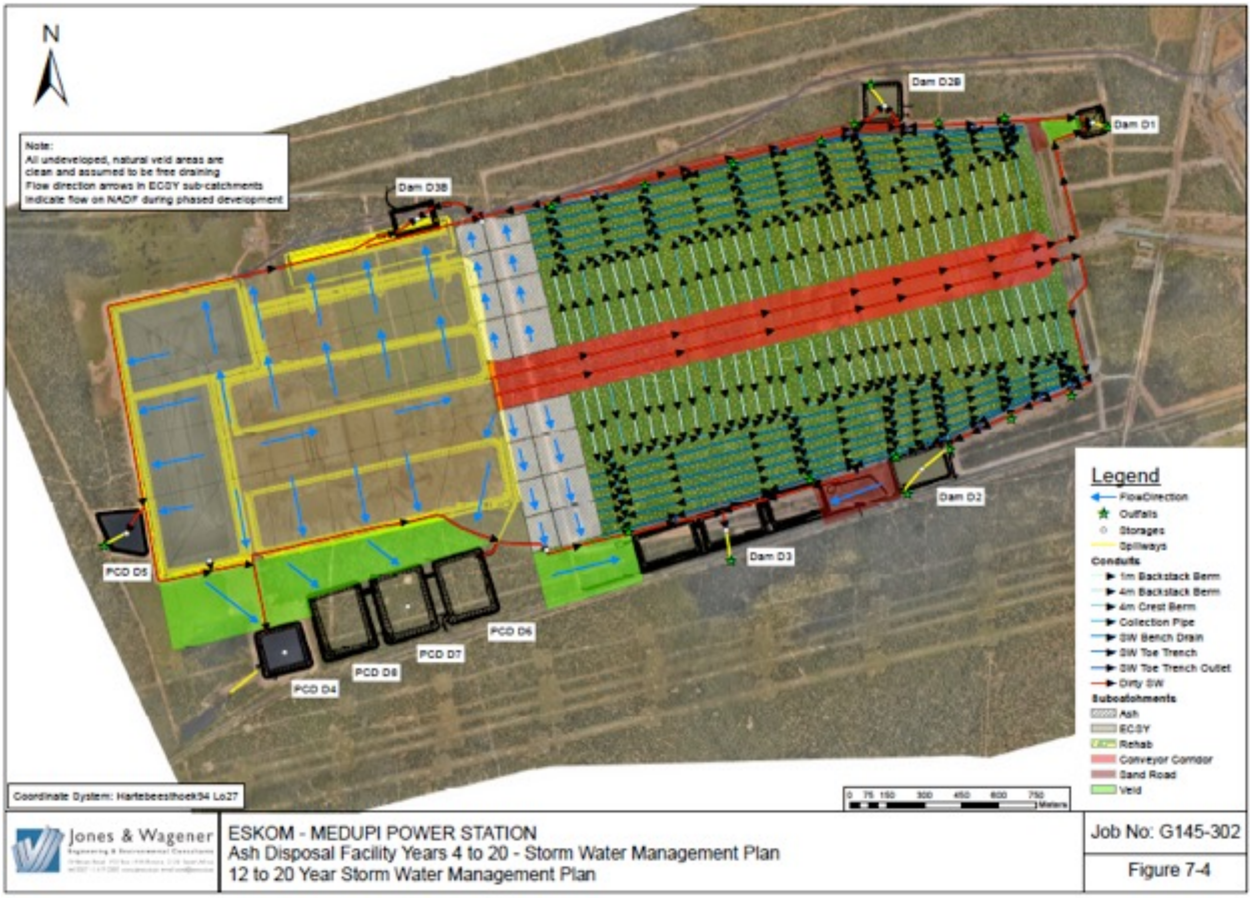
ANNEXURE 5 – EXAMPLE OF A PUBLIC MEETING WHERE THERE WAS A NEED FOR PUBLIC ENFORCEMENT

The meeting was held in 2016 and was disrupted by angry disgruntled youth who threatened violence if the meeting was not disbanded or they were engaged by senior Eskom representatives. Chants of "iAgenda yama Capitalists asiyifuni, we want jobs" which loosely translated means "We do not support capitalist agenda's, we want jobs". The youth spoke at length about the scourge of unemployment and lack of consideration for the locals in Medupi construction activities currently underway at Medupi.

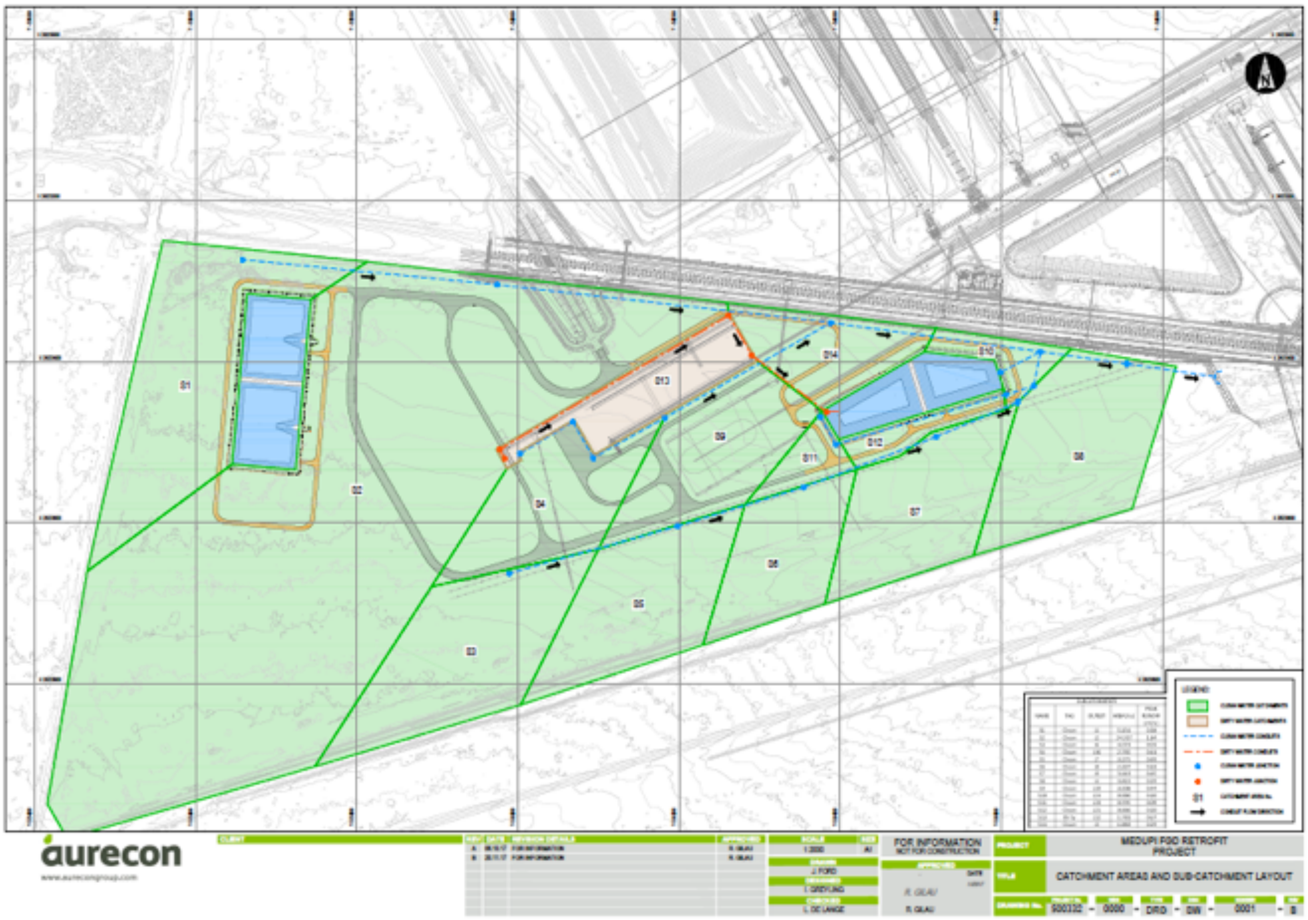

POLICE

ANNEXURE 6 – UPDATES TO PROJECT SCOPE 2017-2018

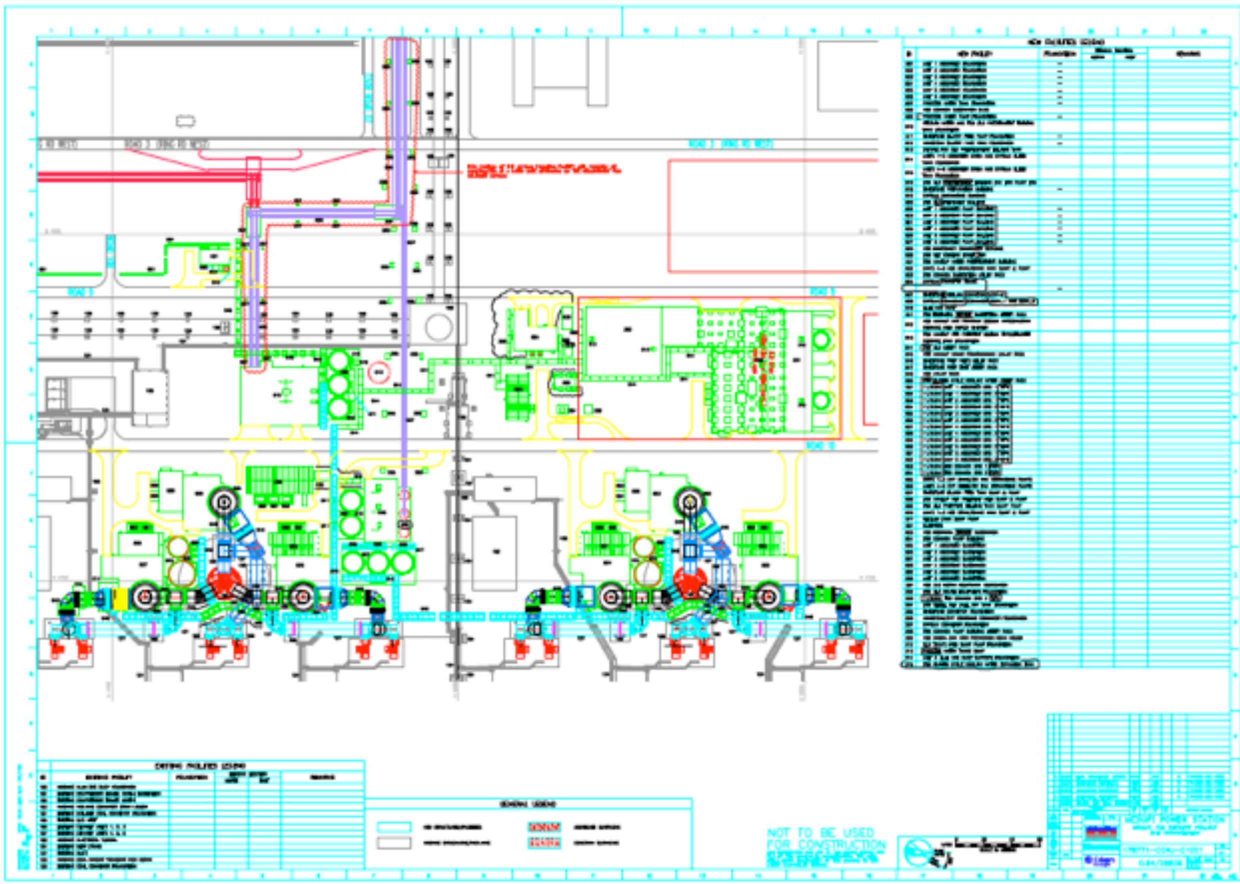
ANNEXTURE 7: ESKOM MEDUPI POWER STATION ASH DISPOSAL FACILITY 4 TO 2O YEARS STORM WATER MANAGEMENT PLAN



ANNEXTURE 8: MEDUPI PGD RETROFIT PROJECT CATCHMENT AREAS AND SUB-CATHCMENT LAYOUT



ANNEXTURE 9: ESKOM MEDUPI POWER STATION FGD RETROFIT PROJECT SITE ARRANGMENT



ANNEXTURE 10: ESKOM MEDUPI POWER STATION RAILWAY YARD LAYOUT