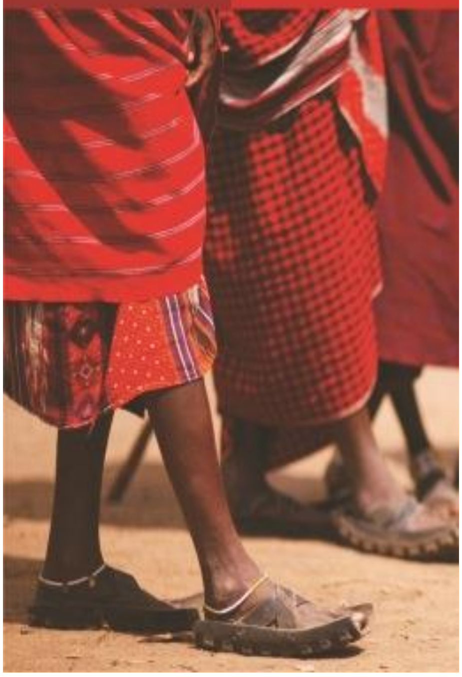

DIGBY WELLS
ENVIRONMENTAL

Environmental Impact Assessment for the Musina-Makhado Special Economic Zone, Limpopo Province

Freshwater Impact Report

Project Number:

LEA5522

Prepared for:

Limpopo Economic Development Agency

September 2019

Digby Wells and Associates (South Africa) (Pty) Ltd
Co. Reg. No. 2010/008577/07. Turnberry Office Park, 48 Grosvenor Road, Bryanston, 2191. Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 069 6801, info@digbywells.com, www.digbywells.com

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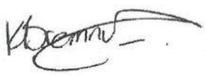
Report Type:	**Freshwater Impact Report**
Project Name:	**Environmental Impact Assessment for the Musina-Makhado Special Economic Zone, Limpopo Province**
Project Code:	**LEA5522**

Name	Responsibility	Signature	Date
Kathryn Roy	Field surveyor and report compiler (Wetlands)		April 2019
Kieren Bremner Pr.Sci.Nat.	Field surveyor, report compiler and review (Aquatics & Wetlands)		May 2019
Byron Bester Pr.Sci.Nat.	Peer review		May 2019

Declaration of the Specialist

I Kieren Jayne Bremner, as the appointed specialist hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
  - other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
  - am not independent, but another specialist that meets the general requirements set out in Regulation 13 have been appointed to review my work (Note: a declaration by the review specialist must be submitted);
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application;
- have ensured/will ensure that information containing all relevant facts in respect of the application was/will be distributed or was/will be made available to interested and affected parties and the public and that participation by interested and affected parties was/will be facilitated in such a manner that all interested and affected parties were/will be provided with a reasonable opportunity to participate and to provide comments;
- have ensured/will ensure that the comments of all interested and affected parties were/will be considered, recorded and submitted to the Department in respect of the application;
- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant;
- have kept/will keep a register of all interested and affected parties that participate/d in the public participation process; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.



Signature of the specialist:

Full Name and Surname of the specialist:

Kieren Jayne Bremner_______________________

Digby Wells Environmental

Name of company:

Date:

EXECUTIVE SUMMARY

The Department of Trade and Industry (DTI) requested the Limpopo Provincial Government to submit potential areas for strategic industrial development in Limpopo. Following the submission and evaluation of areas that align with potential growth, the DTI approved two areas, one of which was a Special Economic Zone (SEZ) located across the Musina and Makhado local municipalities and which fall under the Vhembe District Municipality.

The proposed Musina-Makhado SEZ is located near the towns of Makhado (located 31 km south) and Musina (located 36 km north) and is proposed to involve the construction of a light industrial and agro-processing cluster (located in Musina) and a metallurgical/mineral beneficiation complex (located in Makhado). The purpose of the project is the development of a new heavy industrial hub that forms part of the Trans-Limpopo Spatial Development Initiative. The project will be established across eight farms, which in total amounts to approximately 8,000 hectares (ha), of which 6,000 ha will be used for the SEZ.

A scoping environmental assessment was prepared by Delta Built Environment Consultants (Pty) Ltd in January 2019. As part of the Authorisation Process, a baseline freshwater impact assessment (including aquatic and wetland components) was to be undertaken within the proposed study area.

A total of 303.74 ha of drainage lines and wetlands were identified on site. The pans categorised as Category A (Natural) displayed no visible impacts. This was attributed to general access restrictions on the farm portion (ANTROBUS 566 – East of N1) on which these pans were observed. This is due to the private access of the game reserve. The main impacts associated with the pans categorised as Category B (Largely natural) included heavy grazing activities (remainder of the farms and portions). The final EIS scores were High for all pans. Wetland buffers were determined to be 51 m for all pans and 100m or the 1:100 year floodline for drainage lines.

In terms of aquatic ecological integrity no PES could determined for each of the biological components at the time of the survey due to the nature of the systems present within the proposed Project area, as such, no integrated EcoStatus could be determined. Nonetheless, it should be noted that the conditions observed at the time of the survey were deemed natural and representative of the region.

Most of the impacts from the construction and operation of the SEZ are major, with little option for mitigation. SEZ’s are intended to be long-term industrial and economic development initiatives; it is thus unlikely for the project to be decommissioned in the foreseeable future. However, in the event that decommissioning, and closure takes place, impacts and mitigation measures were provided. Monitoring recommendations were also provided.

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1 Introduction

Biodiversity within inland water ecosystems in southern Africa is both highly diverse and of great regional importance to local livelihoods and economies, as these valuable natural resources (including any associated biota) provide a broad array of goods and services (Darwall, Smith, Tweddle, & Skelton, 2009; Dudgeon et al., 2006). However, the fact that these freshwater systems may well be the most endangered ecosystems in the world threatens any of the 126,000 described species that depend upon freshwater habitats for any critical part of their life cycle, as well as any associated provisioning and/or regulatory ecosystem services (Dudgeon et al., 2006).

Major global threats identified within these species-rich systems include ecosystem destruction, habitat alteration, changes in water chemistry, and direct additions and/or losses of aquatic biota (Malmqvist & Rundle, 2002). The magnitude of the threat to, and loss of, biodiversity in these vulnerable ecosystems is an indicator of the extent to which current practices are unsustainable. Hence, the importance of implementing conservation and management strategies that protect all elements of freshwater biodiversity, which in turn, also help to guarantee water availability in the future (Dudgeon et al., 2006).

The fact that South Africa is a water-scarce country makes these aquatic ecosystems even more susceptible to anthropogenic activities and their associated impacts. Consequently, the state (quality and quantity) of the county's water resources is fully dependant on good land management practices within catchments. Therefore, in order to achieve ecological and socio-economic sustainability, our natural water resources rely upon an integrated ecosystem-based approach to natural resource management (i.e. Integrated Water Resource Management).

1.1 Project Description

The Department of Trade and Industry (DTI) requested the Limpopo Provincial Government to submit potential areas for strategic industrial development in Limpopo. Following the submission and evaluation of areas that align with potential growth, the DTI approved two areas, one of which was a Special Economic Zone (SEZ) located across the Musina and Makhado local municipalities and which fall under the Vhembe District Municipality (see Figure 1-1 and Figure 1-2).

A scoping environmental assessment was prepared by Delta Built Environment Consultants (Pty) Ltd in January 2019. As part of the Authorisation Process, a baseline freshwater impact assessment (including aquatic and wetland components) was to be undertaken within the proposed study area.

1.2 Project Background

The proposed Musina-Makhado SEZ (hereafter the project) is located near the towns of Makhado (located 31 km south) and Musina (located 36 km north) and is proposed to involve the construction of a light industrial and agro-processing cluster (located in Musina) and a metallurgical/mineral beneficiation complex (located in Makhado). The purpose of the project is the development of a new heavy industrial hub that forms part of the Trans-Limpopo Spatial Development Initiative. The project will be established across eight farms, which in total amounts to approximately 8,000 hectares (ha), of which 6,000 ha will be used for the SEZ.

The project is envisaged to comprise of mixed land uses and infrastructure provision, so as to ensure optimal manufacturing operations within the energy and metallurgical complex once established, including the following:

- Power plant;
- Coke plant;
- Ferrochromium plant;
- Ferromanganese plant;
- Pig iron plant;
- Carbon steel plant;
- Stainless steel plant;
- Lime plant;
- Silicon-manganese plant;
- Metal silicon plant; and
- Calcium carbide plant.

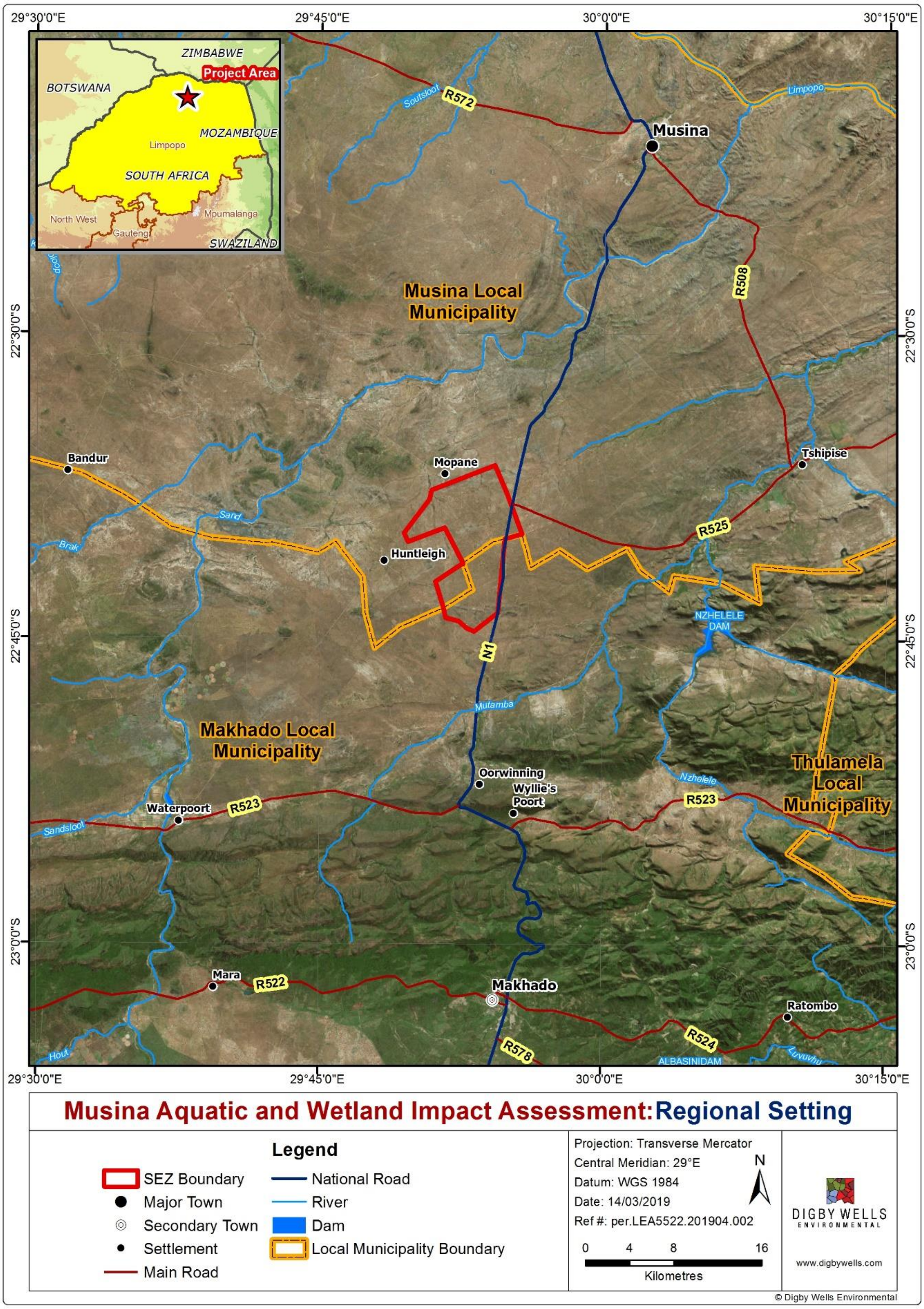


Figure 1-1: Regional setting

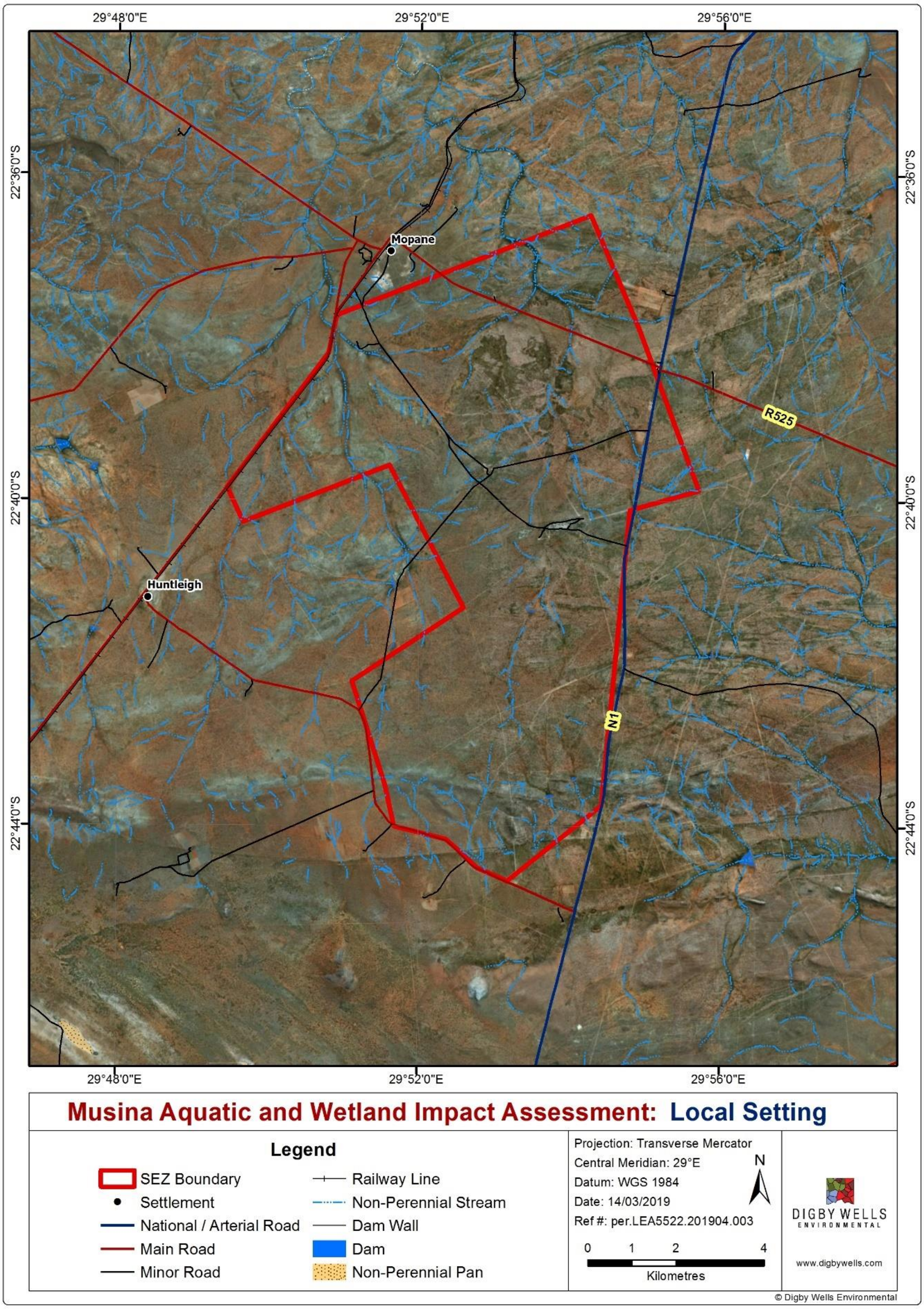


Figure 1-2: Local setting

1.3 Terms of Reference

Digby Wells Environmental (hereafter Digby Wells) was commissioned by the Limpopo Economic Development Agency (hereafter LEDA) to conduct the freshwater (aquatic and wetland) specialist studies to inform the Environmental Impact Assessment (EIA) process being undertaken for the proposed project. Through the mechanisms of the EIA phase, the aim is to provide a report and accompanying maps describing the following:

- Conduct a baseline freshwater specialist assessment within the proposed project area:
  - Identification and delineation of the freshwater resources within the area;
  - A description and characterisation of the freshwater systems present;
  - Determination of the Present Ecological Status (PES; or Ecological Category) of the freshwater resources, where possible;
  - An assessment of the Ecological Importance and Sensitivity (EIS), as well as the ecological service provision associated with each of the freshwater systems observed, where applicable;
- Assess the potential impacts to the freshwater resources present likely to originate from the proposed project activities:
  - Identify potential impacts (incl. direct, indirect and cumulative) upon the freshwater resources implicated by the proposed infrastructure and project activities;
  - Provide a professional opinion and assessment of the potential impacts (including assessment of duration, extent, magnitude, nature, etc.) of each of the identified potential impacts; and
  - Recommend appropriate mitigation measures, management objectives and interventions, as well as identify any potential fatal flaws associated with the proposed activities, if and when applicable.

This report presents the findings of the desktop freshwater specialist assessment, for which the field survey was conducted between the 3rd – 8th March 2019.

1.4 Policy and Legal Framework

The freshwater resource assessment aims to support the following regulations, regulatory procedures and guidelines:

- Section 19 of the National Water Act (NWA, Act 36 of 1998);
- Section 21 (c), (g) and (i) of the NWA (Act 36 of 1998);
- Section 24 of the Constitution – Environment (Act 108 of 1996);
- National Environmental Management Biodiversity Act (NEMBA), 2004 (Act 10 of 2004); and

- Section 5 of the National Environmental Management Act (NEMA), 1998 (Act No. 7 of 1998).

1.5 Assumptions and Limitations

The following limitations were encountered during this study:

- Wetland ecology component:
  - Access to full extent of the identified systems was limited due to the areas occurring on private property and/or game reserves. However, these systems that could not be ground-truthed at the time of the field survey were scrutinised at a desktop level and have been demarcated as such for transparency;
  - Due to the large number of pan systems present, each pan was not assessed for PES and EIS separately. Based on the similarity of impacts, some pans were grouped together when being assessed for PES and EIS; and
  - While no PES or EIS was calculated for the ephemeral watercourses observed, these have been delineated on a desktop level (with limited field verification) and indicated for sensitivity mapping purposes.
- Aquatic ecology component:
  - In order to obtain a comprehensive understanding of the dynamics of the aquatic biota present within a watercourse (e.g. migratory pathways, seasonal prevalence, breeding cycles, etc.), studies should include investigations conducted during different seasons, over a number of years and through extensive sampling efforts. Given the time constraints of the baseline assessment, such long-term studies were not feasible and could not be conducted. Therefore, the findings presented are based on professional experience, supported by a literature review, and extrapolated from the data collected at the time of the field survey;
  - In light of the semi-arid nature of the study area, a number of “dry sites” were observed. However, these conditions are regarded as natural within the study area and as such, are expected to flow irregularly (e.g. 2-year cycles) within the freshwater systems (i.e. ephemeral watercourses). Many of these systems were observed to be dry at the time of the survey, while selected pans/impoundments observed were still observed to be inundated to some extent; and
  - Although SASS5 is not recommended for use in temporary watercourses (Chutter, 1998; Dickens & Graham, 2002), no other method has yet been developed. Therefore, it was deemed to be the most appropriate tool available at the time of the study (Watson & Dallas, 2013). This limitation extended to a number of the assessment indices (Section 4) and as such, caution should be applied during interpretation of these results due to highly dynamic changes expected within these systems following sufficient rainfall within the area.

1.6 Conditions of this report

Findings, recommendations and conclusions provided in this report are based on the authors' best scientific and professional knowledge and information available at the time of compilation. No form of this report may be amended or extended without the prior written consent of the author and/or a relevant reference to the report by the inclusion of an appropriately detailed citation.

Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

2 Details of the Specialists

Kathryn Roy: Wetlands Consultant; Kathryn received a Bachelor of Science in Ecology and Environmental Science and an Honours degree in Environmental Management from the University of Cape Town. She has also received her MSc in Restoration Ecology through the University of KwaZulu-Natal and has over 6 years of experience in the environmental field. Kathryn focuses on wetland assessments throughout South Africa as well as wetland and rehabilitation monitoring programmes within the mining and energy production sectors. She has also completed flora surveys and site-specific rehabilitation plans. Kathryn previously worked extensively with alien invasive species removal programmes, ecological restoration projects and sustainable development programmes within the Government Sector.

Kieren Jayne Bremner: Wetlands Manager. Kieren completed an M.Sc (Aquatic Health) from the University of Johannesburg and has 11 years of consulting experience. In her early career she was exposed to various sectors of the Environmental Management field such as water use licensing, BAs, EIAs and public participation. During this time she was given the opportunity to initiate and manage various aquatic biomonitoring programmes within the mining and energy production sectors within South Africa. In 2009, Kieren began to focus largely on wetland and aquatic specialist assessments, gaining invaluable and extensive experience in the biomonitoring and water monitoring field in rivers and wetlands throughout South Africa. International countries of project experience include: Botswana, the Democratic Republic of Congo, Malawi, Mali, Senegal and Ghana. Kieren is registered by the SA RHP as an accredited aquatic biomonitoring specialist.

3 Description of Environment

3.1 Biophysical Description

The project area is located within the Limpopo Plain ecoregion (Level II Ecoregion 1.01), falling under the greater Zambezian Lowveld freshwater ecoregion according to Darwall et al. (2009). Table 3-1 provides a summary of the main attributes of the Limpopo Plain ecoregion according to Kleynhans, Thirion, & Moolman (2005).

Table 3-1: Main attributes of the Limpopo Plain Ecoregion

Main Attributes	Limpopo Plain
Terrain Morphology: Broad division (dominant types in bold) (Primary)	**Plains; Low Relief;** Plains Moderate Relief; Lowlands; Hills and Mountains; Moderate and High Relief; Closed Hills; Mountains; Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	**Mopane Bushveld; Sweet Bushveld; Mixed Bushveld** Waterberg Moist Mountain Bushveld; Clay hills; Mountains; Kalahari Plains Thorn Bushveld
Altitude (m a.m.s.l)	300-1100 (1100-1300 limited)
MAP (mm) (Secondary)	200 to 600
Coefficient of Variation (% of annual precipitation)	25 to 40
Rainfall concentration index	60 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp. (°C)	18 to >22
Mean daily max. temp. (°C): February	26 to 32
Mean daily max. temp. (°C): July	20 to >24
Mean daily min. temp. (°C): February	16 to >20
Mean daily min temp. (°C): July	2 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 to 60 (60-100 limited)

3.1.1 Climate

Altitudes range from 800-950 m above mean sea level (a.m.s.l.). The regional climate ranges from temperate and semi-arid in the south to extremely arid in the north. The area within the Limpopo Water Management Area (WMA) is characterised by a flat topography with grassland, sparse bushveld shrubs and trees. Consequently, in addition to the prevalence of sandy soils in the area, surface runoff is regarded as low despite the presence of some loam and clay soils (Sikosana and de Jager, 2016).

Relative to the country's average mean annual precipitation (MAP) of 490 mm, area receives an average of 305 mm rainfall per annum (which falls predominantly during early- to mid-summer) with an average potential evaporation rate of 2000 mm per annum, as stipulated by the Water Resources of South Africa 2012 Study (Kleynhans, Thirion, Moolman, & Gaulana, 2007; Worldwide Fund for Nature - South Africa, 2016).

The mean annual temperature ranges between 18-22°C, with mean daily maximum temperatures in February ranging between 28-32°C and mean daily minimum temperatures ranging between 18-24°C in July (Kleynhans et al., 2007).

3.1.2 Regional Vegetation

The project area is located within the Mopane Bioregion (Musina Mopane Bushveld and the Limpopo Ridge Bushveld), as described by Mucina and Rutherford (2006, Figure 3-1).

The landscape features are characteristic of the Musina Mopane Bushveld including undulating, irregular plains and hills. This vegetation type occurs within the Limpopo Province at an altitude of 300 m – 800 m (Mucina & Rutherford, 2006) and is dominated by small trees, such as *Colophospermum mopane*. Table 3-2 lists the plant species that occur in the Musina Mopane Bushveld (Mucina & Rutherford, 2006).

Table 3-2: Plant Species Characteristic of the Musina Mopane Bushveld

Plant Form	Species
Tall trees	*Acacia nigrescens, Adansonia digitata, Sclerocarya birrea* subsp. *caffra*
Small Trees	*Colophospermum mopane, Combretum apiculatum, Acacia senegal* var. *leiorhachis, A. tortilis* subsp. *heteracantha, Boscia albitrunca, B. foetida* subsp. *rehmanniana, Commiphora glandulosa, C. tenuipetiolata, C. viminea, Sterculia rogersii, Terminalia prunioides, T. sericea, Ximenia americana*
Tall Shrubs	*Grewia flava, Sesamothamnus lugardii, Commiphora pyracanthoides, Gardenia volkensii, Grewia bicolor, Maerua parvifolia, Rhigozum zambesiacum, Tephrosia polystachya*
Low Shrubs	*Acalypha indica, Aptosimum lineare, Barleria senesis, Dicoma tomentosa, Felicia clavipilosa* subsp. *transvaalensis, Gossypium herbaceum* subsp. *africanum, Hermannia glanduligera, Neuracanthus africanus, Pechuel-Loescha leubnitziae, Ptycholobium contortum, Seddera suffruticosa*
Succulent Shrub	*Hoodia currorii* subsp. *lugardii*
Herbaceous Climber	*Mormordica balsamina*
Graminoids	*Schmidtia pappophoroides, Aristida adscensionis, A. congesta, Bothriochloa insculpta, Brachiaria deflexa, Cenchrus ciliaris, Digitaria eriantha* subsp. *eriantha, Enneapogon cenchroides, Eragrostis lehmanniana, E. pallens, Fingerhuthia africana, Heteropogon contortus, Sporobolus nitens, Stipagrostis hirtigluma* subsp. *patula, S. uniplumis, Tetrapogon tenellus, Urochloa mosambicensis*
Herbs	*Acrotome inflata, Becium filamentosum, Harpagophytum procumbens* subsp. *transvaalense, Heliotropium steudneri, Hermbstaedtia odorata, Oxygonum delagoense*
Succulent herbs	*Stapelia gettliffei, S. kwebensis*

The Musina Mopane Bushveld is categorised as least threatened with a target of 19% and only 2% statutorily conserved mainly in the Mapungubwe National Park and the Nwanedi and Honnet Nature Reserves. It is the most diverse mopaneveld type in South Africa (Mucina & Rutherford, 2006).

The Limpopo Ridge Bushveld is considered 'Least threatened' with 18% being statutorily conserved (Target of 19%). The vegetation structure is moderately open savannah with a poorly developed ground layer. *Kirkia acuminata* (White Seringa) is prominent on many of the ridges along with *A. digitata* (Baobab). On shallow calcareous gravel and calc-silicate soils, the shrub *Catophractes alexandri* is dominant. Table 3-3 lists the species characteristic of the Limpopo Ridge Bushveld (Mucina & Rutherford, 2006).

Table 3-3: Plant Species Characteristic of the Limpopo Ridge Bushveld

Plant Form	Species
Tall trees	*Adansonia digitata* (d), *Senegalia nigrescens*, *Sclerocarya birrea* subsp. *caffra*.
Small Trees	*Colophospermum mopane* (d), *Commiphora glandulosa* (d*), C. tenuipetiolata* (d), *Terminalia prunioides* (d), *Senegalia senengal var. leiorhachis*, *Vachellia. tortilis* subsp. *heteracantha*, *Boscia albitrunca*, *Combretum apiculatum*, *C. imberbe*, *Commiphora mollis*, *Ficus abutilifolia*, *F. tettensis*, *Kirkia acuminata*, *Sterculia rogersii*, *Ximenia americana*.
Tall Shrubs	*Catophractes alexandri*, *Commiphora pyracanthoides*, *Gardenia resiniflua*, *Grewia bicolor*, *G. villosa*, *Hibiscus calyphyllus*, *H. micranthus*.
Low Shrubs	*Barleria affinis, Blepharis diversispina, Neuracanthus africanus, Plinthus rehmannii, Ptycholobium contortum*.
Woody Climber	*Cissus cornifolia*
Graminoids	*Aristida adscensionis, A. stipitata subsp. graciliflora, Digitaria eriantha subsp. eriantha, Enneapogon cenchroides, Panicum maximum, Schmidtia pappophoroides, Stipagrostis uniplumis.*
Herbs	*Tavaresia barklyi*
Endemics	Pavonia dentata, *Cleome oxyphylla var. robusta*

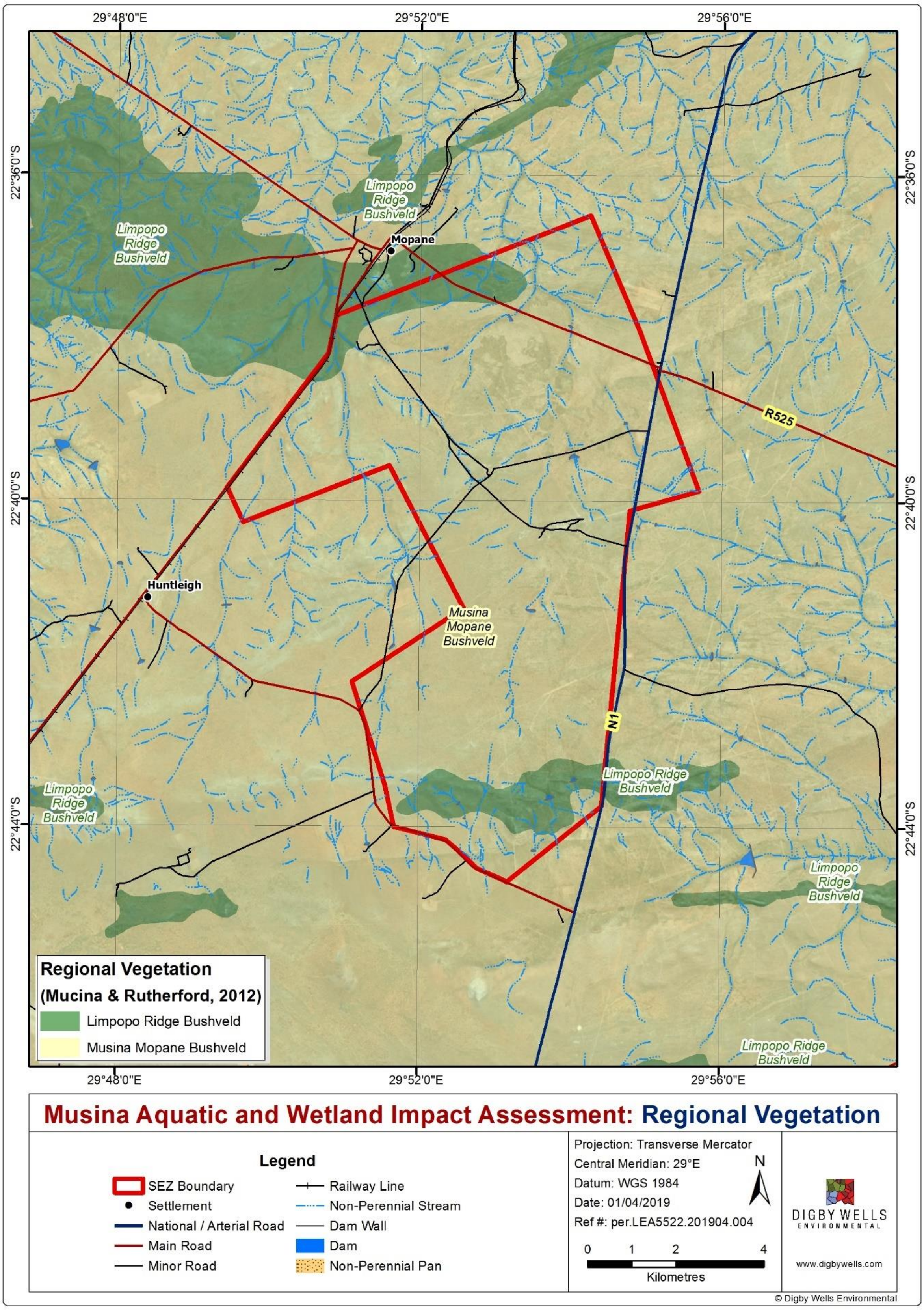


Figure 3-1: Regional Vegetation

3.1.3 Associated Watercourses

The SEZ site falls within primary drainage region A of the Limpopo WMA and the A71K and A80F quaternary catchments.

Figure 3-2 indicates the freshwater resource management classification associated with the study area, as well as the associated perennial and non-perennial drainage features. While no permanent watercourses were observed within the project area at the time of the assessment, several non-perennial streams and ephemeral drainage lines, as well as some natural pans and artificial impoundments exist within the demarcated project area.

The primary drainage feature associated with the proposed project is a perennial river, namely the Sand River, which falls within the Sub-Quaternary-Reach (SQR) A71K-00031, situated north-west of the project area and may be regarded as Moderately Modified, with a *High* degree of Ecological Importance and a *Moderate* degree of Ecological Sensitivity (Table 3-4) according to the desktop assessment by the Department of Water and Sanitation (2014).

Table 3-4: Desktop status of the Sub-Quaternary Reach for the Sand River (SQR A71K-00031)

PES Category Description	Mean Ecological Importance Class	Mean Ecological Sensitivity	Default Ecological Category
Moderately Modified	High	Moderate	B

The southern portion of the project area is associated with a number of drainage lines which form part of the upper catchment of the Mutamba River, which falls with the SQR A80F-00063, situated south of the project area and may be regarded as Moderately Modified, with a *Moderate* degree of Ecological Importance and a *High* degree of Ecological Sensitivity according to the desktop assessment by the Department of Water and Sanitation (2014).

Table 3-5: Desktop status of the Sub-Quaternary Reach for the Mutamba River (SQR A80F-00063)

PES Category Description	Mean Ecological Importance Class	Mean Ecological Sensitivity	Default Ecological Category
Moderately Modified	Moderate	High	B

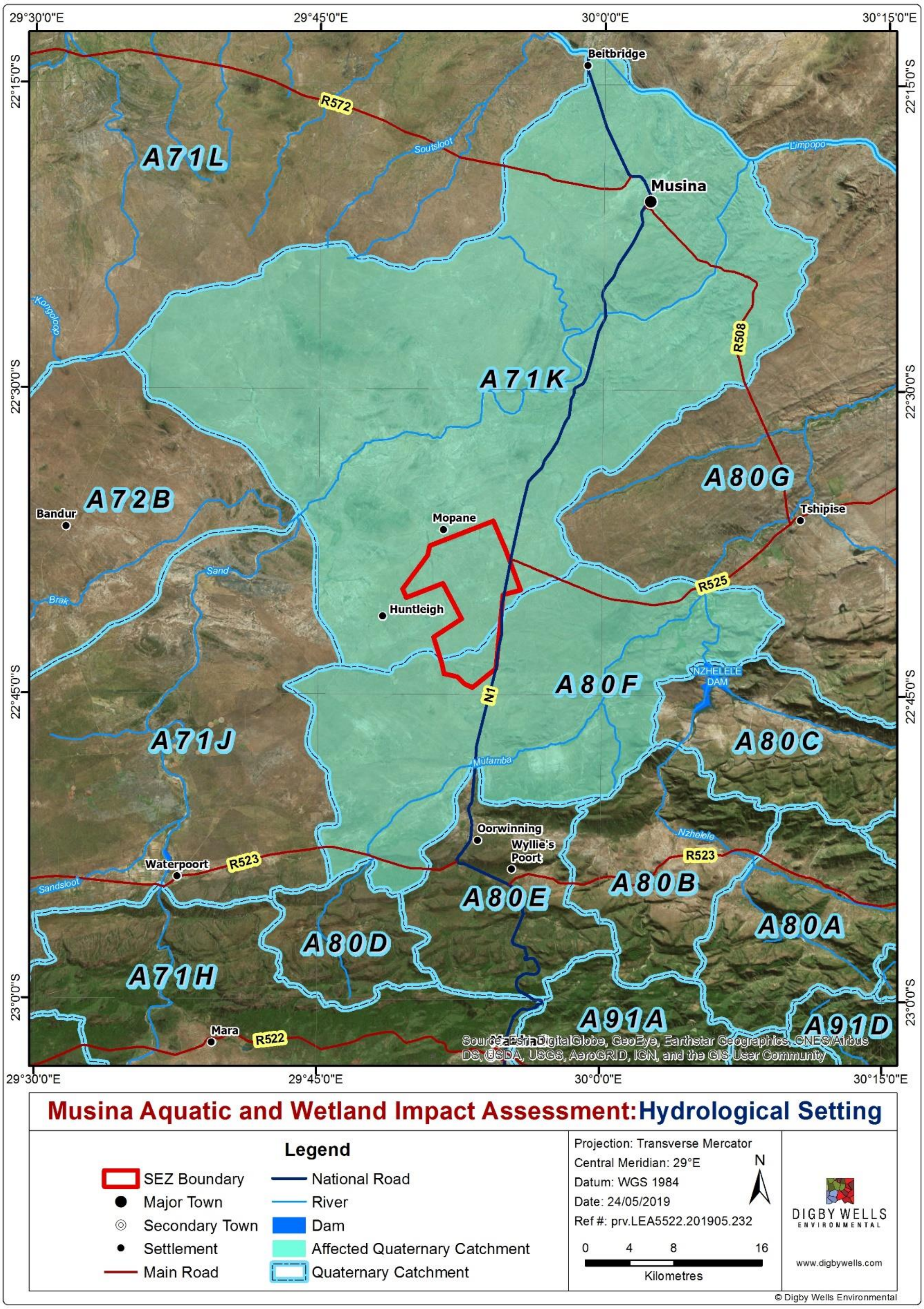


Figure 3-2: Associated watercourses

3.2 Bioregional Context

The project area is located within the Zambezian Lowveld freshwater ecoregion, which represents an overlap region of tropical Zambezian and southern temperate faunas (Darwall et al., 2009). Although not necessarily within the present study area, approximately 120 freshwater fish species are known to inhabit the waters of the Zambezian Lowveld ecoregion, of which 22 are endemic.

Dominant fish within the Zambezian Lowveld ecoregion include cichlids, cyprinids, gobies and mochokid catfishes, with many species found in fresh, brackish and saline waters, while several catadromous species also found in the ecoregion spend part of their life cycle in the freshwater coastal rivers and streams (e.g. several members of the Anguillidae family; Dallas, 2013). Endemics of the ecoregion include several rock catlets (*Chiloglanis* spp.), the Sibayi goby (*Silhouettea sibayi*) and the turquoise killifish (*Nothobranchius furzeri*; Skelton, 1994; cited in Dallas, 2013).

In light of the arid nature of the project area, many of the aforementioned fish species are likely to be absent. However, there is still a possibility of opportunistic fish species inhabiting recently inundated areas e.g. killifish within temporary pan systems and some of the impoundments observed within the proposed project area.

Table 3-6 provides a summary of the relevant location-specific environmental attributes associated with the study area.

Table 3-6: Summary of site characteristics and attributes of the associated study area.

Political Region	Limpopo
Level 1 Ecoregion	1. Limpopo Plain
Level 2 Ecoregion	1.01
Freshwater Ecoregion	Zambezian Lowveld
Geomorphic Province	Limpopo Flats
Vegetation Type	Musina Mopane Bushveld Limpopo Ridge Bushveld
Water Management Area	1. Limpopo
Secondary Catchment	A7, A8
Quaternary Catchment	A71K and A80F

Watercourse	Sand River and adjoining tributaries; Mutamba River and adjoining tributaries
Slope Class	E – Lower Foothills Z - Unclassified
Seasonality	Perennial Ephemeral

3.3 Regional Biodiversity Importance

3.3.1 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity within the context of equitable social and economic development. The second aim is comprised of two separate components: the (i) national component aimed to align DWA (or currently the DWS) and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems, while the (ii) sub-national component is aimed to use three case studies to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes. The project further aimed to maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver et al., 2011).

Based on current outputs of the NFEPA project (Nel et al., 2011; Figure 3-3), the sub-quaternary catchment associated with the Sand River was defined as a FEPA catchment, as a result of both river and wetland ecosystem types, as well as a few wetland clusters. These catchments help to achieve national biodiversity targets, as the ecological condition of the associated systems are currently regarded as being in a good condition (A or B ecological category) and as such, these catchments and adjacent areas should be managed in a way that maintains their ecological condition, so as to conserve freshwater ecosystems and protect water resources for sustainable human use (Nel et al., 2011).

Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts (Driver et al., 2011).

Based on a desktop-based modelled wetland condition and a combination of special features, including expert knowledge (e.g. intact peat wetlands, presence of rare plants and animals, etc.) and available spatial data on the occurrence of threatened frogs and wetland-dependent birds, each of the wetlands within the inventory were ranked in terms of their biodiversity importance and as such, Wetland FEPA's were identified in an effort to achieve biodiversity targets (Driver et al., 2011). Table 3-7 below indicates the criteria that were considered for the ranking of each of these wetland areas.

Table 3-7: NFEPA Wetland Classification Ranking criteria

NFEPA Wetland Criteria	NFEPA Rank
Wetlands that intersect with a RAMSAR site.	1
Wetlands within 500 m of an IUCN threatened frog point locality; Wetlands within 500 m of a threatened water bird point locality; Wetlands (excluding dams) with the majority of their area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes; Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional Biodiversity importance, with valid reasons documented; and Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose.	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of biodiversity importance, but with no valid reasons documented.	3
Wetlands (excluding dams) in A or B condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion); and Wetlands in C condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion).	4
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing Impacted Working for Wetland sites.	5
Any other wetland (excluding dams).	6

The identified wetlands within the landscape comprise of bench flat wetlands and seep wetlands (Figure 3-4), although these were mostly identified as dams during the field survey. The identified 'wetlands' are categorised as Rank 6.

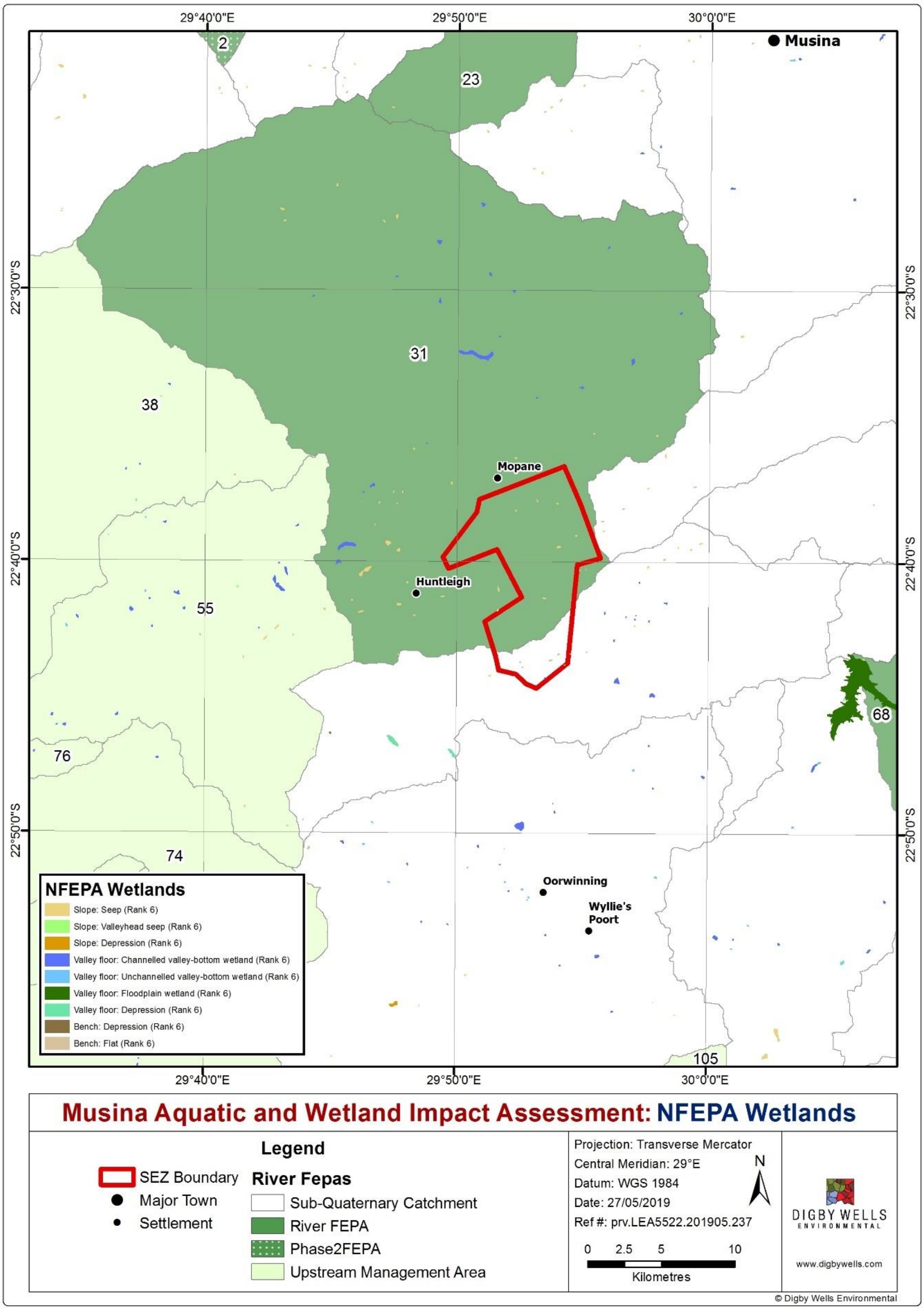


Figure 3-3: FEPA catchment areas and FEPA wetlands

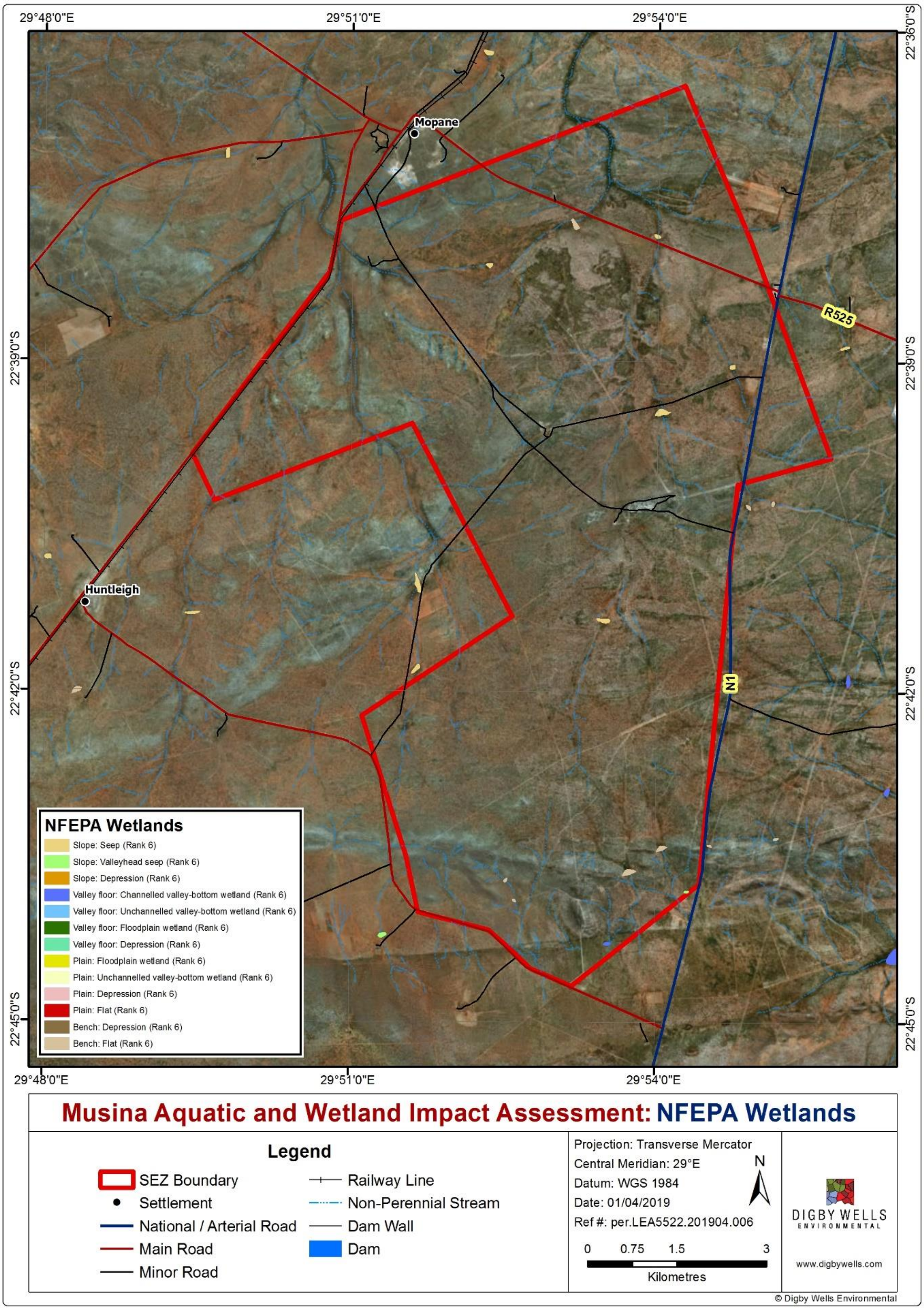


Figure 3-4: NFEPA Wetlands

3.3.2 The Limpopo C-Plan

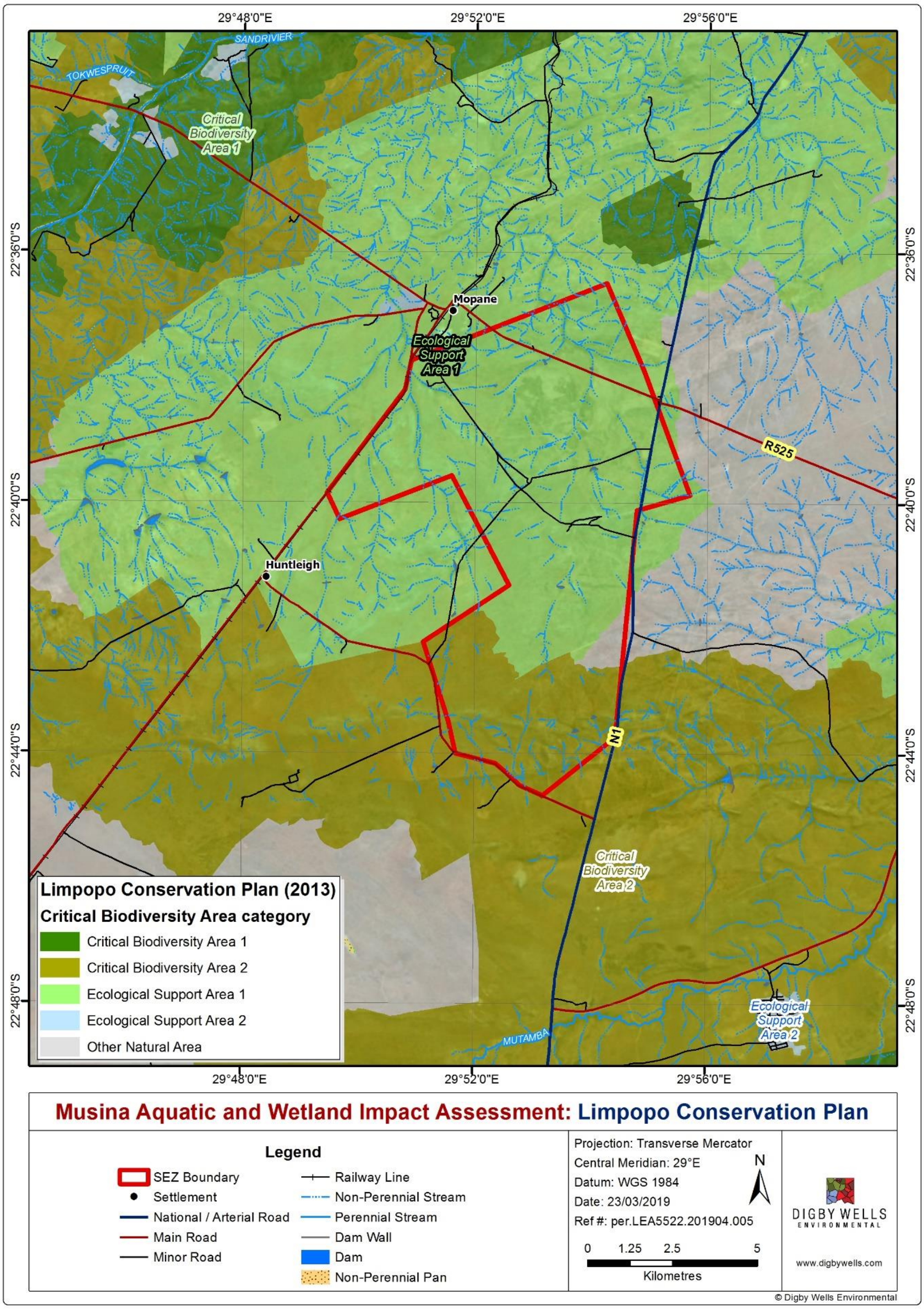
To facilitate biodiversity conservation within provincial priority areas outside the protected area network, a bioregional plan is developed to inform land-use planning, environmental assessment and authorisations, and natural resource management (Desmet, Holness, Skowno, & Egan, 2013). In light of this, the purpose of the Limpopo Conservation Plan was to develop the spatial component of the provincial bioregional plan, which was revised to Version 2, by developing and executing a quantitative systematic spatial biodiversity planning methodology that:

- Addresses the deficiencies of the original provincial plan (i.e. Version 1);
- Takes into account the most up-to-date spatial data and institutional and expert knowledge;
- Aligns the methods and terminology of the plan with the national guidelines for the development of bioregional plans (Government Gazette No.32006, 16 March 2009);
- Takes into account existing spatial biodiversity planning products; and
- Involves skills transfer through working with LEDET staff on the development of the Critical Biodiversity Area (CBA) map and Gap analysis.

The purpose of a conservation plan is to inform land-use planning, environmental assessments and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. The important biodiversity areas for the Limpopo C-Plan are defined and summarised below:

- **Protected Areas:** Formal Protected Areas and Protected Areas pending declaration under National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003) (NEMPA);
- **Critical Biodiversity Area 1:** Irreplaceable sites. Areas required for biodiversity pattern and/or ecological process targets. No alternative sites are available;
- **Critical Biodiversity Area 2:** Best Design Selected sites. Areas selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets;
- **Ecological Support Areas 1**: Natural, near natural and degraded areas supporting CBAs by maintaining ecological processes;
- **Ecological Support Areas 2:** Areas with no natural habitat that are important for supporting ecological processes; and
- **Other Natural Areas:** Natural and intact but not required to meet targets, or identified as CBA or Ecological Support Area (ESA).

Based on these primary outputs, the SEZ falls predominantly within the area classified as ESA1 as well as CBA2 with a small portion as “other natural areas” (Figure 3-5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29°52'0"E
29°56'0"E
22°36'0"S
22°40'0"S
22°44'0"S
22°48'0"S
SANDRIVIER
TOKWESPRUIT
Critical Biodiversity Area 1
Mopane
Ecological Support Area 1
R525
Huntleigh
N1
Critical Biodiversity Area 2
MUTAMBA
Ecological Support Area 2
Limpopo Conservation Plan (2013)
Critical Biodiversity Area category
Critical Biodiversity Area 1
Critical Biodiversity Area 2
Ecological Support Area 1
Ecological Support Area 2
Other Natural Area
Musina Aquatic and Wetland Impact Assessment: Limpopo Conservation Plan
Legend
SEZ Boundary
Settlement
National / Arterial Road
Main Road
Minor Road
Railway Line
Non-Perennial Stream
Perennial Stream
Dam Wall
Dam
Non-Perennial Pan
Projection: Transverse Mercator
Central Meridian: 29°E
Datum: WGS 1984
Date: 23/03/2019
Ref #: per.LEA5522.201904.005
N
0 1.25 2.5 5
Kilometres
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Figure 3-5).

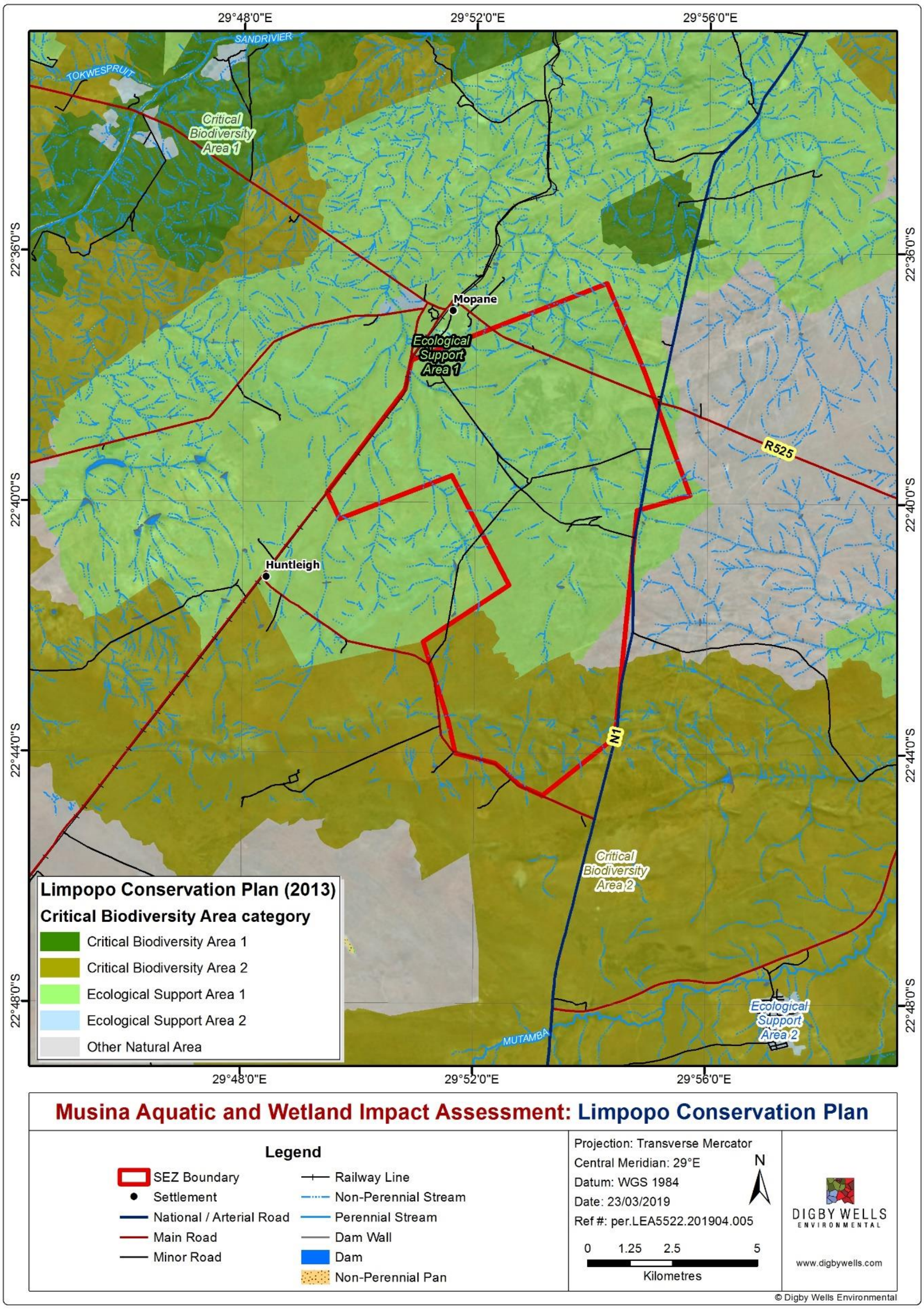


Figure 3-5: Limpopo C-Plan Critical Biodiversity Areas

4 Methodology

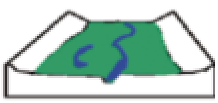
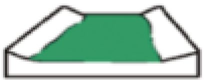
4.1 Wetland Ecology Assessment Approach

The following sections describe the methodology that was adopted during the wetland ecology field assessment.

4.1.1 The Wetland Identification and Classification

In accordance with the guidelines provided by the Department of Water and Sanitation (DWS, formerly known as the Department of Water Affairs and Forestry), wetlands are identified and classified into various Hydro-geomorphic (HGM) Units based on their individual characteristics (DWAF, 2005). The HGM Unit system of classification focuses on the hydro-geomorphic setting of wetlands which incorporates geomorphology; water movement into, through and out of the wetland; and landscape / topographic setting. Once wetlands have been identified, they are categorised into HGM Units as shown in Table 4-1.

Table 4-1: Description of the various HGM Units for Wetland Classification

Hydromorphic wetland type	Diagram	Description
Floodplain		Valley bottom areas with a well-defined stream channel stream channel, gently sloped and characterised by floodplain features such as oxbow depression and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by the net loss of sediment. Water inputs from the main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.

Hydromorphic wetland type	Diagram	Description
Isolated hillslope seepage		Slopes on hillsides that are characterised by colluvial transport (transported by gravity) movement of materials. Water inputs are from sub-surface flow and outflow either very limited or through diffuse sub-surface flow but with no direct link to a surface water channel.
Pan/Depression		A basin-shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. It is inward draining). It may also receive subsurface water. An outlet is usually absent and so this type of wetland is usually isolated from the stream network.

4.1.1.1 Soil Form Indicator

Hydromorphic soils are taken into account for the Soil Form Indicator (SFI), which will display unique characteristics resulting from prolonged and repeated water saturation (DWAF, 2005). The continued saturation of the soils results in the soils becoming anaerobic and thus resulting in a change of the chemical characteristics of the soil. Iron and manganese are two soil components, which are insoluble under aerobic conditions and become soluble when the soil becomes anaerobic and thus begin to leach out into the soil profile. Iron is one of the most abundant elements in soils and is responsible for the red and brown colours of many soils.

Resulting from the prolonged anaerobic conditions, iron is dissolved out of the soil, and the soil matrix is left a greying, greenish or bluish colour, and is said to be "gleyed". Common in wetlands which are seasonally or temporarily saturated is a fluctuating water table, resulting in alternation between aerobic and anaerobic conditions in the soil (DWAF, 2005). Iron will return to an insoluble state in aerobic conditions, which will result in deposits in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWAF, 2005).

4.1.1.2 Soil Wetness Indicator

In practice, the Soil Wetness Indictor (SWI) is used as the primary indicator (DWAF, 2005). Hydromorphic soils are often identified by the colours of various soil components. The frequency and duration of the soil saturation periods strongly influences the colours of these components. Grey colours become more prominent in the soil matrix the higher the duration and frequency of saturation in a soil profile (DWAF, 2005). A feature of hydromorphic soils are coloured mottles which are usually absent in permanently saturated soils and are most prominent in seasonally saturated soils, and are less abundant in temporarily saturated soils (DWAF, 2005). The hydromorphic soils must display signs of wetness within 50 cm of the soil surface, as this is necessary to support hydrophytic vegetation.

4.1.1.3 Vegetation Indicator

Plant communities undergo distinct changes in species composition along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas. Valuable information for determining the wetland boundary and wetness zone is derived from the change in species composition. A supplementary method for employing vegetation as an indicator is to use the broad classification of the wetland plants according to their occurrence in the wetlands and wetness zones (DWAF, 2005). This is summarised in Table 4-2 below.

Table 4-2: Classification of Plant Species According to Occurrence in Wetlands

Type	Description
Obligate Wetland species (OW)	Almost always grow in wetlands: >99% of occurrences.
Facultative Wetland species (FW)	Usually grow in wetlands but occasionally are found in non-wetland areas: 67 – 99 % of occurrences.
Facultative species (F)	Are equally likely to grow in wetlands and non-wetland areas: 34 – 66% of occurrences.
Facultative dry-land species (FD)	Usually grow in non-wetland areas but sometimes grow in wetlands: 1 – 34% of occurrences.

(Source: DWAF, 2005)

When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWAF, 2005). Areas where soils are a poor indicator (black clay, vertic soils), vegetation (as well as topographical setting) is relied on to a greater extent and the use of the wetland species classification as per Table 4-2 becomes more important. If vegetation was to be used as a primary indicator, undisturbed conditions and expert knowledge are required (DWAF, 2005). Due to this uncertainty, greater emphasis is often placed on the SWI to delineate wetland areas.

In this assessment, where possible, the SWI has been relied upon to delineate wetland areas due to the high level of anthropogenic impacts characterising the wetlands and freshwater resources of the general area. The identification of indicator vegetation species and the use of plant community structures have been used to validate these boundaries.

4.1.2 Wetland Ecological Health Assessment (WET-Health)

According to Macfarlane, Kotze, & Ellery (2009) the health of a wetland can be defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. Due to the large size of the study area, a level 1 WET-Health assessment was done to determine the integrity (health) of the characterised HGM units within the study area, in accordance with the method described by Macfarlane et al. (2009). A Present Ecological State (PES) analysis was conducted to establish baseline integrity (or ecological health) for the associated wetlands. The health assessment attempts to evaluate the hydrological, geomorphological and vegetation health in three separate modules to attempt to estimate similarity to (or deviation from) natural conditions.

Central to WET-Health is the characterisation of HGM Units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), and the pattern of water flow through the wetland unit (diffusely or channelled).

The overall approach is to quantify the impacts of human activity (including both obvious and perceived disturbances) on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of the impact of individual activities and then separately assessing the *intensity* of the impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact, which is then classified into the Present State categories provided in Table 4-3 (Macfarlane et al., 2009).

Table 4-3: Impact Scores and Present Ecological State Categories for WET-Health

Impact Category	Description	Combined Impact Score	PES Category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota has taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Critical	Modifications have reached a critical level and ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 4-4, Macfarlane et al., 2009).

Table 4-4: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland

Change Class	Description	HGM change score	Symbol
Substantial improvement	State is likely to improve substantially over the next 5 years	2	↑↑
Slight improvement	State is likely to improve slightly over the next 5 years	1	↑
Remain stable	State is likely to remain stable over the next 5 years	0	→
Slight deterioration	State is likely to deteriorate slightly over the next 5 years	-1	↓
Substantial deterioration	State is expected to deteriorate substantially over the next 5 years	-2	↓↓

Once all HGM Units have been assessed, a summary of health for the wetland as a whole needs to be calculated. This is achieved by calculating a combined score for each component by area-weighting the scores calculated for each HGM Unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provide a summary of impacts, Present State, Trajectory of Change and Health for individual HGM Units and for the entire wetland.

4.1.3 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) tool was derived to assess the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The purpose of assessing importance and sensitivity of water resources is to be able to identify those systems that provide higher than average ecosystem services, biodiversity support functions or are especially sensitive to impacts. Water resources with higher ecological importance may require managing such water resources in a better condition than the present to ensure the continued provision of ecosystem benefits in the long term.

The methodology outlined in Rountree, Malan, & Weston (2013) was used for this study. In this method there are three suites of importance criteria; namely:

- **Ecological Importance and Sensitivity:** incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWA 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 or freshwater resource may provide; and

- **Importance in terms of Basic Human Benefits:** this suite of criteria considers the subsistence uses and cultural benefits of the wetland or freshwater system.

These determinants are assessed for the wetlands and the freshwater resources present on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. It is recommended that the highest of these three suites of scores be used to determine the overall Importance and Sensitivity category of the wetland or freshwater system, as defined in Table 4-5 (Rountree et al., 2013).

Table 4-5: Interpretation of overall Ecological Importance and Sensitivity (EIS) scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Scores
Very high	
Wetlands that are considered ecologically important and sensitive on a national or even 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.	>3 and <=4
High	
Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
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.	>1 and <=2
Low/marginal	
Wetlands that 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.	>0 and <=1

4.1.4 Buffers

Wetland buffers are generally required by the DWS, particularly for Water Use Licence applications where wetland areas will or may be negatively impacted by a specific activity. A guideline was developed; ‘Buffer Zone Guidelines for Wetlands, Rivers and Estuaries’, (Macfarlane & Bredin, 2017), which was applied to this Project to assist in determining buffers (or zones of exclusion) for the identified wetlands on site. However; buffer determination must also rely on professional opinion of a qualified specialist, which would need to assess each specific area on a case-by-case basis.

For the application of the guideline, data is inserted into a series of excel-based Buffer Zone Tools, which then provides the buffer zone requirements for a particular activity at a particular site. The excel spreadsheets then informs a buffer model, which is populated automatically from the data capture sheets provided. Further to this, the guideline provides a list of land-use sectors used to evaluate the threat of the proposed activities, which informs the mitigation measures to be applied. The main sectors include agriculture, industry, mixed use/commercial/retail/business, civic and social, residential, open space, transportation, service infrastructure and mining. These sector and sub-sectors play a role in the buffer width outcomes.

4.2 Aquatic Ecology Assessment Approach

The following sections describe the methodology that was adopted during the aquatic (or instream) ecology field assessment.

4.2.1 Selection of Sampling Sites

In an effort to identify trends regarding the occurrence of species present within the watercourses associated with the project area, as well as provide a comparative basis for which future impacts can be evaluated, a number of sampling sites were selected based on accessibility, availability of sampling habitat and in relative proximity to associated potential impacts originating from the study area.

Co-ordinates of the sampling sites utilised during this investigation were determined using a Garmin global positioning device (GPS) and a visual assessment of each site was carried out to aid in the interpretation of the data collected.

4.2.2 Water Quality Parameters

Selected *in situ* water quality variables were measured at each of the selected sampling sites using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter and an ExStik DO600 Dissolved Oxygen Meter. Temperature, pH, electrical conductivity and dissolved oxygen were recorded prior to sampling, while the time of day at which the measurements were assessed was also noted for interpretation purposes.

The water quality objectives as stipulated within the Target Water Quality Range (TWQR), as described in (Department of Water Affairs and Forestry, 1996) were utilised as guidelines for this assessment.

4.2.3 Index of Habitat Integrity, Version 2

The Index of Habitat Integrity (Version 2, Kleynhans, C.J., pers. comm., 2015) (IHI-96-2) aims to assess the number and severity of anthropogenic perturbations along a river/stream/wetland and the potential inflictions of damage toward the habitat integrity of the system (Dallas, 2005). Various abiotic (e.g. water abstraction, weirs, dams, pollution, dumping of rubble, etc.) and biotic (e.g. presence of alien plants and aquatic animals, etc.) factors are assessed, which represent some of the most important and easily quantifiable, anthropogenic impacts upon the system (Table 4-6).

As per the original IHI approach (C. J. Kleynhans, 1996), the instream and riparian components were each analysed separately to yield two separate ecological conditions (i.e. Instream and Riparian components). However, it should be noted that the data for the riparian area is primarily interpreted in terms of the potential impact upon the instream component and as a result, may be skewed by a potentially deteriorated instream condition.

Table 4-6: Descriptions of criteria used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Metric	Relevance
Water abstraction	Direct impact upon habitat type, abundance and size. Also impacted in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in the temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included
Water quality modification	Originates from point and diffuse sources. Measured directly, or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Alien/Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Alien/Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.

Metric	Relevance
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

While the recently upgraded index (i.e. IHI-96-2; Dr. C. J. Kleynhans, pers. comm., 2015) replaces the aforementioned comprehensive and expensive IHI assessment model developed by Kleynhans (1996), it is important to note that the IHI-96-2 does not replace the IHI model developed by Kleynhans et al. (2008a), which is recommended in instances where an abundance of data is available (e.g. intermediate and comprehensive Reserve Determinations). Accordingly, the IHI-96-2 model is typically applied in cases where relatively few river reaches need to be assessed, the budget and time provisions are limited, and/or any detailed available information is lacking (i.e. rapid Reserve Determinations and for REMP/RHP purposes).

In accordance with the magnitude of the impact created by the abovementioned criterion, the assessment of the severity of the modifications was based on six descriptive categories/ratings (Table 4-6):

- 0 (no impact);
- 1 to 5 (small impact);
- 6 to 10 (moderate impact);
- 11 to 15 (large impact);
- 16 to 20 (serious impact); and
- 21 to 25 (critical impact).

Based on available knowledge of the site and/or adjacent catchment, a confidence level (high, medium, low) was assigned to each of the scored metrics.

Given the subjective nature of the scoring procedure utilised within the general approach to habitat integrity assessment (including IHI-96-2), the most recent version of the IHI application (Kleynhans et al., 2008) and the Model Photo Guides (Graham & Louw, 2008) were used to calibrate the severity of the scoring system. It should be noted that the assessment was limited to observed and/or suspected impacts present within the immediate vicinity of the delineated assessment units, as determined through the use of aerial photography (e.g. Google Earth) and observations made at each of the assessed sampling points during the field survey. However, in cases where major upstream impacts (e.g. construction of a dam, major water abstraction, etc.) were confirmed, potential impacts within relevant sections were considered and accounted for within the application of the method.

Table 4-7: Descriptive of scoring guidelines for the assessment of modifications to habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Impact Category	Description	Score
None	No discernible impact or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.	0
Small	The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 - 5
Moderate	The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6 - 10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced	11 - 15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability of almost the whole of the defined section are affected. Only small areas are not influenced.	16 - 20
Critical	The modification is present overall with a high intensity; the habitat quality, diversity, size and variability in almost the whole of the defined section are detrimentally influenced.	21 - 25

Each of the allocated scores was then moderated by a weighting system (Table 4-8), which is based on the relative threat of the impact to the habitat integrity of the riverine system. The total score for each impact is equal to the assigned score multiplied by the weight of that impact. The estimated impacts (assigned score / maximum score [25] X allocated weighting) of all criteria are then summed together, expressed as a percentage and then subtracted from 100 to determine the Present Ecological State score (PES; or Ecological Category) for the instream and riparian components, respectively.

In cases where selected instream component criteria (i.e. water abstraction, flow, bed and channel modification, water quality and inundation) and/or any of the riparian component criteria exceeded ratings of large, serious or critical, an additional negative weight was applied. The aim of this is to accommodate the possible cumulative effect (and integrated) negative effects of such impacts (Kemper, 1999). The following rules were applied in this respect:

- Impact = Large, lower the integrity status by 33% of the weight for each criterion with such a rating.
- Impact = Serious, lower the integrity status by 67% of the weight for each criterion with such a rating.

- Impact = Critical, lower the integrity status by 100% of the weight for each criterion with such a rating.

Table 4-8: Criteria and weightings used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality modification	14	Water abstraction	13
Inundation	10	Inundation	11
Alien/Exotic macrophytes	9	Flow modification	12
Alien/Exotic aquatic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**	**TOTAL**	**100**

Subsequently, the negative weights were added for both instream and riparian components of the assessment and the total additional negative weight subtracted from the provisionally determined integrity to arrive at a final habitat integrity estimate (Kemper, 1999). The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific habitat integrity ecological category (Table 4-9).

Table 4-9: Ecological Categories for the habitat integrity scores (Kleynhans, 1999a; cited in Dallas, 2005)

Ecological Category	Description	Score (% of Total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and there has been an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 - 19

4.2.4 Invertebrate Habitat Assessment System, Version 2.2

Assessment of the available habitat for aquatic macroinvertebrate colonisation at each of the sampling sites is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with the South African Scoring System, Version 5 (SASS5) as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorized according to the values in Table 4-7.

However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until further studies have been conducted (Ollis, Boucher, Dallas, & Esler, 2006). In the interim and for the purpose of this assessment, the IHAS method was adapted by excluding the assessment of the *general stream characteristics*, which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned table.

Table 4-10: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

IHAS Score (%)	Description
>75	**Excellent**
65-74	**Good**
55-64	**Adequate / Fair**
<55	**Poor**

4.2.5 South African Scoring System, Version 5

While there are a number of indicator organisms that are used within these assessment indices, there is a general consensus that benthic macroinvertebrates are amongst the most sensitive components of the aquatic ecosystem. This was further supported by their largely non-mobile (or limited mobility) within reaches of associated watercourses, which also allows for the spatial analysis of disturbances potentially present within the adjacent catchment area. However, it should also be noted that their heterogeneous distribution within the water resource is a major limitation, as this results in spatial and temporal variability within the collected macroinvertebrate assemblages (Dallas & Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates collected on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (Dallas, 1997). However, the method relies on a standardised sampling technique using a handheld net (300 mm x 300 mm, 1000 micron mesh size) within each of the various habitats available for standardised sampling times and/or areas. Niche habitats (or biotopes) sampled during SASS5 application include:

- Stones (both in-current and out-of-current);
- Vegetation (both aquatic and marginal); and
- Gravel, sand and mud.

Once collection is complete, aquatic macroinvertebrates are identified to family level and a number of assemblage-specific parameters are calculated including the total SASS5 score, the number of taxa collected, and the Average Score per Taxa i.e. SASS5 score divided by the total number of taxa identified (Davies & Day, 1998; Dickens & Graham, 2002; Gerber & Gabriel, 2002; C. A. Thirion, Mocke, & Woest, 1995). The SASS5 assessment index has been proven to be an effective and efficient means to assess water quality impairment and general river health (Chutter, 1998; Dallas, 1997).

4.2.6 Macroinvertebrate Response Assessment Index (MIRAI)

To determine the PES (or Ecological Category) of the aquatic macroinvertebrates collected/observed, the SASS5 data is used as a basic input (i.e. prevalence and abundance) into the improved MIRAI (Version 2, Thirion. C., *pers. comm.*, 2015). This biological index integrates the ecological requirements of the macroinvertebrate taxa in a community (or assemblage) and their response to flow modification, habitat change, water quality impairment and/or seasonality (C. Thirion, 2008). The presence and abundance of aquatic macroinvertebrates are compared to a derived list of families/taxa that are expected to be present under natural, un-impacted conditions. Consequently, the aforementioned metric groups were combined within the model to derive the ecological condition of the site in terms of aquatic macroinvertebrates (Table 4-11).

Table 4-11: Allocation protocol for the determination of the Present Ecological State for aquatic macroinvertebrates following application of the MIRAI

MIRAI (%)	Ecological Category	Description
90-100	**A**	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	**B**	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	**C**	Moderately modified. Community structure and function are less than the reference condition. Community composition is lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	**D**	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	**E**	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	**F**	Critically modified. Few species present. Only tolerant species present, if any.

4.2.7 Fish Response Assessment Index

Assessment of the Present Ecological State (PES; or Ecological Category) of the fish assemblage of the watercourses associated with the proposed project area was conducted by means of the FRAI (Kleynhans, 2008). This procedure is an integration of ecological requirements of fish species in an assemblage and their derived (or observed) responses to modified habitat conditions. In the case of the present assessment, the observed response was determined by means of fish sampling, as well as a consideration of species requirements and driver changes (Kleynhans, 2008). The expected fish species assemblage within the study area was derived from (C. J. Kleynhans, Louw, & Moolman, 2008) and aquatic habitat sampled.

Although the FRAI uses essentially the same information as the Fish Assemblage Integrity Index (FAII), it does not follow the same procedure. The FAII was developed for application in the broad synoptic assessment required for the River Health Programme, and subsequently does not offer a particularly strong cause-and-effect basis. The purpose of the FRAI, on the other hand, is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblage from the perceived reference condition(C. J. Kleynhans, 2008a).

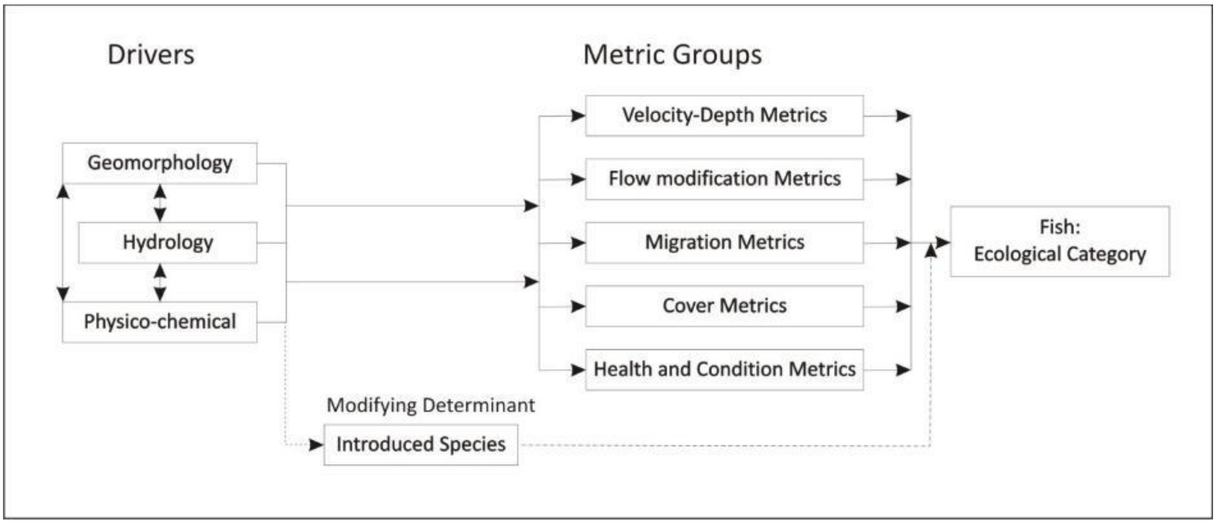


Figure 4-1: Relationship between drivers and fish metric groups

The FRAI is based on the assessment of a number of metrics within metric groups, which are assessed in terms of:

- Habitat changes (observed/derived);
- The impact of such habitat changes on species with particular preferences and tolerances; and
- The relationship between the drivers used in the FRAI and the various fish response metric groups, as are indicated in Figure 4-1. Table 4-12 provides the steps and procedures required for the calculation of the FRAI.

Table 4-12: Main steps and procedures followed in calculating the Fish Response Assessment Index

STEP	PROCEDURE
River section earmarked for assessment	As for study requirements and design
Determine reference fish assemblage: species and frequency of occurrence	• Use historical data & expert knowledge • Model: use ecoregional and other environmental information

	• Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	• Hydrology • Physico-chemical • Geomorphology; or • Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	• Assess fish habitat potential Assess fish habitat condition
Representative fish sampling at site or in river section	• Sample all velocity depth classes per site if feasible • Sample at least three stream sections per site if feasible
Collate and analyse fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	• Rate the FRAI metrics in each metric group • Enter species reference frequency of occurrence data • Enter species observed frequency of occurrence data • Determine weights for the metric groups • Obtain FRAI value and category • Present both modelled FRAI & adjusted FRAI.

Interpretation of the FRAI score follows a descriptive procedure in which the FRAI score is classified into a particular PES (or Ecological Category) based on the aforementioned integrity classes (C. J. Kleynhans, 1999b). Each category describes the generally expected conditions for a specific range of FRAI scores (Table 4-13).

Table 4-13: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) of the sampled/observed fish assemblage following application of the FRAI

FRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

4.2.8 Ecostatus4 1.02 Model

For the purpose of the present assessment, the latest ECOSTATUS4 1.02 model was used, which is an upgraded and refined version of the original ECOSTATUS4 model (Kleynhans & Louw, 2008). The results obtained from the fish and aquatic macroinvertebrate response indices (i.e. FRAI and MIRAI) are to be integrated within the model to determine an Instream Ecological Category, whereas the riparian elements from the IHI-96-2 model can be used as a surrogate for the Riparian Ecological Category in the following manner (Dr. C.J. Kleynhans, pers. comm., 2015):

*Riparian Vegetation EC = 100-(((IHI 'Natural vegetation removal')+(IHI 'Exotic Vegetation Encroachment'))/50*100)*

4.3 Impact Assessment Methodology

Details of the impact assessment methodology used to determine the significance of potential impacts associated with the project are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 4-16. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this EIA/EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 4-15, which is extracted from Table 4-14. The description of the significance ratings is discussed in Table 4-16.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 4-14: Impact Assessment Parameter Ratings

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 4-15: Probability/Consequence Matrix

	Significance																																					
Probability 7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Consequence																																					

Table 4-16: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive)
36 to 72	An important positive impact. The impact is insufficient by itself to justify the implementation of the project. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative)
-36 to -72	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe effects	Moderate (negative)
-109 to -147	A very serious negative impact which may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative)

5 Results and Discussion

5.1 Wetland Ecology Assessment

In March 2019, a site visit was conducted to delineate the wetlands within the project area and determine the current PES and EIS along, as well as identify potential impacts that the proposed development will have on the existing wetland systems.

5.1.1 Wetland Delineation and Classification

Based on the findings of the field assessment, it is evident that the wetlands and freshwater features within the project area consist mostly of pans, ephemeral drainage lines and artificial impoundments (dams; Figure 5-4). The pan or depression wetland HGM setting is described as a basin shaped area with a closed elevation contour that usually is not connected to the drainage network (Ellery *et al*, 2009). Pans can receive water both from surface and groundwater flows, which then accumulates in the depression owing to a generally impervious underlying layer, which prevents the water draining away (Goudie and Thomas, 1985; Marshall and Harmse, 1992). Ephemeral drainage systems were also extensive. These systems are fed by surface flows and only flow at certain times of the year. Additionally, a number of artificial impoundments that lie within drainage lines were also noted and this is attributed to the nature of the land use, which are required for the game farming and cattle grazing practices in such an arid environment.

The systems observed within the Project area are discussed in the sections below.

5.1.1.1 Pans

A total of 17 pans, covering a total area of 1.3 ha were observed within the proposed project area at the time of the assessment. Pans were observed to be largely homogenous within the project area and were relatively small in size. Variances were attributed to land use differences and not vegetation or structure. The majority of pans were bare, with limited grass cover and surrounded by woody vegetation. Few pans were inundated with water at the time of the assessment. Examples of the pans identified within the proposed project area are indicated in Figure 5-1.

Grass species that grow in damp areas were noted within the pans. These include: *Bothriochloa insculpta, Brachiaria deflexa, Echinochloa colona, Digitaria velutina, Eragrostis trichophora* and *Eragrostis rotifer*. Other grass species include: *Aristida adscensionis*, *Cenchrus ciliaris*, *Schmidtia pappophoroides* and *Tragus berteronianus.*

Small trees surrounded the pans, these include *Colophospermum mopane, Terminalia prunioides, Ximenia Americana Vachellia tortilis, Commiphora glandulosa* and a few individuals of *Boscia albitrunca, B. foetida, Combretum apiculatum,* and *Commiphora viminea* with small stands of *Dichrostachys cinerea.*

Figure 5-1: Examples of pans identified within the proposed project area.

5.1.1.2 Drainage lines

An extensive network of drainage lines, covering approximately 296.21 ha, was observed within the proposed project area. These ranged from wide, deep, sandy ephemeral systems to small rocky features in isolated parts of the proposed project area. The addition of dams within drainage lines has resulted in the impoundment of water. The drainage lines had very similar species composition to the pans, with the addition of *Adansonia digitata.* Examples of the drainage lines are indicated in Figure 5-2.

Figure 5-2: Examples of drainage lines identified within the proposed project area.

5.1.1.3 Artificial Impoundments

A number of artificial impoundments were noted within the Project area, amounting to a total area of 6.23 ha. Most of these were inundated with water, but not to a great extent. Utilisation by cattle was high, with cattle being present at almost all of the dams.

Very low graminoid and herbaceous cover was noted around these systems, with high levels of trampling as well as notable deterioration of water quality.

Figure 5-3 illustrates some of the artificial impoundments observed within the Project area.

Figure 5-3: Examples of artificial impoundments identified within the proposed project area.

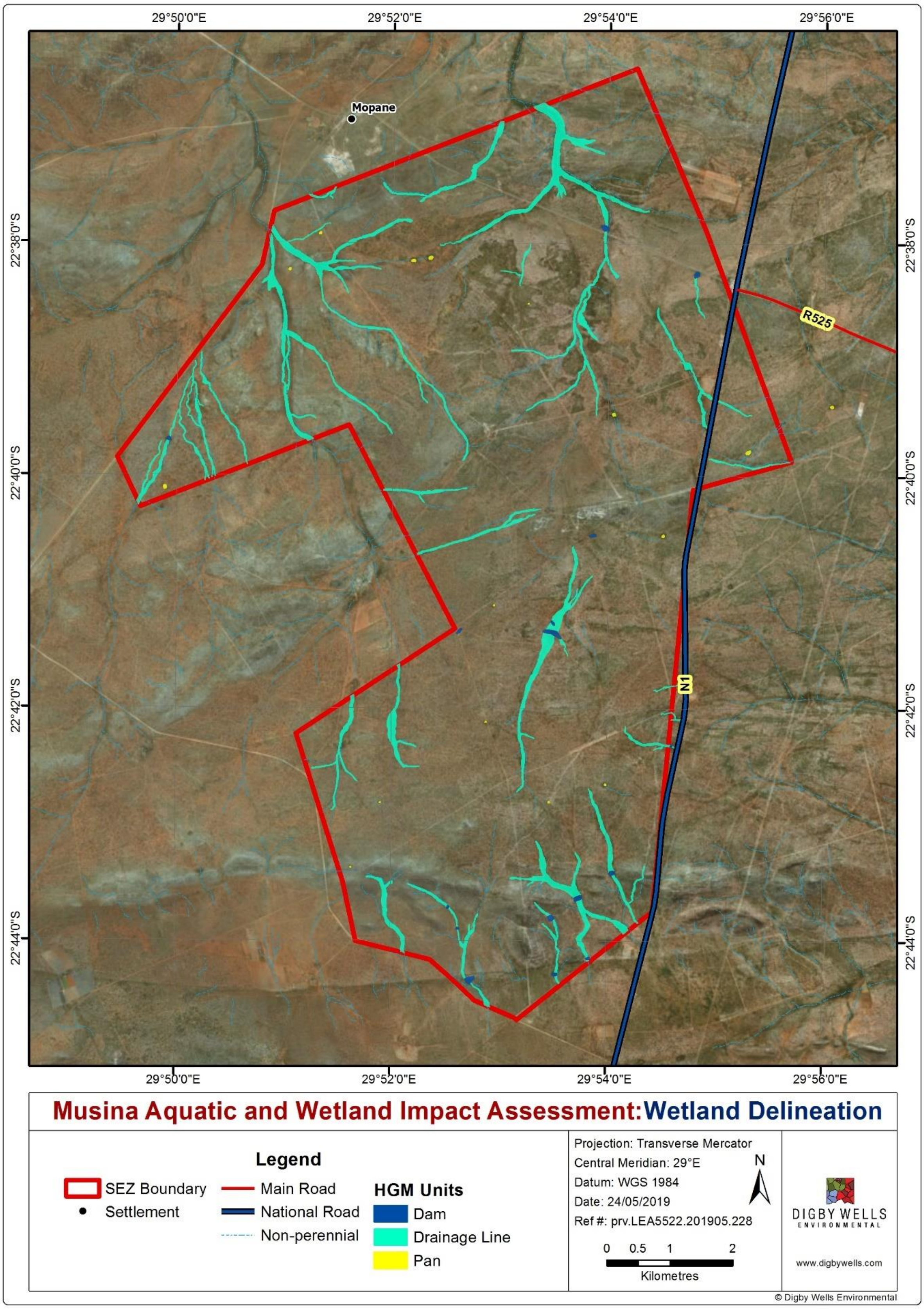


Figure 5-4: Wetland delineation

5.1.2 Sensitivity

Pans were observed to be largely homogenous within the project area. For assessment of sensitivity and health, pans were grouped according to land use practices as that aspect was the only differentiation between the pans. The pans situated on Antrobus 566 (East of N1) were grouped together, as game farming is the current land use. The pans situated on the remainder of the farms were grouped together, as cattle grazing is the current land use.

The relevant tools for wetland assessment used in the determination of PES and EIS calculations are not intended for use in ephemeral systems or artificial systems (dams) and therefore they have not been applied to these systems.

5.1.2.1 Wet-Health

The general features of the identified wetland units within the study area were assessed in terms of impacts to the integrity of these systems. Due to the large number of pans, these were grouped according to the type of land use for assessment purposes (as mentioned above).

The pans categorised as Category A (*Natural*) displayed no visible impacts. This was attributed to general access restrictions on the farm portion (ANTROBUS 566 – East of N1) on which these pans were observed. This is due to the private access of the game reserve.

The main impacts associated with the pans categorised as Category B (*Largely natural*) included heavy grazing activities (remainder of the farms and portions to the west of the N1). Cattle-grazing activities were observed to have resulted in impacts such as overgrazing, trampling and erosion. Furthermore, impacts to water quality of the wetlands associated with the site were expected. These activities have resulted in increased sedimentation of the systems due to an increased extent of exposed substrate. Sedimentation alters the natural hydrological and geomorphological functioning of the wetlands and may have had an impact on aquatic life. The impaired water quality may also have resulted from additional loading of phosphates due to the presence of cattle and game.

The PES values are tabulated in Table 5-1 and illustrated in Figure 5-5.

Table 5-1: Present Ecological Health Scores

HGM Unit	Hydrological Health Score	Geomorphological Health Score	Vegetation Health Score	Ecological Health Score	PES Score
Pans (ANTROBUS 566 – East of N1)	0	0.1	1.3	0.39	A
Pans (All remaining farms)	1	0.4	3.4	1.51	B

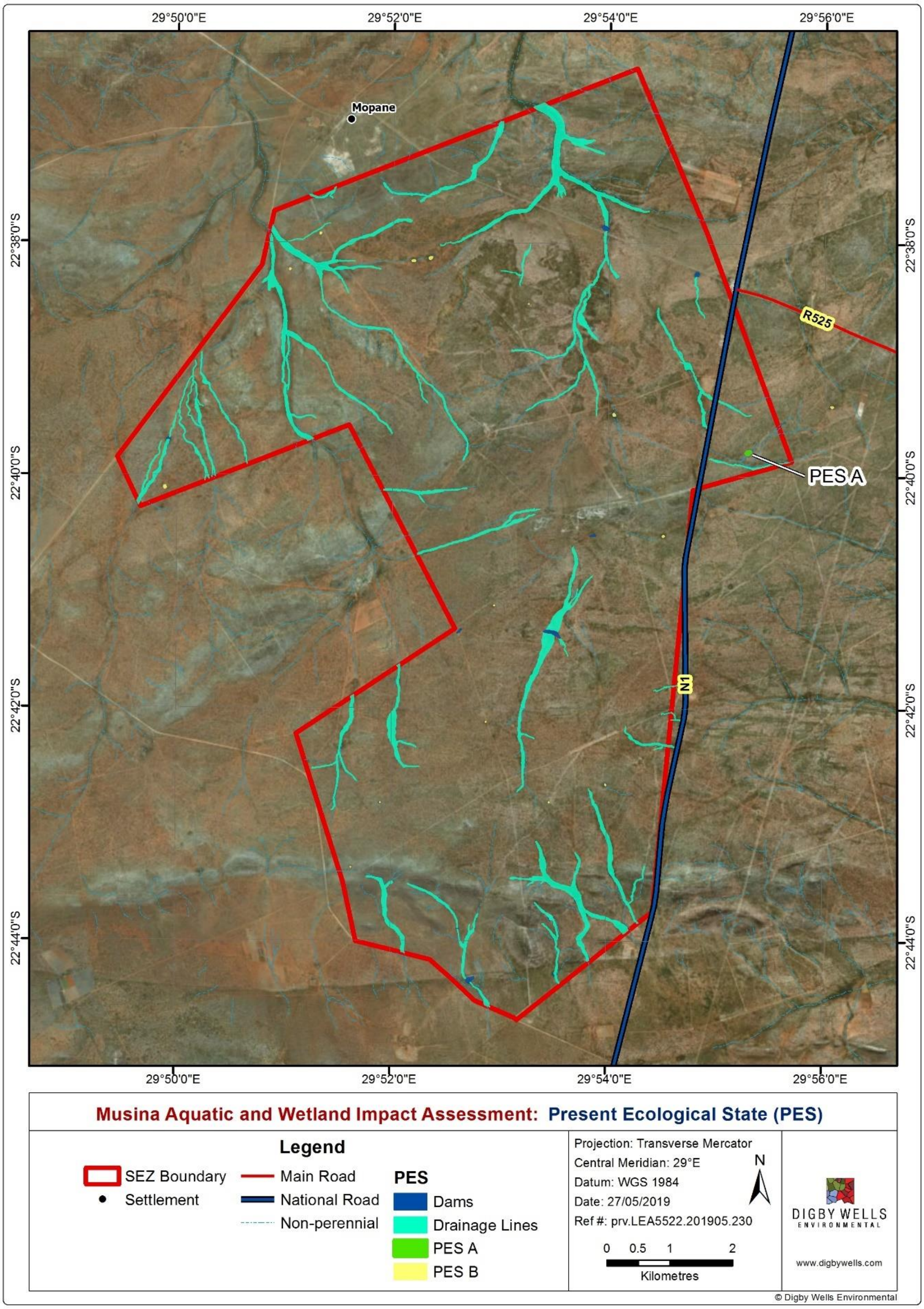


Figure 5-5: PES values

5.1.2.2 Ecological Importance and Sensitivity

The majority of the pans achieved high biodiversity scores, as they were observed to provide habitat for various plant and animal species. Most notably, a number of branchiopod crustaceans, which are specially adapted to temporary systems such as pans, were observed to occur within these systems, which has increased the ecological importance of these pans (discussed in detail in Section 5.2.5).

Hydrological importance values were low due to the nature of the HGM unit type. The isolation of pans from stream networks results in limited flood attenuation and streamflow regulation abilities. In non-perennial pans, such as the ones encountered in the Project area, some of the salts and nutrients that have accumulated over time within the pans (such as organic nitrogen, and various phosphate and sulphate salts) can be transported by wind, out of the system, and be deposited on the surrounding areas, altering the nutrient cycles (Kotze, Marneweck, Batchelor, Lindley, & Collins, 2005)

Direct human benefits were moderate. The pans on Farm Antrobus 566 (East of N1) have tourism benefits, as well as water for animals, whereas the remainder of the farms are utilised for cattle watering and grazing.

The final EIS scores were *High* (2.3-2.4).

Table 5-2 indicates the EIS scores for the various HGM Units with EIS scores represented visually in Figure 5-6

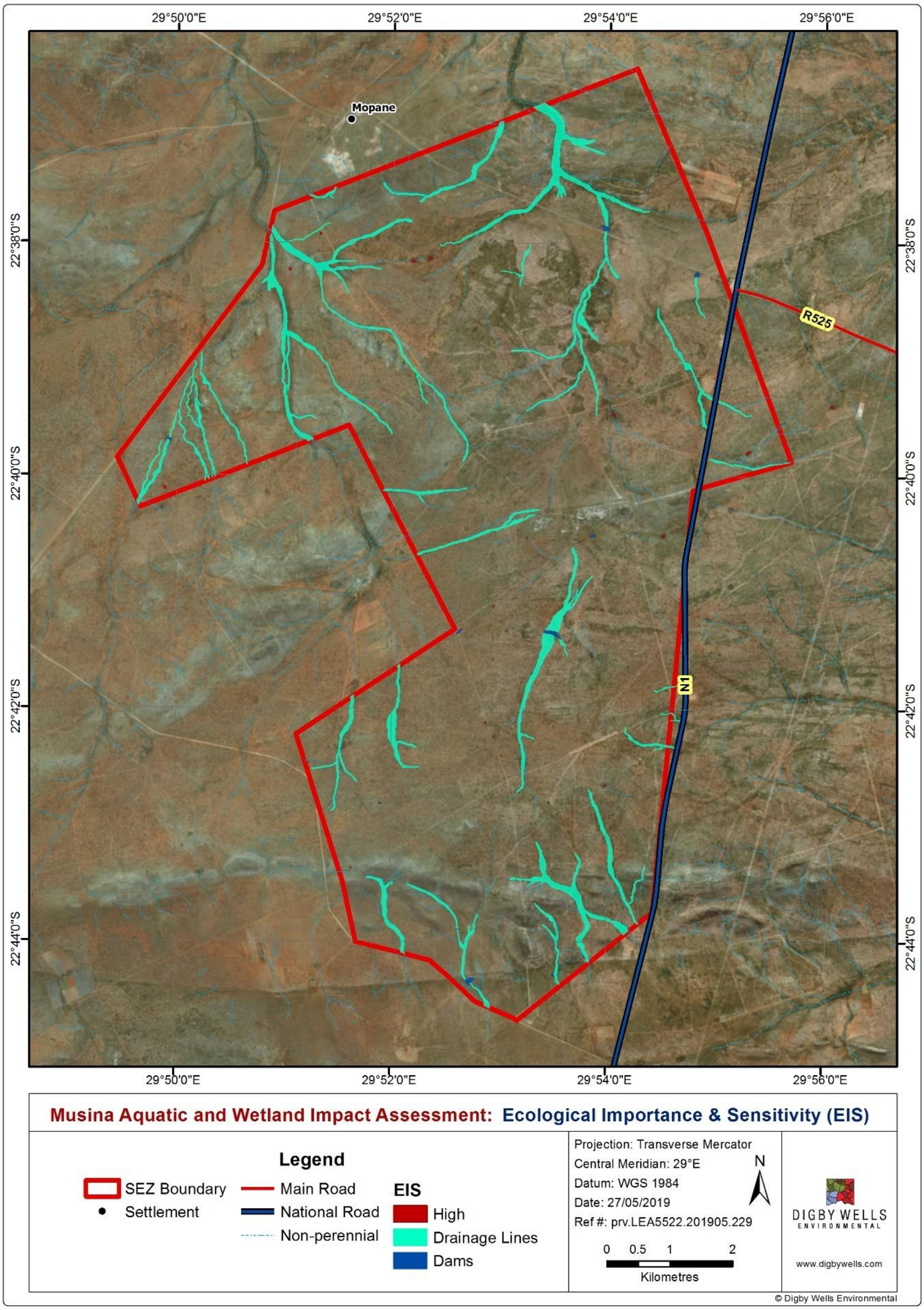


Figure 5-6.

Table 5-2: EIS Scores

HGM Unit	Ecological Importance & Sensitivity	Hydrological/Functional Importance	Direct Human Benefits	Final EIS Score	Final EIS Category
Pans (ANTROBUS 566 – East of N1)	2.4	0.8	0.7	2.4	High
Pans (All remaining farms)	2.3	0.8	1	2.3	High

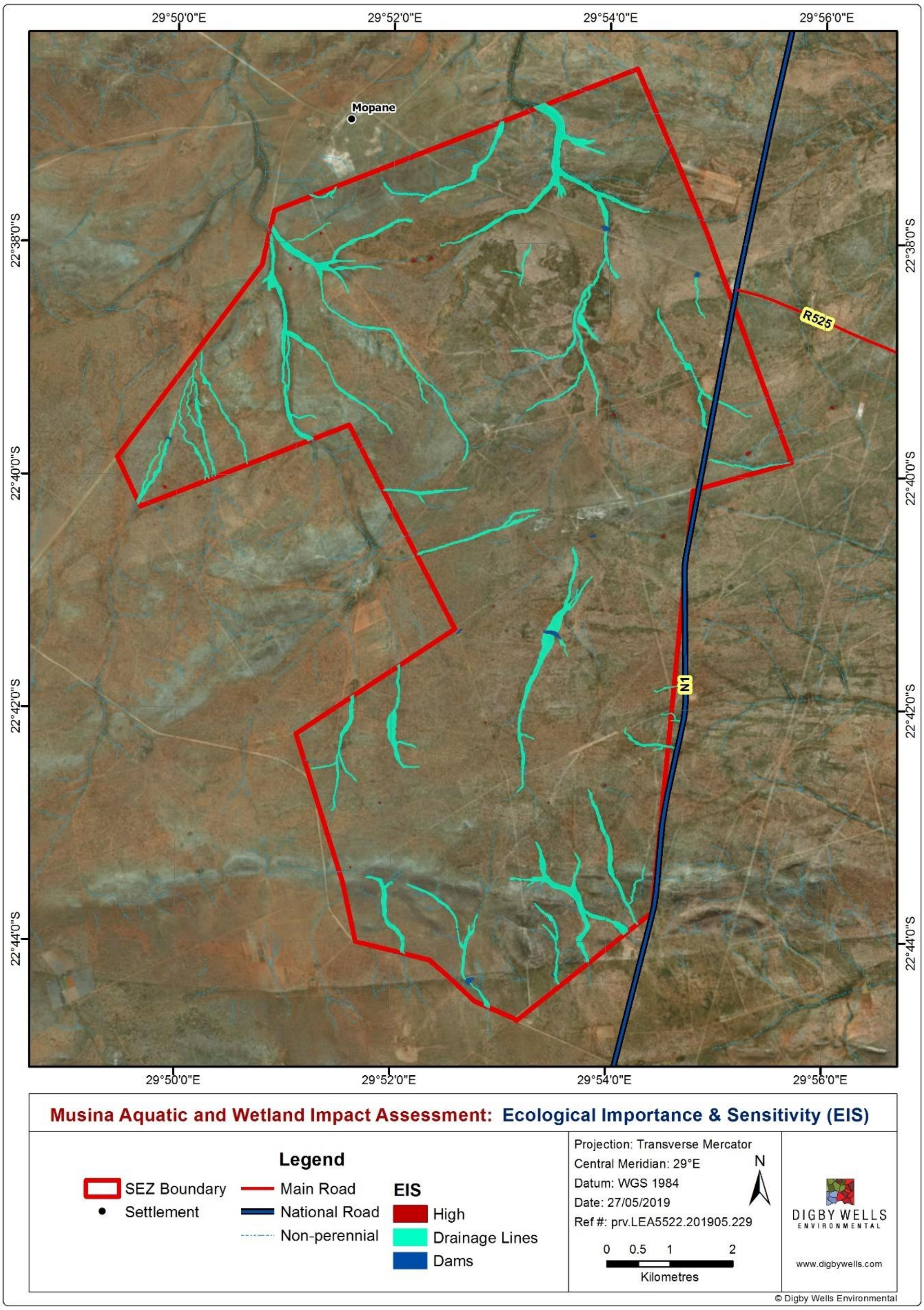


Figure 5-6: EIS values

5.1.3 Buffers

As discussed previously, wetland buffers are generally required by the DWS, particularly for Water Use Licence applications where wetland areas will or may be negatively impacted by a specific activity.

The 'Buffer Zone Guidelines for Wetlands, Rivers and Estuaries' (Macfarlane & Bredin, 2017) was applied to this Project to assist in determining buffers (zones of exclusion) for the identified wetlands within the project area. As this project is industrial in nature, the land use applied to the buffer is that of *Industry*, and the sub-sector *Electricity Generation Works* was then considered. The sector *Mining* was also applied, with the sub-sector being *Plant and Plant Waste from Mining Operations – High Risk Activities* as there are various plants proposed (Ferrochromium, Ferromanganese, Coking coal, Carbide etc.). The application of this sector did not however, alter the buffer width. The wetland buffers calculated for this Project are presented in Table 5-3 and illustrated in Figure 5-7

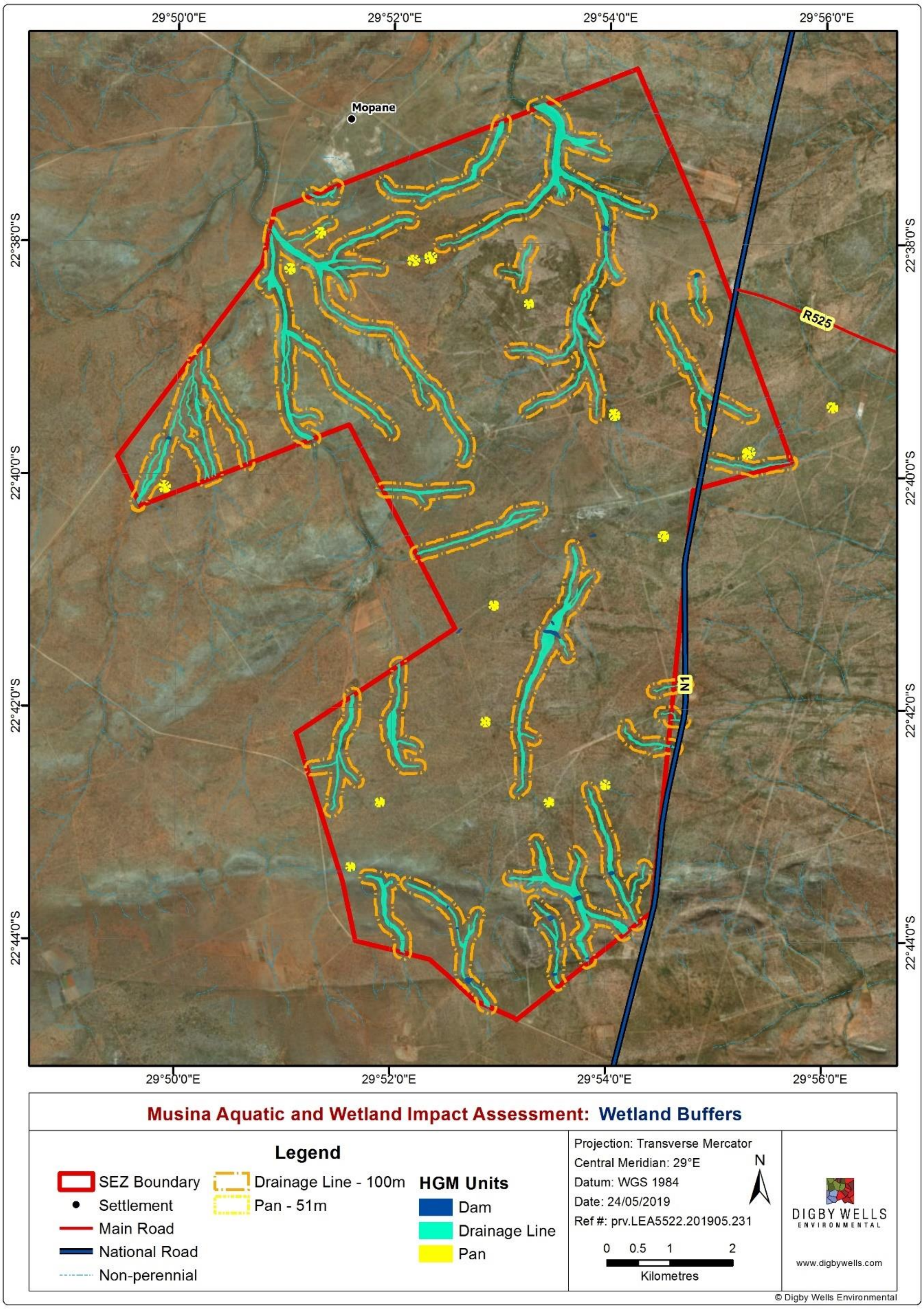


Figure 5-7.

Table 5-3: Buffer widths

HGM Unit	Buffer width (m)
Pans (ANTROBUS 566 – East of N1))	51
Pans (All remaining farms)	51

It is imperative that all activities within the buffer (other than those provided for in an approved Water Use License (WUL)) are prohibited. Wetlands and associated buffers must be clearly demarcated and avoided wherever possible to protect the integrity of the wetlands on site. It is especially important that the buffers are adhered to as the SEZ is situated in a CBA 2 area, as well as an ESA 1 area. Additionally, careful attention must be paid to any infrastructure that is placed on slopes (predominantly in the south of the project area) due to the increased risk for erosion and subsequent sedimentation of systems downstream. It is important to ensure erosion does not take place, thereby increasing sedimentation within the HGM units. If erosion does occur, it is imperative that the erosion is remedied as soon as possible. Mitigation measures have been recommended in the impact assessment section of this report.

The buffer tool was not applied to determine river and drainage line buffers as these are not considered wetlands, but it is suggested that all activity is excluded from within 100 m of any rivers or drainage lines, or from within the 1:100 year floodline. It should be noted that these aquatic impact buffers are measured from the boundary of the active channel of the watercourse and as a result, it may occur within the regulated area of the watercourse (within the riparian area and/or 1:100 year floodline).

In the absence of any pertinent biodiversity concerns identified, such as a rare species with specific habitat requirements, and/or a major hydrological driver exists, these setback requirements should be amended to include these hydrological inputs and any potentially sensitive habitats for species of special concern.

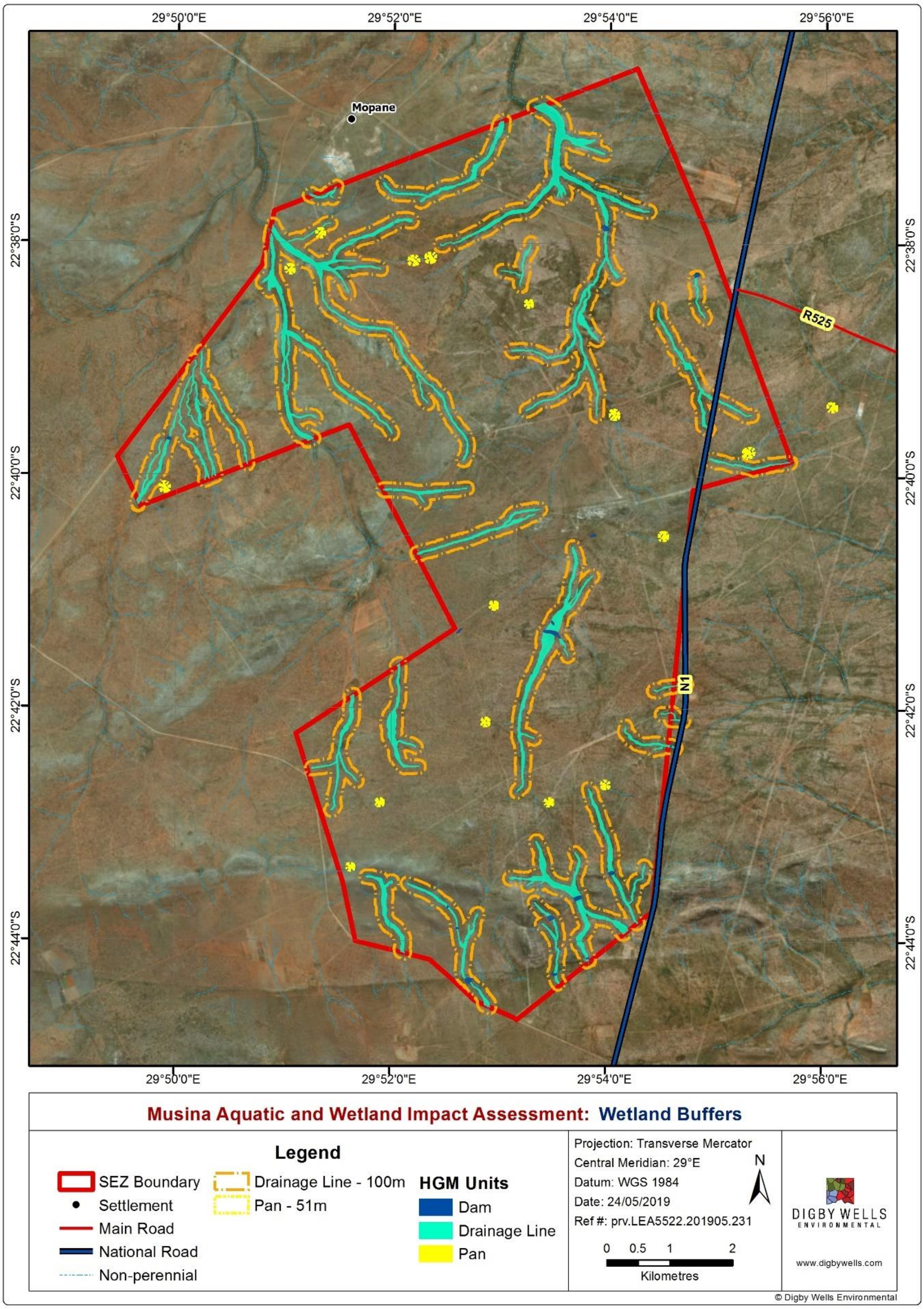


Figure 5-7: Wetland buffers

5.2 Aquatic Ecology Assessment

5.2.1 Site Selection

Co-ordinates of the sampling sites utilised during this investigation (Table 5-4) were determined using a Garmin Global Positioning (GPS) device and are presented

graphically in Figure 5-8

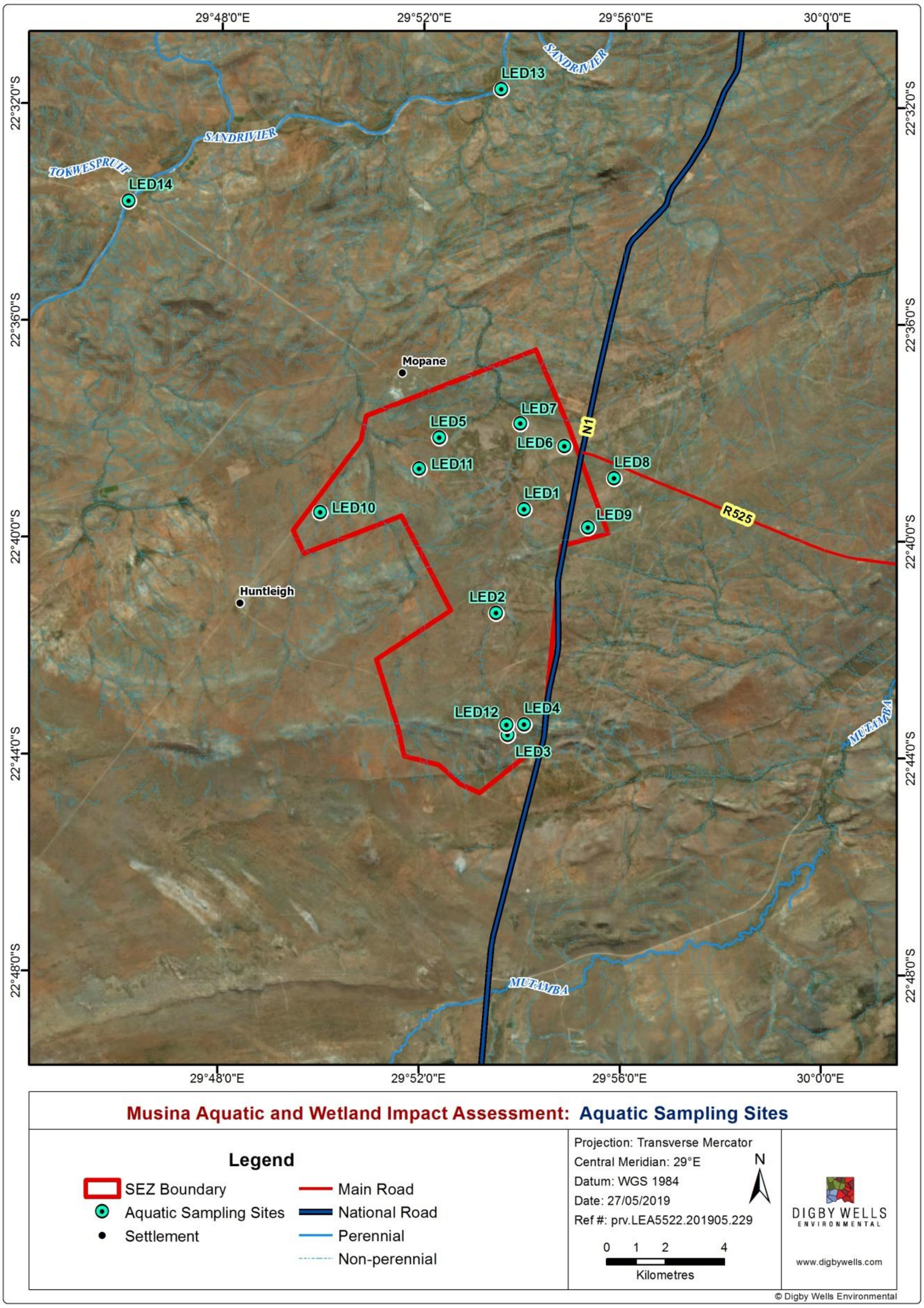


Figure 5-8. Table 5-4 provides a brief description of the characteristics observed at each of the assessment sites, accompanied by a photograph of each.

Table 5-4: Location and description of the aquatic sampling sites assessed

Site	Co-Ordinates	Description
LED1	22°39'27.06"S 29°54'2.39"E	A pan located on the central portion of the Farm Antrobus 566 and within the proposed project area. The site is situated directly south of a small holding and a dam wall has been constructed between the small holding and the pan.
LED2	22°41'21.93"S 29°53'29.40"E	An artificial impoundment located along a relatively large unnamed ephemeral drainage line on the central portion of the Farm Somme 661. The site was utilised for cattle watering at the time of the assessment.
LED3	22°43'37.16"S 29°53'44.44"E	An artificial impoundment located along an unnamed ephemeral drainage line on the Farm Lekkerlag 580.
LED4	22°43'25.12"S 29°54'3.70"E	An artificial impoundment located along an unnamed ephemeral drainage line on the Farm Lekkerlag 580.
LED5	22°38'8.31"S 29°52'20.84"E	A pan located on the eastern portion of the Farm Van der Bijl 528 and within the proposed project area. The site was utilised for cattle watering at the time of the assessment.
LED6	22°38'17.01"S 29°54'49.70"E	A pan located along the south eastern boundary of the Farm Dreyer 526 (adjacent to the R525) and within the proposed project area.
LED7	22°37'51.95"S 29°53'57.20"E	An artificial impoundment located on the Farm Dreyer 526 along an unnamed ephemeral drainage line adjacent to the R525 on the north-eastern portion of the proposed project area. Access to this site was restricted and thus only a visual assessment was possible. The site was utilised for cattle watering at the time of the assessment.
LED8	22°38'52.31"S 29°55'49.11"E	An artificial impoundment located along an unnamed ephemeral drainage line situated approximately 800 m east of the proposed project area. While not within the project boundary, the site is regarded as representative of the freshwater resources present within and in the vicinity of the proposed project.
LED9	22°39'46.86"S 29°55'18.51"E	A pan situated within the proposed project area on the Farm Antrobus 566 and east of the N1.

LED10	22°39'31.52"S 29°49'59.19"E	An unnamed ephemeral drainage line situated on the north-western portion of the proposed project area and on the Farm Van der Bijl 528 draining the proposed project area in a north-eastern direction.
LED11	22°38'42.80"S 29°51'57.08"E	An unnamed ephemeral drainage line situated on the northern portion of the proposed project area on the Farm Van der Bijl 528 and draining the proposed project area in a north-western direction.
LED12	22°43'25.98"S 29°53'42.70"E	An unnamed ephemeral drainage line situated on the southern portion of the proposed project area on the Farm Lekkerlag 580 and draining the proposed project area in a southern direction.
LED13	22°31'42.27"S 29°53'31.93"E	Located along the mainstem Sand River, downstream of the proposed project area and any of the associated drainage.
LED14	22°33'47.77"S 29°46'8.92"E	Located upstream of the proposed project area along the mainstem Sand River, directly downstream of the bridge coming from the town of Mopane.

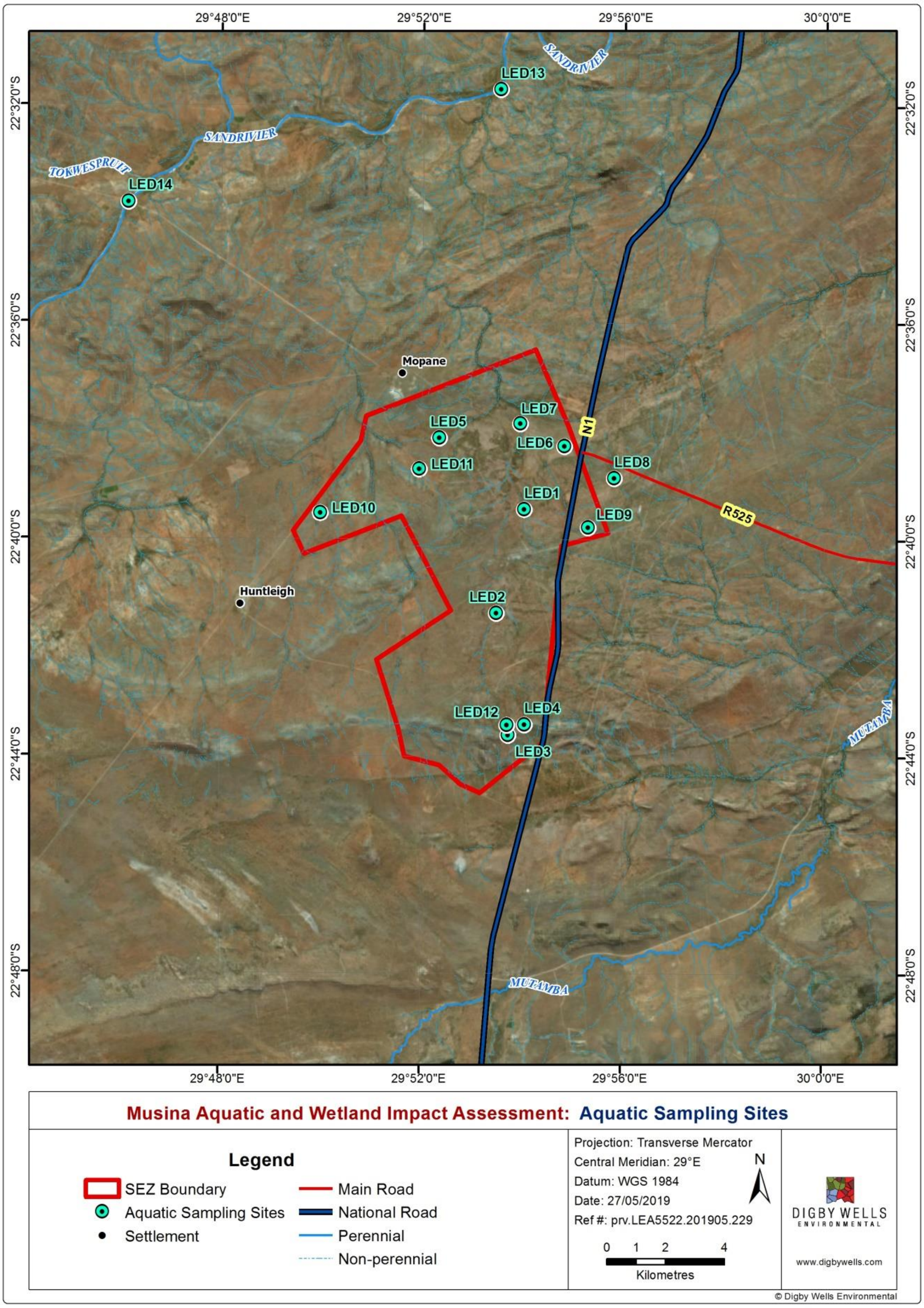


Figure 5-8: Aquatic sampling sites

Table 5-5: Visual assessment and site characteristics

Sampling site	Attributes		Photographs	Sampling site	Attributes		Photographs
LED1	Substrate	Mud deposits and aquatic vegetation. Isolated algal proliferation.		**LED2**	Substrate	Mud and sand deposits, some algal proliferation noted.	
	Depth profiles	Very shallow, <0.5m deep			Depth profiles	Relatively shallow, 0.5m in the deeper areas of the impoundment	
	Flow condition	Standing/still			Flow condition	Standing/still	
	Riparian zone characteristics	Woody riparian zone with a relatively well vegetated understory comprising of small shrubs and grasses.			Riparian zone characteristics	Woody riparian zone, however, bankside vegetation was absent.	
	Water clarity and odour	Clear, no odour			Water clarity and odour	Opaque, no odour	
LED3	Substrate	Mud and sand deposites, isolated algal blooms observed.		**LED4**	Substrate	Mud	
	Depth profiles	Relatively shallow, 0.5m in the deeper areas of the impoundment			Depth profiles	<0.25m	
	Flow condition	Standing/still			Flow condition	Standing/still	
	Riparian zone characteristics	Woody riparian zone, however, bankside vegetation was absent.			Riparian zone characteristics	Woody riparian zone, however, bankside vegetation was absent.	
	Water clarity and odour	Opaque, no odour			Water clarity and odour	Opaque, no odour	
LED5	Substrate	Mud deposits and aquatic vegetation.		**LED6**	Substrate	Mud and sand deposits and aquatic vegetation. Moderate algal proliferation observed	
	Depth profiles	0.25 – 0.5m			Depth profiles	0.25 – 0.5m	
	Flow condition	Standing/still			Flow condition	Standing/still	
	Riparian zone characteristics	Woody riparian zone with a relatively well vegetated understory comprising of small shrubs and grasses.			Riparian zone characteristics	Woody riparian zone. Large areas of bare soil. Grasses and sedges observed in closer proximity to water.	
	Water clarity and odour	Opaque, no odour			Water clarity and odour	Discoloured, no odour	

LED7	Substrate	Mud and sand		**LED8**	Substrate	Mud deposits	
	Depth profiles	Unknown			Depth profiles	Relatively shallow, 0.5m in the deeper areas of the impoundment	
	Flow condition	Standing/still			Flow condition	Standing/still	
	Riparian zone characteristics	Woody riparian zone, however, bankside vegetation was largely absent.			Riparian zone characteristics	Woody riparian zone, however, bankside vegetation was absent.	
	Water clarity and odour	Opaque, no odour			Water clarity and odour	Opaque, no odour	
LED9	Substrate	Mud, grasses and sedges		**LED10**	Substrate	Alluvial sand deposits	
	Depth profiles	<0.25m			Depth profiles	NA	
	Flow condition	Standing/still			Flow condition	NA	
	Riparian zone characteristics	Woody riparian zone with a grassy understory			Riparian zone characteristics	Woody riparian zone, bankside vegetation absent	
	Water clarity and odour	Opaque, no odour			Water clarity and odour	NA	
LED11	Substrate	Alluvial sand deposits		**LED12**	Substrate	Alluvial sand deposits	
	Depth profiles	NA			Depth profiles	NA	
	Flow condition	NA			Flow condition	NA	
	Riparian zone characteristics	Woody riparian zone, scattered shrubs and grasses			Riparian zone characteristics	Woody riparian zone, scattered shrubs and grasses	
	Water clarity and odour	NA			Water clarity and odour	NA	
LED13	Substrate	Alluvial sand deposits		**LED14**	Substrate	Alluvial sand deposits	
	Depth profiles	NA			Depth profiles	NA	
	Flow condition	NA			Flow condition	NA	
	Riparian zone characteristics	Woody riparian zone, reeds, sedges, shrubs and grasses			Riparian zone characteristics	Woody riparian zone, reeds, sedges, shrubs and grasses	
	Water clarity and odour	NA			Water clarity and odour	NA	

*NA = Not Applicable

5.2.2 *In Situ* Water Quality

Of the 14 aquatic sampling sites assessed, *in situ* water quality was collected at six of the pans and artificial impoundments, where surface water was observed during the March 2019 aquatic assessment. Water quality at the remaining sites could not be collected due to a range of factors, including absence or lack of sufficient surface water (i.e. the semi-arid nature of the proposed project area), access restrictions and safety considerations. Table 5-6 provides the *in situ* water quality data obtained.

Table 5-6: In situ water quality variables recorded at each of the sites assessed during the March 2019 aquatic assessment

Site	Temp. (°C)	pH	Electrical Conductivity (µS/cm)	Dissolved oxygen	
				(mg/ℓ)	(% sat)
LED2	31.2	7.55	58.7	2.86	37.6
LED3	29.8	7.37	69.7	2.96	24.4
LED5	31.7	9.30	208.0	1.81	24.6
LED6	30.1	7.78	56.8	1.39	18.1
LED8	22.7	6.57	27.3	1.65	23.2
LED9	24.8	6.71	64.8	1.25	15.3

.

Temperature ranges recorded at each of the sampling sites were regarded as natural in relation to both the diurnal and seasonal timings of each site surveyed.

Most aquatic systems within South Africa are relatively well-buffered, as a result of dissolved bicarbonate/carbonate ions originating from exposed geological formations and atmospheric deposits, and as such, most of the stereotypical systems usually exhibit close-to-neutral pH levels (i.e. pH 6-8; Department of Water Affairs and Forestry (DWAF), 1996; Dallas & Day, 2004). Thus, the pH values observed at all of the sites surveyed (with the exception of LED5 which had a pH of 9.30), were regarded as within the natural ranges expected for a water body in South Africa.

Upon further investigation, literature reveals that the water quality within the Limpopo WMA is largely dependent on the interaction of water with its geological environment, leading to varying water quality variables in specific geological environments (DWAF, 2003). In light of the wetland nature of LED5 (a pan), it is likely that this system would be largely groundwater fed in relation to the artificial impoundments observed (LED2, LED3, LED6 and LED8), which are largely surface water fed, and this may be considered a potential driver of the elevated pH observed. It should be noted that extreme rates of photosynthesis, whether natural or as a result of eutrophication, have been commonly observed to cause alkaline pH values in standing waters (Dallas & Day, 2004). The potential for the occurrence of this phenomenon at LED5 is supported by the observation of well vegetated banks and extensive aquatic vegetation, as well as the elevated electrical conductivity observed at this site, both of which were absent at each of the artificial impoundments.

Similarly, with the exception of that observed at LED5, the electrical conductivity recorded at each of the sites may be regarded as relatively low. This was attributed to the breakdown and decay of plant material, as well as the addition of organic matter associated with livestock watering.

Dissolved oxygen saturation levels of 80-20% are considered necessary to protect all life stages of the vast majority of aquatic organisms that are endemic (or adapted) to inhabiting aerobic warm water habitats (Department of Water Affairs and Forestry, 1996). In light of this expected range, the dissolved oxygen saturation levels fell well below the accepted range. All of the pans and artificial impoundments assessed present an innate limitation to a diversity of habitats and flows (comprising of standing/still water bodies of variable depths throughout the proposed project area) and dissolved oxygen levels are expected to be low. Furthermore, the solubility of oxygen in water is inversely related to temperature (Dallas & Day, 2004), which may have been a factor contributing to the low dissolved oxygen concentrations observed at each of the sites.

5.2.3 Index of Habitat Integrity, version 2

The ephemeral systems identified within the proposed Project area were not deemed to be suitable for the application of the IHI due to its applicability to permanent river systems (C. J. Kleynhans, 2008b). A low confidence assessment was undertaken for the portions of the main stem Sand River, which could not be accessed due to the presence of fence lines and privately owned properties immediately adjacent to the river.

For the purposes of the present study, the habitat unit assessed comprised of the main stem Sand River between sites LED14 and LED13 along the A71K-00031 SQR. The perceived ecological condition of the instream and riparian habitats is described in Table 3-1.

Typical habitat of the Sand River was dominated by sandy substrates within a wide seasonal channel (mostly alluvial) with isolated pools and shallow areas[1]. Due to the lack of surface water observed at either site LED14 or LED13 at the time of the assessment, selected assessment criteria relating to the instream habitat conditions along the main-stem Sand River were not determined in the field. Thus, criteria such as the physico-chemical parameter, were weighted based on the desktop information provided in the PESEIS database compiled by the Department of Water and Sanitation (2014).

[1] While no pools or shallow water areas were observed at either LED14 or LED13 at the time of the assessment, a review of aerial imagery between these two sites suggests the presence in isolated areas along this portion of the Sand River.

The instream component was determined to represent moderately modified conditions (Ecological Category C), while the riparian component was determined to represent largely natural to moderately modified conditions (Ecological Category B/C).

Table 5-7: Index for Habitat Integrity (IHI) values obtained for the upstream and downstream sites on the main stem Sand River.

Reach	Component	IHI (%)	Ecological Category	Major Impacts
Sand River	Instream Habitat	75.1	**C**	- Water abstraction was flagged as a *large* impact due to irrigation schemes (i.e. pivot arms) in close proximity to the river. - *Moderate* impacts to physico-chemical water quality was identified based on the information provided in the PESEIS database area (Department of Water and Sanitation, 2014). - *Small* impacts relating to bed and channel modifications were related to the increased incidence of cultivation observed in some areas.
	Riparian Habitat	77.1	**B/C**	- *Large* impact due to vegetation removal for agriculture in the upper section of the reach assessed. - *Small* impacts related to bank erosion due to cattle watering were observed. - Water abstraction is likely to have resulted in *moderate* impacts to the riparian zone due to loss of sub-surface water supply, which has the potential to result in moisture stress and loss of vegetation integrity.

5.2.4 Invertebrate Habitat Assessment System

The Invertebrate Habitat Assessment System (IHAS, Version 2.2), developed by McMillan (1998), has routinely been used in conjunction with the SASS5 approach as a measure of variability in the quantity and quality of representative aquatic macroinvertebrate biotopes available during sampling. However, the IHAS could not be applied at the time of the March 2019 aquatic field assessment, as it is restricted for application within flowing systems and therefore, it was not deemed to be appropriate for use within any of the pans and artificial impoundments sampled.

5.2.5 South African Scoring System, version 5

Non-perennial rivers are ecosystems that place extreme stress on the organisms inhabiting them by exhibiting highly variable physical and chemical attributes, of which the most obvious is the unpredictable and highly variable flow patterns of the watercourses themselves

(Rossouw et al., 2005). Consequently, only biota with specific coping mechanisms and/or a wide tolerance of water quality impairment can survive in these systems. The ability to rapidly recolonise a dry system once re-inundation has occurred is one such mechanism that many macroinvertebrate taxa have developed to help to ensure survival. These specialised strategies vary widely between families, but the three main sources of re-colonisation originate from previously laid resting eggs, invertebrate forms capable of aestivation, and eggs laid by flying adults immediately after re-inundation (Harrison, 1966). However, in systems with constructed dams or weirs, sections of this system remain inundated for extended periods (i.e. Sites LED2, LED3, LED6 and LED8) and as a result, these systems often serve as 'refugia' for previously established aquatic biota during the dry season and facilitate a more efficient re-colonisation process.

The re-colonisation of non-perennial watercourses by aquatic macroinvertebrates families are few, however, according to Rossouw et al. (2005) and Harrison (1966), early colonisers include Chironomidae (Midges), Oligochaeta (Earthworms), Simulidae (Black Flies), small crustaceans and small insect larvae, while species typical of permanent streams only returned within one month of re-inundation in standing pools and within 4-6 weeks in flowing streams (Rossouw et al., 2005).

At this stage, it is important to note that the application of the SASS5 Index within non-perennial watercourses and/or impoundments should be interpreted with caution, as the assessment index was primarily designed to be used exclusively within flowing systems. Nevertheless, for the purpose of using a standardised sampling approach the SASS5 method was deemed sufficient for the determination of the baseline macro-invertebrate community assemblages within the pans and artificial impoundments assessed

Historical data and specialist knowledge was used to compile an expected species list for aquatic macro-invertebrates in the main stem Sand River, whereby 37 different macroinvertebrate taxa were identified as likely to occur within the proposed project area (Department of Water and Sanitation, 2014). In total, 16 families were observed within the proposed project area, which comprised of a total of four pans and artificial impoundments where surface water and available habitat was considered suitable for sampling, namely LED2, LED3, LED5, and LED6. These are indicated in Table 5-8 below.

Table 5-8: Expected and observed aquatic macroinvertebrate taxa associated with the watercourses in the vicinity of the proposed project area.

Expected Species	Observed Species			
	LED2	LED3	LED5	LED6
Turbellaria				
Oligochaeta				
Hirudinea				
Potamonautidae*				
Atyidae				

Hydracarina			X	X
Baetidae			X	X
Caenidae				
Coenagrionidae			X	
Aeshnidae				X
Lestidae				X
Corduliidae				X
Gomphidae				
Libellulidae	X			X
Belostomatidae*		X		X
Corixidae*			X	X
Gerridae*			X	X
Hydrometridae*				
Naucoridae*	X			X
Nepidae*				
Notonectidae*	X	X	X	X
Pleidae*				
Veliidae*			X	X
Hydropsychidae				
Leptoceridae				
Dytiscidae*		X	X	
Gyrinidae*				
Hydrophilidae*				
Ceratopogonidae				
Chironomidae				X
Culicidae*			X	
Muscidae				
Tabanidae				
Tipulidae				
Ancylidae				
Lymnaeidae*				
Physidae*				X
* = Air-breathers				

Of the 17 species observed, nine are air-breathers, meaning that these species are not reliant on dissolved oxygen within the water column to ensure their survival and are thus more tolerant of low levels of dissolved oxygen, which is often typical of standing/still water systems, such as pans or artificial impoundments. However, some more sensitive species such as Hydracarina, Aeshnidae, Lestidae and Corduliidae serve as an indication that conditions are adequate for maintaining a relatively high degree of biodiversity despite the limited surface water and habitat diversity observed.

In addition, various branchiopod crustacean families were observed in large numbers at all of the sites sampled during the March 2019 aquatic field survey. These branchiopods have developed life strategies and unique adaptations that allow them to cope with harsh environments (regular desiccation; Ferreira, Wepener, & van Vuren, 2011). They produce eggs that are resistant to desiccation, have short life-cycles, grow rapidly and reproduce early. As such, they are usually restricted to these temporary ecosystems and are allopatric (i.e. not always occurring; Ferreira et al., 2011). It is thus often easy to overlook the presence of these species. The branchiopod species observed included large numbers of Anostraca (Fairy Shrimps), fewer numbers of Triopsidae (Tadpole Shrimps) and isolated Conchostraca (Clam Shrimps) and as a result, a greater level of biodiversity was shown to be supported within the egg banks contained within the sediments of the pans and artificial impoundments throughout the site.

Figure 5-9: Branchiopod crustaceans observed within the proposed project area – Triopsidae (Tadpole Shrimps, left) and Anostraca (Fairy Shrimps) and Conchostraca (Clam Shrimps, right)

5.2.6 Macroinvertebrate Response Assessment Index (MIRAI)

Due to the dry conditions observed at the time of the survey and the inappropriate application of SASS5 Index within the pans and artificial impoundments assessed, no PES could be determined, as the application of the MIRAI is intended exclusively for application within flowing systems.

5.2.7 Fish Response Assessment Index

A total of 18 fish species were expected to occur in the vicinity of the proposed project area (Department of Water and Sanitation, 2014). However, no fish were collected at the time of the field survey carried out in March 2019 (Table 5-9).

Table 5-9: Expected fish species in the Sand River

Fish Species	Common Name	Conservation Status (Darwall et al., 2009)
Enteromius mattozi	Papermouth	Least Concern
Enteromius paludinosus	Straightfin Barb	Least Concern
Enteromius toppini	East Coast Barb	Least Concern
Enteromius trimaculatus	Threespot barb	Least Concern
Enteromius unitaeniatus	Longbeard Barb	Least Concern
Enteromius viviparus	Bowstripe Barb	Least Concern
Clarias gariepinus	African Catfish	Least Concern
Chiloglanis paratus	Sawfin Suckermouth	Least Concern
Labeo cylindricus	Redeye Labeo	Least Concern
Labeo molybdinus	Leaden Labeo	Least Concern
Labeo rosae	Rednose Labeo	Least Concern
Labeo ruddi	Silver Labeo	Least Concern
Labeobarbus marequensis	Lowveld largescale Yellowfish	Least Concern
Micralestes acutidens	Sharptooth Tetra	Least Concern
Mesobola brevianalis	River Sardine	Least Concern
Oreochromis mossambicus	Mozambique Tilapia	Near Threatened
Pseudocrenilabrus philander	Southern Mouthbrooder	Not Evaluated
Schilbe intermedius	Butter Catfish	Least Concern

It is envisaged, however, that the majority of the aforementioned fish species will be limited to the main stem Sand River during periods of inundation, where some areas of surface water and sufficient habitat cover are likely to be present. It is unlikely that the majority of the larger species would occur within the proposed project area due to the largely ephemeral nature of the watercourses and drainage lines observed. Furthermore, in the unlikely event that some of the listed fish species were to occur within the proposed project area, it is suspected that these would most likely have migrated further downstream (where possible) to find refuge within isolated pools and/or inundated impoundments, or alternatively have died due to a lack of surface water and available habitat.

In light of the dry conditions of the ephemeral watercourses and drainage lines and lack of any fish species observed in the pans and artificial impoundments assessed, the application of the FRAI was not deemed to be necessary and as such, no PES could be determined.

5.2.8 Ecostatus4 1.02 Model

The EcoStatus4 1.02 Model allows for the provision of an integrated ecological state representing the drivers (hydrology, geomorphology, physico-chemical) and responses (fish, aquatic invertebrates and riparian vegetation; Kleynhans & Louw, 2008).

However, as no PES could determined for each of the biological components at the time of the survey due to the nature of the systems present within the proposed Project area, no integrated EcoStatus could be determined. Nonetheless, it should be noted that the conditions observed at the time of the survey were deemed natural and representative of the region. Thus, for the purpose of determining a PES at the time of the survey, the available desktop data as provided in the PESEIS (Department of Water and Sanitation, 2014) indicates that the main stem Sand River (SQR A71K-00031) is representative of a moderately modified condition (Ecological Category C). This is comparable to the scores obtained in the IHI assessment (Section 4.2.3).

6 Impact Assessment

This section aims to rate the significance of the identified potential impacts pre-mitigation and post-mitigation. The potential impacts identified in this section are a result of both the environment in which the proposed Project activities take place, as well as the actual activities. The potential impacts are discussed per aspect and per each phase of the project i.e. the Construction Phase, Operational and Decommissioning/Post Closure Phases where applicable.

Table 6-1: Project Activities

Projects	Area (ha)
Power Plant	300
Coke Plant	500
Ferrochromium Plant	500
Ferromanganese Plant	100
Pig Iron Plant	600
Carbon steel plant	200
Stainless steel plant	500
Lime plant	500
Silicon-manganese plant	100
Metal silicon plant	50
Calcium carbide plant	50
Infrastructure	2600
Total	**6000**

The Musina-Makhado SEZ will comprise mixed land uses and infrastructure provision to ensure the optimal manufacturing operations in the energy and metallurgical complex. It is envisaged that the energy and metallurgical complex shall comprise the manufacturing plants outlined in Table 6-1. Table 6-2 highlights the activities per phase of the project which have been assessed in the Impact Assessment.

The due to the high density of the development, the worst-case scenario is assumed where infrastructure is placed within pans, ephemeral drainage lines or ephemeral watercourses and movement of the infrastructure out of these areas is considered a mitigation measure.

Table 6-2: Project Activities

Activity	Phase of Project
Site clearing and increased vehicular movement within the project area; Construction of infrastructure including roads, solid waste, water treatment works, substation and bulk water supply and reservoirs.	Construction phase
Operational activities relating to various plants, the production of liquid effluents and solid wastes; Increased vehicular movement and thoroughfare; Development of human settlements.	Operational phase
Removal and decommissioning of all surface infrastructures; Rehabilitation of affected areas.	Decommissioning and closure phase

6.1 Construction Phase

6.1.1 Construction Phase Impact Description

Impacts during the construction phase include those associated with site access and construction activities such as site clearing, soil disturbance, crossing of wetlands and watercourses, increased vehicular movement, stockpiling of topsoils, storage and dumping of building materials associated with the construction of the various industrial plants, as well as construction activities within each of the infrastructure footprints. The main impacts resulting from this includes complete degradation of habitat through the physical removal/destruction of wetland vegetation, soil compaction, surface hardening, loss of catchment yield and fragmentation of the ephemeral drainage lines and watercourses observed.

These impacts have the potential to result in further severe impacts in terms of erosion due to the creation of sheet runoff from hardened surfaces and areas where vegetation removal and clearing has occurred. This in turn may result in the increased potential for sedimentation of the downstream freshwater resources (i.e. The Sand River and its associated tributaries). Impacts to water quality may occur due to contamination from hydrocarbons and building materials.

The impacts to the freshwater ecology are tabulated in Table 6-3.

Table 6-3: Impact assessment parameter ratings for the construction phase – site access and construction

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearance and construction of man-made structures within the Musina-Makhado SEZ wetland habitat and river catchment			
Impact Description: ▪ Direct loss of wetland and other freshwater habitat for infrastructure and the various proposed activities; ▪ Loss of connectivity (cutting off drainage lines); ▪ Surface hardening and loss of catchment yield; ▪ Onset of erosion; ▪ Sedimentation and the potential for the establishment of alien hydrophytic and terrestrial plant species; ▪ Deterioration of wetland PES and provision of ecosystem services; ▪ Loss of biodiversity.			
Prior to Mitigation/Management			
Duration	Permanent (7)	The direct loss of pans and drainage lines is irreversible, even with management, and will remain after the life of the project.	-112 Major (negative)
Extent	Local (3)	Increased erosion and general scouring due to surface hardening. Loss of catchment yield due to construction of infrastructure and degraded habitat will affect the immediate watercourses. Loss of pans is local as these are only small in size.	
Intensity x type of impact	Irreplaceable loss of moderately to highly sensitive environments (6)	The removal of pans is an irreplaceable loss, especially in an area that is water scarce.	
Probability	Definite (7)	Impacts to the wetlands present are considered definite if pans are replaced with infrastructure	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions			
Design the footprint of the infrastructure so as not to fall within the pans and drainage lines or their buffers. The following should be adhered to: ▪ Construction should take place during the dry season to minimise runoff; ▪ Ensure construction activities are limited to the project footprint and that no vehicles are allowed to drive indiscriminately around the proposed Project area; ▪ Sequential removal of the vegetation should take place (not all vegetation immediately); ▪ Revegetate the construction footprint and vehicular pathways as soon as possible; ▪ Storm water should be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; ▪ Implement and maintain an alien vegetation management programme. This must be put in place so as to prevent further encroachment by invasive species as a result of disturbance to the surrounding terrestrial zones; and ▪ Active rehabilitation, re-sloping, and re-vegetation of disturbed areas immediately after construction.			
Post-Mitigation			
Duration	Project Life (5)	The impact will cease after the life of the project.	-55 Minor (negative)
Extent	Local (3)	Degraded habitat and loss of catchment yield will affect the immediate watercourses.	
Intensity x type of impact	Moderate environmental effects (3)	Due to the flat terrain and nature of the systems (mostly pans and ephemeral drainage lines), should appropriate management or mitigation measures be employed, activities could be reduced to moderate medium-term impacts.	
Probability	Likely (5)	Should appropriate precautionary measures be implemented, further impacts to the wetlands present may be reduced to likely.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction: Stockpiling and storage of construction materials			
Impact Description: ▪ Soil compaction and loss of freshwater habitat areas. ▪ Onset of erosion. ▪ Sedimentation and the potential for the establishment of alien hydrophytic and terrestrial plant species. ▪ Deterioration of wetland PES and loss of the provision of ecosystem services.			
Prior to Mitigation/Management			
Duration	Beyond project life and potentially irreversible even with management. (6)	The compaction of soils has the potential to result in irreversible losses in soil capabilities.	-65 Minor (negative)
Extent	Municipal (4)	Increased erosion and general scouring from sedimentation, as well as degraded habitat due to water quality deterioration has the potential to affect the municipal watercourses (I.e. Sand River and groundwater supplies).	
Intensity x type of impact	Moderate environmental effects (3)	Due to the flat terrain and nature of the systems (mostly pans and ephemeral drainage lines), should no management or mitigation measures be employed, activities could result in moderate medium-term impacts.	
Probability	Likely (5)	Should no precautionary measures be implemented, further impacts to the wetlands present are considered likely.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions			
▪ Revegetate the construction footprint and vehicular pathways as soon as possible; ▪ Ensure all stockpiles are within the construction footprint and ensure vehicles remain on demarcated roads; ▪ Storm water should be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow; ▪ Construction should take place during the dry season to minimise runoff; and ▪ Sequential removal of the vegetation should take place (not all vegetation immediately).			
Post-Mitigation			
Duration	Short term (2)	The impact will cease after construction has been completed and any leftover material has been removed.	-24 Negligible (negative)
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the decommissioning phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present.	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature			

6.1.2 General Construction Phase Mitigation Measures

- Ensure a soil management programme is implemented and maintained to minimise erosion and sedimentation;
- An appropriate dirty and clean water separation system should be in place before activities commence;
- During the construction phase, erosion berms should be installed on roadways and downstream of stockpiles to prevent gully formation and siltation of the freshwater resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has a slope of less than 2%, berms every 50m should be installed;

    - Where the track slopes between 2% and 10%, berms every 25m should be installed;
    - Where the track slopes between 10%-15%, berms every 20m should be installed; and
    - Where the track has slope greater than 15%, berms every 10m should be installed.
- Limit the footprint area of the construction activities to what is essential to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in wetland areas);
- If it is unavoidable that any of the pans or ephemeral drainage lines present (not withstanding those already accounted for in the proposed activities) will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the pans and ephemeral drainage lines present takes place;
- All erosion noted within the construction footprint should be remedied immediately and included as part of an ongoing rehabilitation plan;
- Actively rehabilitate, re-slope, and re-vegetate disturbed areas immediately after construction;
- All soils compacted because of construction activities should be ripped/scarified (<300mm) and profiled;
- Implement and maintain a suitable Alien Invasive Plant (AIP) control programme to prevent further encroachment because of disturbance to the surrounding terrestrial zones;
- Permit only essential personnel within the assigned buffers for all freshwater features identified (refer to Table 5-3 for buffer widths);
- No unnecessary crossing of the wetland features and their associated buffers should take place and the substrate conditions of the wetlands and downstream stream connectivity must be maintained;
- No material may be dumped or stockpiled within any rivers, tributaries or drainage lines;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any wetland or instream areas and their associated zones of regulation (notwithstanding those areas to be directly impacted upon as a result of the proposed activities). All vehicles must remain on demarcated roads and within the construction footprint;
- All vehicles must be regularly inspected for leaks;
- Re-fueling must take place at a diesel facility, on a sealed surface area away from wetlands to prevent ingress of hydrocarbons into topsoil;

- All hydrocarbon spills should be immediately cleaned up and treated accordingly;
- Wetlands should be monitored quarterly during construction; and
- Appropriate sanitary facilities must be provided for the duration of the construction activities and all waste must be removed to an appropriate waste facility.

6.2 Operational Phase

6.2.1 Operational Phase Impact Description

The main activities during the operational phase that could result in impacts to the freshwater ecology of the area are associated with operation of the industrial plants, and the production of liquid effluents and solid wastes. Additional potential impacts include compaction of soils and hardening of surfaces, loss of catchment yield and surface water recharge, erosion and sedimentation, the potential loss of biodiversity and habitat, loss of natural migration routes for instream fauna and further fragmentation of the systems present.

Further to this, the potential for ongoing contamination of the freshwater resources present are deemed likely based on the ingress of hydrocarbons associated with increased vehicular activity. Removal of indigenous vegetation is likely to give rise to an increased potential for encroachment by robust pioneer species and AIPs, further altering the natural vegetation profiles of the freshwater resources encountered in the vicinity of the project footprint.

Hardened surfaces have the potential to result in sheet runoff and there is likely to be a loss in wetland service provision. Storage of water and water supply, which is an important service, provided by wetlands in this area, will be compromised. Further alterations to the natural flow regimes will take place and is likely to result in the creation of preferential flow paths over time, which may give rise to erosion and sedimentation, thus affecting the drainage patterns and in turn, the downstream resources.

The potential impacts to the freshwater ecology identified during the operational phase are detailed in the tables below.

Table 6-4: Impact assessment parameter ratings for the operational phase – operation of infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interactions: Surface operation activities			
Impact description: Ongoing contamination of the freshwater resources is deemed likely based on the ingress of hydrocarbons associated with increased vehicular activity and contamination from the industrial plant. Additional potential impacts include compaction of soils and hardening of surfaces, loss of catchment yield and surface water recharge, erosion and sedimentation, the potential loss of biodiversity and habitat, loss of natural migration routes for instream fauna and further fragmentation of the systems present.			
Prior to Mitigation/Management			

Dimension	Rating	Motivation	Significance
Duration	Project Life (5)	The impact will cease the after the project has been completed.	-120 Major (negative)
Extent	Regional (5)	Increased erosion and general scouring from sedimentation, as well as degraded habitat due to water quality deterioration will affect the regional watercourses.	
Intensity x type of impact	Serious environmental impacts (5)	Due to the high density and nature of the SEZ, activities could result in serious impacts to sensitive environments.	
Probability	Almost certain (6)	Should no precautionary measures be implemented, further impacts to the wetlands present are considered almost certain.	
Nature	Negative		
Mitigation/Management Actions			
▪ Appropriate storm water and waste water systems must be in place; ▪ Incidents of erosion should be remedied as soon as possible; ▪ Any pollutants should be removed to reduce contamination of the water quality. The contaminated material should then be discarded at the correct facility; ▪ Leak detection of the industrial plant pipelines must be done on a regular basis; ▪ Limit the footprint area of the operational activities to what is essential to minimise impacts as a result of any potential vegetation clearing and compaction of soils (all areas but critically so in freshwater areas); ▪ All areas of increased ecological sensitivity should be designated as “No-Go” areas and be off limits to all unauthorised vehicles and personnel; ▪ No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads; ▪ All vehicles must be regularly inspected for hydrocarbon leaks; ▪ Re-fuelling must take place on a sealed surface area away from freshwater features to prevent ingress of hydrocarbons into topsoil; ▪ All hydrocarbon spills should be immediately cleaned up and treated accordingly; ▪ Appropriate sanitary facilities must be provided for the duration of the operational activities and all waste must be removed to an appropriate waste facility; ▪ Permit only essential personnel within the various zones of regulation/buffers for all freshwater features identified.			
Post-Mitigation			

Dimension	Rating	Motivation	Significance
Duration	Project Life (5)	The impact will cease after the project has been completed, even with mitigation measures in place.	-44 Minor (negative)
Extent	Local (3)	Increased erosion and general scouring from sedimentation, as well as degraded habitat due to water quality deterioration will affect the local watercourses.	
Intensity x type of impact	Moderate environmental impacts (3)	Due to the high density and nature of the SEZ, activities could result in moderate impacts to sensitive environments where mitigation measures are in place.	
Probability	Probable (4)	Should mitigation measures be implemented, further impacts to the wetlands present are reduced and considered probable.	
Nature	Negative		

6.2.2 Operational Phase Mitigation Measures

- Removal of AIPs, specifically with a focus on water-loving species such as. *Eucalyptus* species, which will aid in rehabilitation. These trees utilise large amounts of water and therefore impact on the hydrology of wetlands. A co-ordinated AIP removal programme should be run annually;
- Incidents of erosion should be remedied as soon as possible to reduce deterioration of the wetland habitat;
- Any contamination from liquid or solid pollutants should be removed to reduce contamination of the water quality. The contaminated material should then be discarded at the correct facility;
- Limit the footprint area of the operational activities to what is essential to minimise impacts as a result of any potential vegetation clearing and compaction of soils (all areas but critically so in freshwater areas);
- If it is unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the freshwater features present takes place because of the proposed operational activities;
- All areas of increased ecological sensitivity should be designated as “No-Go” areas and be off limits to all unauthorised vehicles and personnel;

- No unnecessary crossing of the wetland features, instream areas and their associated buffers, as well as the constructed berms or canals should take place and the substrate conditions of the wetlands, instream areas and downstream stream connectivity must be maintained;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads where possible;
- All vehicles must be regularly inspected for leaks and drip trays should be used for vehicles that are standing for a long duration of time;
- Re-fuelling of machinery must take place on a sealed surface area away from freshwater features to prevent ingress of hydrocarbons into topsoil;
- All hydrocarbon spills should be immediately cleaned up and treated accordingly;
- Appropriate sanitary facilities must be provided for the duration of the operational activities and all waste must be removed to an appropriate waste facility;
- Monitor all systems for erosion and incision;
- Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation;
- All soils compacted because of construction activities should be ripped/scarified (<300mm) and profiled;
- If significant rehabilitation measures are required, mitigation measures of the construction phase must be implemented;
- Permit only essential personnel within the assigned buffers for all freshwater features identified (refer to Table 5-3 for buffer widths).

6.3 Decommissioning, Closure and Rehabilitation Phase

6.3.1 Decommissioning, Closure and Rehabilitation Phase Impact Description

SEZ's are intended to be long-term industrial and economic development initiatives; it is thus unlikely for the project to be decommissioned in the foreseeable future. However, in the event that decommissioning and closure takes place, it is expected that there may be minor potential impacts to soil and water quality, as a result of the ingress of hydrocarbons and mechanical spills associated with moving machinery required for the decommissioning activities.

Larger impacts include compaction of soils, potential loss of natural vegetation and the increased potential for erosion and sedimentation in the decommissioned areas resulting in impacts further downstream.

Any temporary storage or dumping of decommissioned infrastructure within wetland or river areas, has the potential to result in loss of stream connectivity, loss of refuge areas, alterations to the terrain profiles of the areas and the creation of preferential flow paths, which may result in sedimentation, alterations to the vegetation structure of the area, encourage alien vegetation encroachment and result in increased erosion and sedimentation potentials.

Removal of vegetation and disturbance of soils in the vicinity of the decommissioning footprint is likely to give rise to an increased potential for encroachment by robust pioneer species and alien invasive vegetation species, further altering the natural vegetation profiles of the wetlands encountered in the vicinity of the decommissioning footprint. The potential impacts associated with the Decommissioning, Closure and Rehabilitation Phase are detailed in Table 6-5.

Table 6-5: Potential Impacts of the Decommissioning, Closure and Rehabilitation Phase – Decommissioning of Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interactions: Decommissioning of all infrastructure			
Impact Description: Potential impacts to soil and water quality as a result of the ingress of hydrocarbons and mechanical spills associated with moving machinery required for the decommissioning activities. Compaction of soils, potential loss of natural vegetation and the increased potential for erosion and sedimentation in the decommissioned areas and resulting in impacts further downstream. Any temporary storage or dumping of decommissioned infrastructure within wetland or river areas, has the potential to result in loss of stream connectivity, loss of refuge areas, alterations to the terrain profiles of the areas and the creation of preferential flow paths, which may result in sedimentation, alterations to the vegetation structure of the area, encourage alien vegetation encroachment and result in increased erosion and sedimentation potentials.			
Prior to Mitigation/Management			
Duration	Medium term (3)	The impact will cease 1-5 years after the decommissioning has taken place.	-45 Minor (negative)
Extent	Local (3)	Increased erosion and general scouring from sedimentation, as well as compaction from moving machinery and degraded habitat due to water quality deterioration will affect the local watercourses.	
Intensity x type of impact	Moderate environmental effects (3)	Should no management or mitigation measures be employed, activities could result in moderate medium-term impacts.	
Probability	Likely (5)	Should no precautionary measures be implemented, further impacts to the wetlands present are considered likely.	

Dimension	Rating	Motivation	Significance
Nature	Negative		
Mitigation/Management Actions			
▪ Limit the footprint area of the decommissioning and rehabilitation activities to what is essential; ▪ Wherever possible, restrict decommissioning activities to the drier winter months to avoid sedimentation of the freshwater resources further downstream; ▪ No material may be dumped or stockpiled within any wetland areas or within 100m in the vicinity of the proposed decommissioning footprint; ▪ Re-fueling must take place at a diesel facility on a sealed and bunded surface area away from wetlands to prevent ingress of hydrocarbons into topsoil; ▪ All existing litter, debris should be removed from the freshwater systems and littering should be prohibited on an ongoing basis; ▪ All spills from machinery should be immediately cleaned up and treated accordingly; ▪ Appropriate sanitary facilities must be provided for the duration of the rehabilitation activities and all waste must be removed to an appropriate waste facility; ▪ Waste generated from decommissioning activities must be disposed of in accordance with waste regulations; and ▪ Any industrial pollutants should be removed and discarded at the correct facility.			
Post-Mitigation			
Duration	Short term (2)	The impact will cease soon after decommissioning has taken place.	-24 Negligible (negative)
Extent	Limited (2)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the decommissioning phase.	
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present.	
Probability	Probable (4)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered probable.	
Nature	Negative		

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Activity and Interactions: Rehabilitation measures and site access</td></tr>
<tr><td colspan="4">Impact description: Potential impacts to soil and water quality as a result of the ingress of hydrocarbons and mechanical spills associated with moving machinery required for the decommissioning activities. Compaction of soils, potential loss of natural vegetation and the increased potential for erosion and sedimentation in the decommissioned areas and resulting in impacts further downstream.</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>Long term (4)</td><td>The impact will continue into the long term if mitigation measures are not adhered to.</td><td rowspan="5">-50
Minor (negative)</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Increased erosion and general scouring from sedimentation, as well as degraded habitat due to water quality deterioration from sloping and shaping will affect the immediate watercourses.</td></tr>
<tr><td>Intensity x type of impact</td><td>Moderate environmental effects (3)</td><td>Should no management or mitigation measures be employed, activities could result in moderate medium-term impacts.</td></tr>
<tr><td>Probability</td><td>Likely (5)</td><td>Should no precautionary measures be implemented, further impacts to the wetlands present are considered likely.</td></tr>
<tr><td>Nature</td><td></td><td></td></tr>
</table>

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions			

- Limit the footprint area of the decommissioning and rehabilitation activities to what is absolutely essential to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in wetland areas);
- All soils compacted as a result of decommissioning activities should be ripped/scarified (<300mm) and profiled;
- Wherever possible, restrict decommissioning activities to the drier winter months to avoid sedimentation of the freshwater resources further downstream;
- An AIP management plan to be implemented and managed for the life of the proposed decommissioning, rehabilitation, closure and post-closure phases;
- As much vegetation growth as possible should be promoted within the proposed development area during all phases. In order to protect soils, vegetation clearance should be kept to a minimum;
- All areas where active erosion is observed should be ripped, re-profiled and seeded with indigenous grasses;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any wetland areas and their associated zones of regulation. All vehicles must remain on demarcated roads and within the project area footprint;
- All vehicles must be regularly inspected for leaks;
- Re-fueling must take place at a diesel facility on a sealed and bunded surface area away from wetlands to prevent ingress of hydrocarbons into topsoil;
- All existing litter, debris should be removed from the freshwater systems and littering should be prohibited on an ongoing basis;
- All spills from machinery should be immediately cleaned up and treated accordingly;
- The road servitude and conveyor have affected the integrity of the wetlands resulting in a loss of habitat and downstream surface water recharge. Rehabilitation during the decommissioning and closure phase should focus on the rehabilitation of these areas. Management in this regard would include removal of the structures, re-profiling of the bed and marginal zones to restore the geomorphological and hydrological integrity and ripping and re-seeding with indigenous wetland grass species.
- All incidents of erosion should be remedied and AIPs removed, as in the operational phase; and
- Any industrial pollutants should be removed and discarded at the correct facility as in the operational phase.

Post-Mitigation			
Duration	Medium term (3)	The impact will cease in the medium term and the project has been completed and rehabilitation has taken place.	-40 Minor (negative)
Extent	Local (3)	Impacts will be limited only to the local area and will be rehabilitated accordingly on completion of the decommissioning phase.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Minor effects on the biological or physical environment (2)	Should the appropriate precautions and management or mitigation measures be employed, the project could result in only a minor ecological impact to the wetland systems present.	
Probability	Likely (5)	Should the proposed project proceed, impacts to the ecological integrity of the systems present are still considered likely.	
Nature			

6.3.2 Decommissioning, Closure and Rehabilitation Phase Mitigation Measures

The following mitigation and management measures have been prescribed for the decommissioning, closure and rehabilitation phase:

- Decant that does not meet required water quality standards must not be discharged into watercourses and an investigation must then be made into improving water quality before it is discharged;
- Ensure that sound environmental management is in place during the proposed decommissioning phase;
- Limit the footprint area of the decommissioning and rehabilitation activities to what is absolutely essential in order to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in wetland areas);
- All erosion noted within the decommissioning area footprint should be remedied immediately and included as part of the ongoing rehabilitation plan;
- All soils compacted as a result of decommissioning activities should be ripped/scarified (<300mm) and profiled;
- Permit only essential personnel within the zones of regulation for all freshwater features identified;
- Wherever possible, restrict decommissioning activities to the drier winter months to avoid sedimentation of the freshwater resources further downstream;
- No material may be dumped or stockpiled within the 1: 100 floodline or within 100 m of any watercourse or whichever is greatest,
- Freshwater resources and their associated zones of regulation are to be clearly demarcated and avoided wherever possible;

- An AIP management plan to be implemented and managed for the life of the proposed decommissioning, rehabilitation, closure and post-closure phases;
- As much vegetation growth as possible should be promoted within the proposed development area during all phases. In order to protect soils, vegetation clearance should be kept to a minimum;
- Monitor all freshwater systems for erosion and incision;
- All areas where active erosion is observed should be ripped, re-profiled and seeded with indigenous grasses;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any wetland areas and their associated zones of regulation. All vehicles must remain on demarcated roads and within the project area footprint;
- Compacted soils should be ripped, re-profiled and re-seeded;
- All vehicles must be regularly inspected for leaks;
- Re-fueling must take place at a diesel facility on a sealed and bunded surface area away from wetlands to prevent ingress of hydrocarbons into topsoil;
- All existing litter, effluents and debris should be removed from the freshwater systems and littering should be prohibited on an ongoing basis;
- All spills from machinery should be immediately cleaned up and treated accordingly and disposed of at an appropriate licenced facility;
- Appropriate sanitary facilities must be provided for the duration of the rehabilitation activities and all waste must be removed to an appropriate waste facility. No temporary sanitary facilities will be located within 100 m of a watercourse where practically possible;
- Monitoring should be carried out as specified in the monitoring programme.
- All incidents of erosion should be remedied and AIPs removed, as in the operational phase; and
- Any industrial pollutants should be removed and discarded at the correct facility as in the operational phase.

7 Cumulative Impacts

The proposed development is likely to result in the onset of a number of cumulative impacts for the area:

- The introduction of the SEZ and the development of an industrial hub is likely to encourage further industrial development in the area. This has the potential to result in severe impacts to the wetland and aquatic ecology of the area due to the already stretched water uses and allocations in the area;

- The Limpopo River and its associated tributaries (including the Sand and Mutamba Rivers) are already under severe pressure due to water abstraction activities and loss of catchment yield due to various developments within the catchment. This development requires substantial water user rights, which have the potential to severely impact on the sensitive riparian zones should water not be obtainable from water sources outside of the Limpopo River catchment. This is applicable on an international scale; and
- The development is likely to result in an influx of individuals seeking potential work, which has the potential to place the freshwater resources under pressure due to the need for water supply for domestic purposes and basic human needs, watering of cattle and crops (related to small-scale subsistence farming) and the increased incidence of pollution to the receiving environment, with special mention of sewage generated by informal settlement areas.

8 Monitoring Requirements

It is highly recommended that an *ad hoc* aquatic study be undertaken, should water courses such as the Sand River become inundated for a period longer than four weeks.

Monitoring by a qualified wetland and aquatic specialist with special mention of suitable riparian habitat assessment experience should take place during construction to ensure mitigation measures are adhered to. Monitoring should take place biennially during the operational phase and quarterly as well as during the decommissioning, rehabilitation and closure phases.

The Environmental Control Officer (ECO) must be present on site during construction and must ensure that the wetland areas (pans) and the ephemeral drainage lines observed and their associated zones of regulation/buffers are clearly demarcated and that no unnecessary clearing of vegetation takes place.

The table below summarises the recommended monitoring requirements to determine potential changes to the ecological functionality and the aquatic biodiversity supported by the associated watercourses:

Table 8-1: Proposed wetland and aquatic biomonitoring programme

Project Phase	Indicator	Frequency	Applicable Monitoring Sites
Wetland Monitoring			
Construction	Visual assessment	Monthly	• Identified pans within project area*
	WET-Health	Quarterly	
Operational	Visual assessment	Biennially	

	WET-Health	Biennially	• Ephemeral drainage lines* (VEGRAI only)
	EcoServices	Biennially	
	Vegetation Response Assessment Index (VEGRAI)	Biennially	
Decommissioning and rehabilitation	Visual assessment	Monthly	
	WET-Health	Quarterly	
Aquatic Monitoring			
Construction	Visual assessment	Quarterly	
	In situ water quality	Quarterly (where possible)	
	Sediment composition	Annually	
	Invertebrate Habitat Assessment System	Annually	
	South African Scoring System	Annually	

Following each of the relevant surveys, it is recommended that comparisons be made to the baseline results for sediment composition and the indicators of aquatic macroinvertebrate assemblage assessment

9 Conclusion

A total of 303.74 ha of drainage lines and wetlands were identified on site. The pans categorised as Category A (Natural) displayed no visible impacts. This was attributed to general access restrictions on the farm portion (ANTROBUS 566 – East of N1) on which these pans were observed. This is due to the private access of the game reserve. The main impacts associated with the pans categorised as Category B (Largely natural) included heavy grazing activities (remainder of the farms and portions). The final EIS scores were High for all pans. Wetland buffers were determined to be 51 m for all pans and 100m or the 1:100 year floodline for drainage lines.

In terms of aquatic ecological integrity no PES could determined for each of the biological components at the time of the survey due to the nature of the systems present within the proposed Project area, as such, no integrated EcoStatus could be determined. Nonetheless, it should be noted that the conditions observed at the time of the survey were deemed natural and representative of the region.

Most of the impacts from the construction and operation of the SEZ are major, with little option for mitigation. SEZ's are intended to be long-term industrial and economic development initiatives; it is thus unlikely for the project to be decommissioned in the foreseeable future. However, in the event that decommissioning, and closure takes place, impacts and mitigation measures were provided. Monitoring recommendations were also provided.

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Appendix A: Appendix Title

Appendix B: Appendix Title