DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RESOURCE QUALITY OBJECTIVES STUDY FOR SECONDARY CATCHMENTS A5 – A9 WITHIN THE LIMPOPO WATER MANAGEMENT AREA (WMA 1) AND SECONDARY CATCHMENT B9 IN THE OLIFANTS WATER MANAGEMENT AREA (WMA 2)

WETLAND ASSESSMENT VOLUME 1

ECOSTATUS AND PRIORITY WETLANDS

FINAL DRAFT

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Cover page photo credit: View of the Luvuvhu River, Makuleke area. Photo from Lee Berger’s Lanner Gorge expedition. 29 July 2007. Author Profberger at English Wikipedia.

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Director

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Reports that will be produced as part of this project are indicated below.

The bold type indicates this report.

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TERMINOLOGY AND ABBREVIATIONS

ACRONYMS	DESCRIPTION
AIP	Alien Invasive Plants
CBA	Critical Biodiversity Area
DSM	Digital Surface Model
DTM	Digital Terrain Model
EI	Ecological Importance
ES	Ecological Sensitivity
ESA	Ecologically Sensitive Area
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Area
HGM	Hydrogeomorphic
IBA	Important Bird and Biodiversity Areas
IEI	Integrated Environmental Importance
IS	Importance Score
IUCN	International Union for Conservation of Nature
NFEPA	National Freshwater Ecosystem Priority Area
NSBA	National Spatial Biodiversity Assessment
NWM	New Wetland Map
PES	Present Ecological State
RQO	Resource Quality Objectives
SCI	Socio-cultural Importance
SQ	Sub-quaternary
SQR	Sub-quaternary Reach
TTG	Technical Task Group
WETCON	Wetland Condition Metric
WMA	Water Management Area
WRCS	Water Resources Classification System
WRUI	Water Resource Use Importance

EXECUTIVE SUMMARY

The global wetland outlook (Convention on Wetlands, 2021) notes that globally "deterioration of wetlands is widespread, but more wetlands are still reported as in 'good' rather than 'bad' ecological character", and that biodiversity losses are linked to land-use change and continue to rise. Impacts of agriculture on wetlands are becoming more apparent and agriculture has been noted as a key driver of wetland degradation with over half of the wetlands of international importance showing damage by agriculture (Convention on Wetlands, 2021). Transformation of the agricultural industry is urgently needed if these trends are to be reversed or kept in check.

In South Africa, 48% of wetland ecosystem types are critically endangered and as a nation we have lost approximately 50% of the original wetland area (Working for Wetlands, 2021). About 300 000 wetlands remain, comprising 2.4% of South Africa's area (Working for Wetlands, 2021). Of the 791 wetland ecosystem types in South Africa, 48% are critically endangered, 12% are endangered, 5% are vulnerable, and 35% are least threatened, making wetlands South Africa's most threatened ecosystems (Working for Wetlands, 2021). In addition, over 70% of South Africa's wetlands have no protection.

This project aims to classify and determine the Reserve and Resource Quality Objectives for all significant water resources in the Secondary catchments (A5-A9) of the Limpopo WMA and B9 in the Olifants WMA.

The Scope of Work, as stipulated in the Terms of Reference, calls for the following:

- Coordinate the implementation of the Water Resources Classification System (WRCS), as required in Regulation 810 in Government Gazette 33541, by classifying all significant water resources in the Limpopo WMA (secondary catchments A5-A9) and Olifants WMA (secondary catchment B9).
- Determine the water quantity and quality components of the groundwater and surface water (rivers and wetlands) Reserve.
- Determine Resource Quality Objectives (RQOs) using the Department of Water and Sanitation Procedures to Determine and Implement Resource Quality Objectives.

This document serves as a milestone wetland report for the wetland prioritisation and ecostatus components of the abovementioned study and covers the following areas:

1) Wetland Prioritisation (approach and results).
2) Determination of the PES and REC for high priority wetlands (approach and results).

The objective of wetland prioritisation was to identify high-priority wetlands or wetland groups since wetlands are numerous and scattered throughout the study area, and limited resources prevent detailed assessment of all of them. Only the highest priority wetlands are therefore earmarked for further analysis in the process. These high-priority areas were selected based on ecological, socio-cultural and water resource use importance and are often areas of high ecological importance where water resources are stressed or may be stressed in future. A simple 7-step process was followed using the best available data (**Figure E 1**):

- Step 1: Determine wetland present ecological state (PES) at sub quaternary catchment scale.
- Step 2: Determine wetland ecological importance (EI) at the same scale as above.
- Step 3: Determine wetland sensitivity (ES) at the same scale as above.
- Step 4: Determine the wetland importance score (IS) by integrating EI, ES and socio-cultural importance (SCI).
- Step 5: Determine the integrated environmental importance of wetland/s (IEI) by integrating IS and PES.
- Step 6: Determine wetland priority by integration of IEI and water resource use importance (WRUI).
- Step 7: Contribute to determining High Priority Areas by integrating with other components.

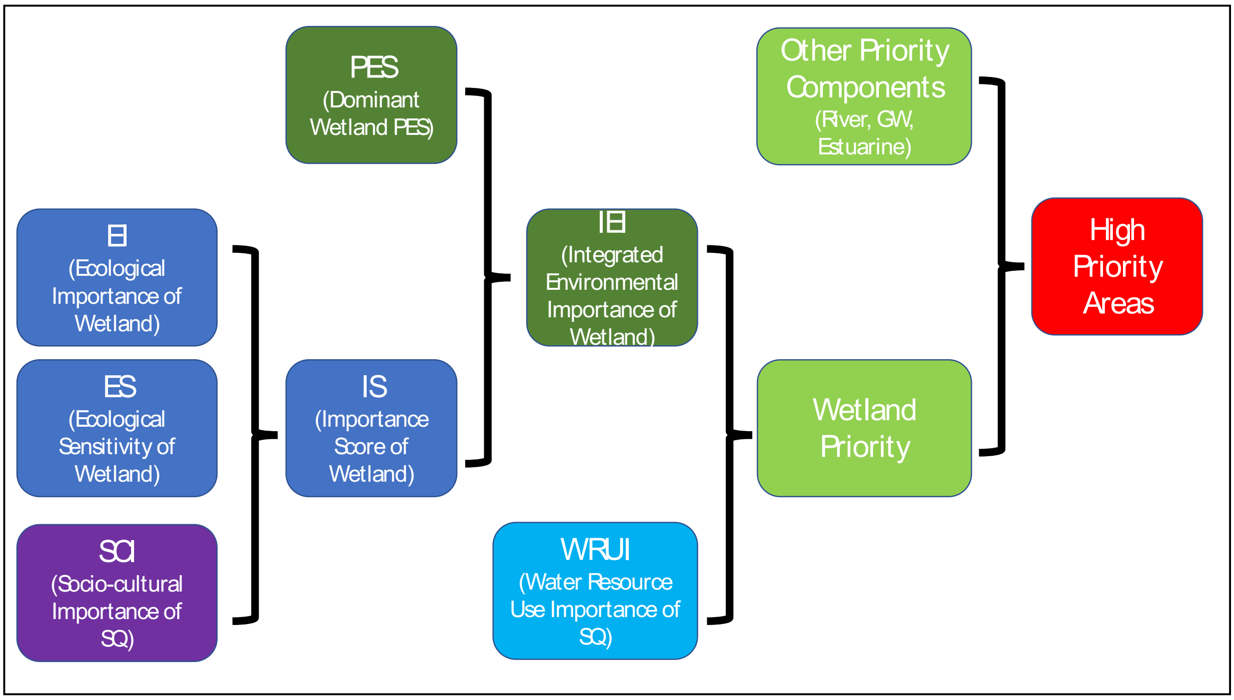

Figure E 1. Summary of the process to identify high-priority wetlands.

The results of wetland prioritisation are geographically shown in **Figure E 2** at the sub-quaternary scale and listed below. SQs with Very High priority comprised 9.7% of SQs and 37.7% of SQs had a High priority leaving just over 52% of SQs with a Moderate or Low priority. The following high priority wetlands were assessed in the field for higher confidence validation / evaluation of the PES:

- Luvuvhu Floodplain (Makuleke)
- Nyl River Floodplain

- Wonderkrater
- Nyl Pans
- Maloutswa Floodplain (Mapungubwe)
- Kolope Wetlands
- Lake Fundudzi
- Mutale Wetlands
- Mokamole wetlands – a tributary of the Mogalakwena River
- Malahlapanga (Peat dome)
- Bububu wetlands – a tributary of the Shingwedzi River

Field data collection for the Makuleke wetlands assessment was conducted from 16 to 22 Oct 2022 with 25 pans and over 600 hand-held XYZ points being surveyed. The Nyl floodplain was surveyed from 16 to 20 January 2023 with over 300 hand-held points, and the remaining high priority wetlands were surveyed in the week of 17-23 April 2023.

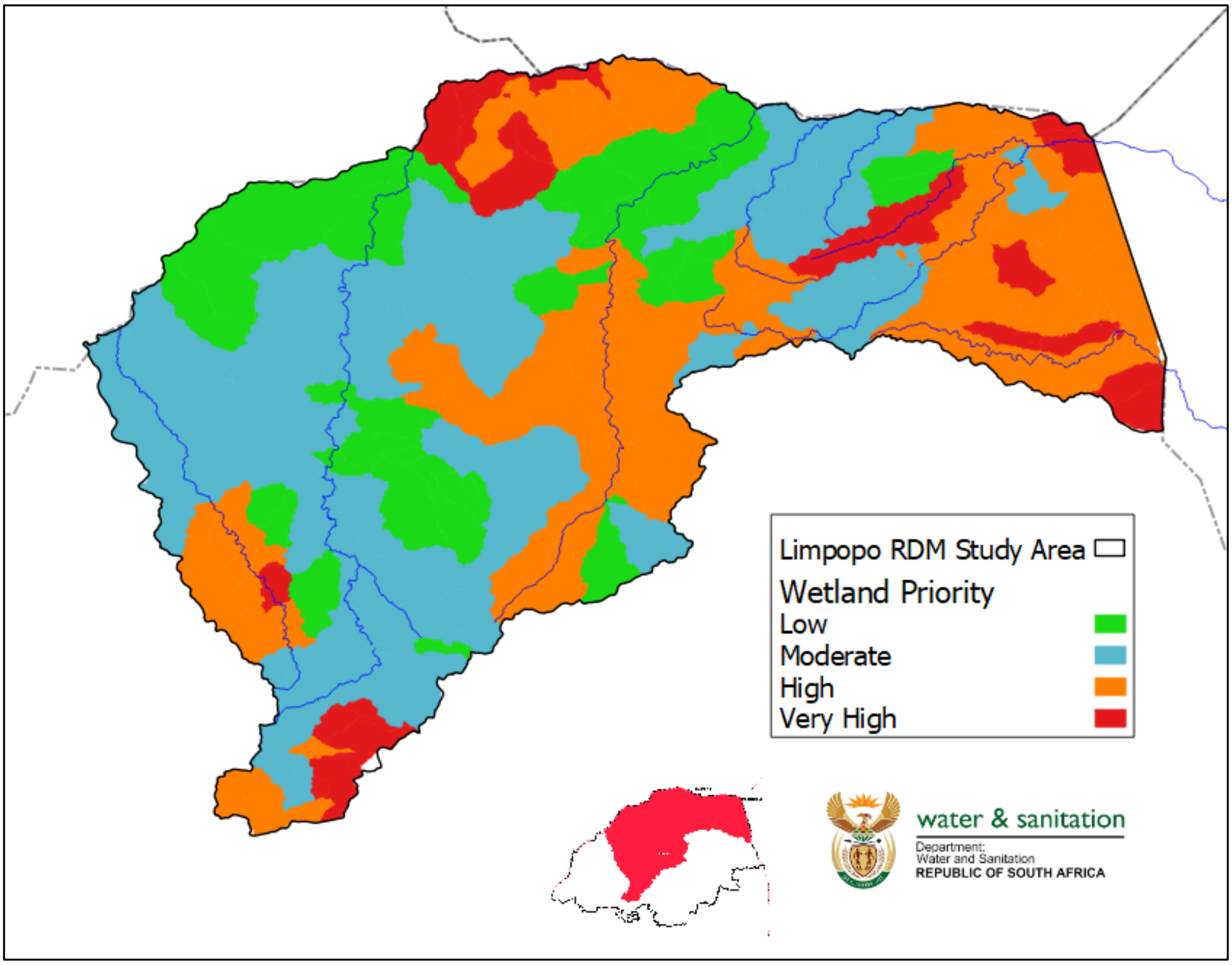

Figure E 2. Wetland priority per SQ.

The assessment of the ecostatus of high priority wetlands was achieved through the:

- Validation of the PES
- Determination of the EIS
- Determination of the REC

Both the WetHealth Level 1 and the Wetland Habitat Integrity (Wetland IHI) were used within the framework of the DWS Decision Support Protocol (DSP; Ollis et al., 2014) to determine the wetland Present Ecological Status (PES). The DSP is specifically for the rapid assessment of Wetland PES, in the form of a series of electronic spreadsheets compiled in a Microsoft Excel (.xls) format and integrates both the WETHealth and IHI tools.

The ecological importance of a wetland is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh *et al.*, 1988; Milner, 1994). The determination of ecological importance considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, 2018)
  - Diversity of wetland hydrogeomorphic (HGMs) within quinary catchment - this is a count of different HGMs within the sub-quaternary (SQ) excluding estuaries.
  - The overall extent of wetlands within a quinary catchment (Ha per SQ).
- NFEPA (2011)
  - RAMSAR status – any wetland designated as a RAMSAR site would automatically be assigned a VERY HIGH EI.
  - Wetland FEPA status – any wetland denoted as a Freshwater Ecosystem Priority Areas (FEPA) wetland was assigned a HIGH EI.
  - Wetland Cluster – does any of the wetlands within the SQ form part of a designated NFEPA wetland cluster?
  - Habitats for rare and endangered species including:
    - Cranes - wetlands (excluding dams) with the majority of its area within a SQ catchment with sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes.
    - Amphibians - wetlands within 500 m of an International Union for Conservation of Nature (IUCN)-threatened frog / toad point locality.

    - Water Birds - wetlands within 500 m of a threatened waterbird point locality.

- PES/EI/ES (DWS, 2014) – EI score (0 - 5) normalised to 4 for integration with other metrics.
- Known important peatland sites.
- Known named National Spatial Biodiversity Assessment (NSBA) wetlands
- Important Birding Areas (2015) - The Important Bird and Biodiversity Areas (IBA) Programme is a BirdLife International Programme to conserve important bird habitats. These areas are defined according to a strict set of guidelines and criteria based on the species in the area.
- Regions / Centres of Plant Endemism (Van Wyk & Smith, 2001) – a wetland that occurs in regions or centres of plant endemism.
- Regional Conservation Plans including (e.g.):
    - Limpopo Conservation Plan, version 2 (2013)
    - KwaZulu Natal - Terrestrial Critical Biodiversity Areas (CBAs) developed in 2010. This is an update to the 2007 terrestrial C-Plan (EKZNW, 2010)
    - Mpumalanga - Mpumalanga Biodiversity Conservation Plan (2006, 2014) comprising the Terrestrial Biodiversity and Freshwater Assessment (Lötter & Ferrar, 2006; Lötter, 2014; MTPA, 2014)

The determination of ecological sensitivity considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, Van Deventer et al., 2018) -
    - Dominant protection level of wetlands within SQR.
    - Dominant threat status of wetlands within SQR.
- Threatened Ecosystems (SANBI, 2011, the remaining extent of natural vegetation; NBA 2018 Technical Report Volume 1: Terrestrial Realm).
- Threatened Plant Species within SQ (SANBI, 2009).
- PES/EI/ES (DWS, 2014) – ES score (0 - 5) normalised to 4 for integration with other metrics.

A summary of the PES scores and categories, EI, ES, REC and how to achieve the REC for all assessed high priority wetlands is shown in Table E 1.

Table E 1. Summary of the PES score and category, the EI and ES and the REC for all wetlands that were assessed.

High Priority Wetland	PES Score	PES Category	EI	ES	REC	How to achieve the REC
Luvuvhu Floodplain (Makuleke)	80.0	**B/C**	Very High	Very High	**B/C**	Maintain PES
Nyl River Floodplain	65.0	**C**	Very High	Very High	**C**	Maintain PES
Wonderkrater	80.0	**B/C**	Very High	High	**B/C**	Maintain PES
Nyl Pans	57.0	**D**	High	Very High	**C/D**	Improve water quality
Maloutswa Floodplain	66.0	**C**	Very High	Very High	**C**	Maintain PES
Kolope Wetlands	90.0	**A/B**	Very High	Low	**A/B**	Maintain PES
Lake Fundudzi	78.0	**B/C**	Very High	Very High	**B/C**	Maintain PES
Mutale Wetlands	62.0	**C/D**	Very High	Very High	**C/D**	Maintain PES
Mokamole (tributary of the Mogalakwena)	80.0	**B/C**	High	High	**B/C**	Maintain PES
Malahlapanga	78.0	**B/C**	Very High	Moderate	**B**	Reduce trampling pressure from megaherbivores
Bububu wetlands (tributary of the Shingwedzi)	97.0	**A**	Very High	High	**A**	Maintain PES

The following recommendations are made:

- All wetland delineations were taken from the new wetland map 5 (van Deventer *et al*., 2018), except the Makuleke wetland complex which was updated using survey points, contours, and ecological notes and the Malahlapanga delineation. It is recommended that these new more accurate delineations be incorporated into the next national wetland map update.
- Frequently the two main drivers of deterioration in the ecostatus of wetlands are agriculture, of different forms, and invasive alien plants. The existence and operation of Working for Water SA recognizes the risks associated with alien plant species but better regulatory policies at the national scale need to take more direct cognizance of agricultural activities within delineated wetlands if wetland condition is to be conserved.

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GLOSSARY

Channel	An open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies.
Channelled valley-bottom wetland	A mostly flat valley-bottom wetland dissected by and typically elevated above a channel (see channel). Dominant water inputs to these areas are typically from the channel, either as surface flow resulting from overtopping of the channel bank/s or as interflow, or from adjacent valley-side slopes (as overland flow or interflow). Water generally moves through the wetland as diffuse surface flow, although occasional, short-lived concentrated flows are possible during flooding events (SANBI, 2009).
Erosion	The weathering, transportation and deposition of the earth's surface by wind, water and other natural forces.
Flat	A near-level wetland area (i.e. with little or no relief) with little or no gradient, situated on a plain or a bench in terms of landscape setting. The primary source of water is precipitation, with the exception of flats along the coast (usually in a plain setting) where the water table (i.e. groundwater) may rise to the surface or near to the surface in areas of little or no relief because of the location near to the base level of the land surface represented by the presence of the ocean (SANBI, 2009).
Floodplain wetland	The mostly flat or gently sloping wetland area adjacent to and formed by a lowland or upland floodplain river, and subject to periodic inundation by overtopping of the channel bank (SANBI, 2009).
Hillslope seep	A wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Water inputs are primarily from groundwater or precipitation that enters the wetland from an up-slope direction in the form of subsurface flow. Water movement through the wetland is mainly in the form of interflow, with diffuse overland flow ('sheetwash') often being significant during and after rainfall events (SANBI, 2009).
Unchannelled valley-bottom wetland	A mostly flat valley-bottom wetland area without a major channel running through it, characterised by an absence of distinct channel banks and the prevalence of diffuse flows, even during and after high rainfall events. Water inputs are typically from an upstream channel, as the flow becomes dispersed, and from adjacent slopes (if present) or groundwater. Water generally moves through the wetland in the form of diffuse surface flow and/or interflow (with some temporary containment of water in depressional areas), but the outflow can be in the form of diffuse or concentrated surface flow (SANBI, 2009).
Valleyhead seep	A gently-sloping, typically concave wetland area located on a valley floor at the head of a drainage line, with water inputs mainly from subsurface flow (although there is usually also a convergence of diffuse overland water flow in these areas during and after rainfall events). Horizontal, unidirectional (down-slope) movement of water in the form of interflow and diffuse surface flow dominates within a valleyhead seep, while water exits at the downstream end as concentrated surface flow where the valleyhead seep becomes a channel (SANBI, 2009).

Wetland	Any ecosystem that has an aquatic base or hydrological driving force and possesses both upland and aquatic characteristics. National Water Act (1998): A wetland is land which is transitional between terrestrial and aquatic systems where the water table is at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

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- Richard Sowry (Section Ranger, Pafuri) for permits and access to KNP and for allotting game guards to field work on the Makuleke wetlands.
- Origin Ndlovu served as our game guard while working on the Makuleke wetlands.

1 INTRODUCTION

A wetland is defined in the National Water Act (Act 36 of 1998) as the land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. Wetlands are crucial ecosystems that provide a wide range of ecological, social, and economic benefits, including biodiversity hotspots, water filtration and purification, flood attenuation, baseflow assurance and maintenance of stream permanency, soil stabilisation, climate change mitigation, recreational and aesthetic value, cultural and spiritual value and their role in research and education. Protecting and preserving wetlands is critical for maintaining biodiversity, ensuring water quality and quantity, and promoting sustainable development.

The global wetland outlook (Convention on Wetlands, 2021) notes that globally "deterioration of wetlands is widespread, but more wetlands are still reported as in 'good' rather than 'bad' ecological character", and that biodiversity losses are linked to land-use change and continue to rise. Impacts of agriculture on wetlands are becoming more apparent and agriculture has been noted as a key driver of wetland degradation with over half of the wetlands of international importance showing damage by agriculture (Convention on Wetlands, 2021). Transformation of the agricultural industry is urgently needed if these trends are to be reversed or kept in check.

In South Africa, 48% of wetland ecosystem types are critically endangered and as a nation we have lost approximately 50% of the original wetland area (Working for Wetlands, 2021). About 300 000 wetlands remain, comprising 2.4% of South Africa's area (Working for Wetlands, 2021). Of the 791 wetland ecosystem types in South Africa, 48% are critically endangered, 12% are endangered, 5% are vulnerable, and 35% are least threatened, making wetlands South Africa's most threatened ecosystems (Working for Wetlands, 2021). In addition, over 70% of South Africa's wetlands have no protection.

Mitsch and Gosselink (2000) noted that "Wetlands do not just do one thing" outlining that they perform many processes simultaneously and have value because their functions have proved to be useful to humans. The importance and value of protecting wetlands contributed to the formation of Working for Wetlands, who began with the restoration of wetlands in South Africa in 2000 in an effort to protect and promote their wise-use and engage in wetland rehabilitation. The National Environmental Management Act 107 of 1998 (NEMA), the National Water Act 36 of 1998 (NWA) and the environmental provisions of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) are meant to ensure that urban and commercial developments do not significantly affect or alter the natural state and function of wetlands (Working for Wetlands, 2021).

According to the latest national wetland map (National biodiversity assessment; van Deventer *et al.*, 2018) there are almost 77 000 Ha of wetlands in the study area (**Figure 1-1**). This includes two

RAMSAR sites, the Nylsvley floodplain and the Makuleke wetland complex associated with the Luvuvhu and Limpopo rivers. The National Spatial Biodiversity Assessment focused on the terrestrial, freshwater and marine components of biodiversity and its aim was to assess where our important biodiversity is, how much we should conserve, and whether the current system of protected areas in the country is adequate. The freshwater assessment identified diversity of river systems in the country amongst other outcomes and also identified and named notable wetlands, and the distribution of springs, thermal springs, oxbows and waterfalls. The details of notable wetlands from this assessment that occur in the study area, are shown in **Table 1-1** (after DWS, 2022a).

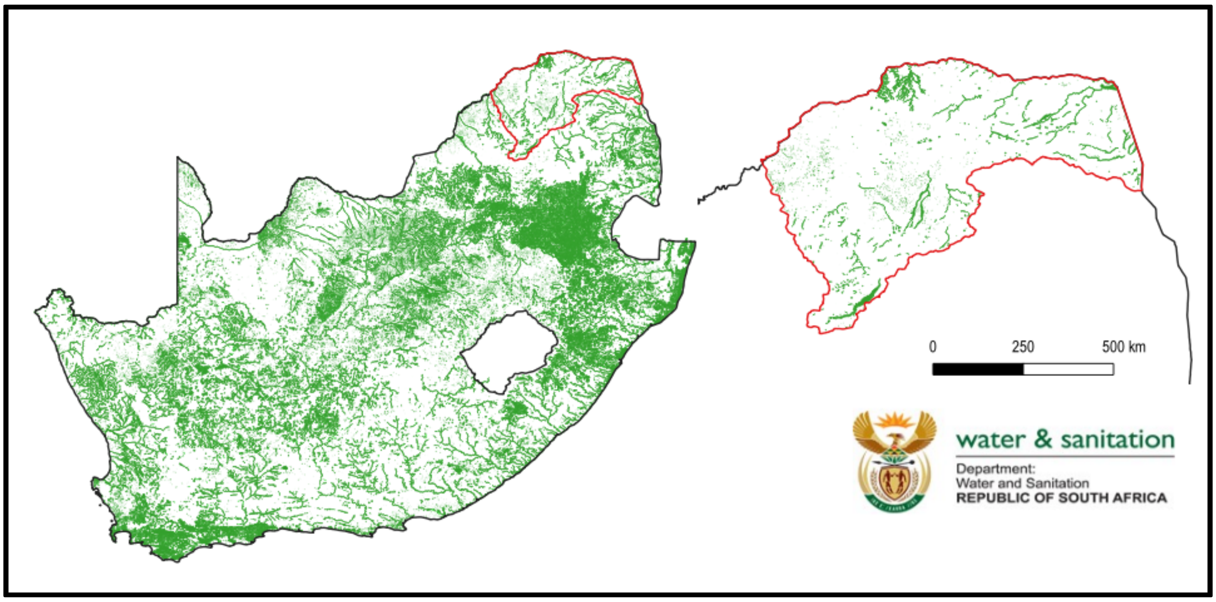

Figure 1-1. Wetlands within South Africa (left) and the study area (right; 2018 updated wetland map 5; van Deventer *et al.*, 2018).

Table 1-1. Detail of named wetlands from the National Spatial Biodiversity Assessment (Driver *et al.*, 2005) that occur in the study area.

Wetland RU	IUA	Name	Source	Description	Status	Threat Status
RU 1	Upper Nyl and Sterk	Nyl Floodplain	riverine	riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland	No legal protection	Moderate threat
RU 2	Upper Nyl and Sterk	Matlapitsi	riverine	permanent rivers and streams, including waterfalls	Unknown	unknown
RU 3	Upper Lephalala	Lephalala	riverine	permanent rivers and streams, including waterfalls	Partly protected	unknown
RU 8	Mapungubwe	Maloutswa Floodplain	riverine	riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland	Partly protected	No known threat
RU 11	Lower Sand	Soutpan	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	No information	No information
RU 11	Lower Sand	Zoutpan	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	No information	High threat
RU 13	Nzhelele / Nwanedi	Melrose Farm	riverine	riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland	No information	No information
RU 14	Upper Luvuvhu / Mutale	Mutale	riverine	permanent rivers and streams, including waterfalls	Unknown	unknown
RU 14	Upper Luvuvhu / Mutale	Fundudzi	lacustrine	permanent freshwater lakes (+8 ha), including shores subject to seasonal or irregular inundation	No information	No information
RU 15	Lower Luvuvhu	Limpopo-Levubu	riverine	riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland	Partly protected	No known threat
RU 15	Lower Luvuvhu	Mutale	riverine	riverine floodplains, including river flats, flooded river basins, seasonally flooded grassland	No information	No known threat

Wetland RU	IUA	Name	Source	Description	Status	Threat Status
RU 15	Lower Luvuvhu	Banyini Pan	lacustrine	permanent freshwater lakes (+8 ha), including shores subject to seasonal or irregular inundation	Fully protected	No known threat
RU 15	Lower Luvuvhu	Makwadzi Pan	lacustrine	permanent freshwater lakes (+8 ha), including shores subject to seasonal or irregular inundation	Fully protected	Moderate threat
RU 15	Lower Luvuvhu	Spokonyolo Pan	lacustrine	permanent freshwater lakes (+8 ha), including shores subject to seasonal or irregular inundation	Fully protected	No known threat
RU 15	Lower Luvuvhu	Mathlaguza	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	Moderate threat
RU 15	Lower Luvuvhu	Ximuweni	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	Minor threat
RU 16	Shingwedzi	Klawer	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	Moderate threat
RU 16	Shingwedzi	Magwitsi	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	High threat
RU 16	Shingwedzi	Masokosa	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	No known threat
RU 16	Shingwedzi	Mintomeni	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	No known threat
RU 16	Shingwedzi	Nwambiya	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	Moderate threat
RU 16	Shingwedzi	Xirhamberhombe Pans	endopans	permanent and seasonal, brackish, saline, or alkaline lakes, flats, pans, and marshes	Fully protected	No known threat

1.1 Background

The Department of Water and Sanitation, Chief Directorate: Water Ecosystems Management initiated a three-year study, which was extended to a fourth year, for the Determination of Water Resource Classes, Reserve and Resource Quality Objectives for Secondary Catchments A5-A9 within the Limpopo Water Management Area (WMA 1) and Secondary Catchment B9 in the Olifants Water Management Area (WMA 2).

The suite of Resource Directed Measure (RDM) tools being implemented in these catchments aims to ensure sustainable utilisation of water resources to meet the ecological, social and economic needs of the communities dependent on them and to provide a mechanism against which the objectives set can be monitored for compliance. One of these RDM tools is the quantification of the Basic Human Needs (BHNR) and Ecological Water Requirements (EWR), the steps of which are shown in **Figure 1-2.**

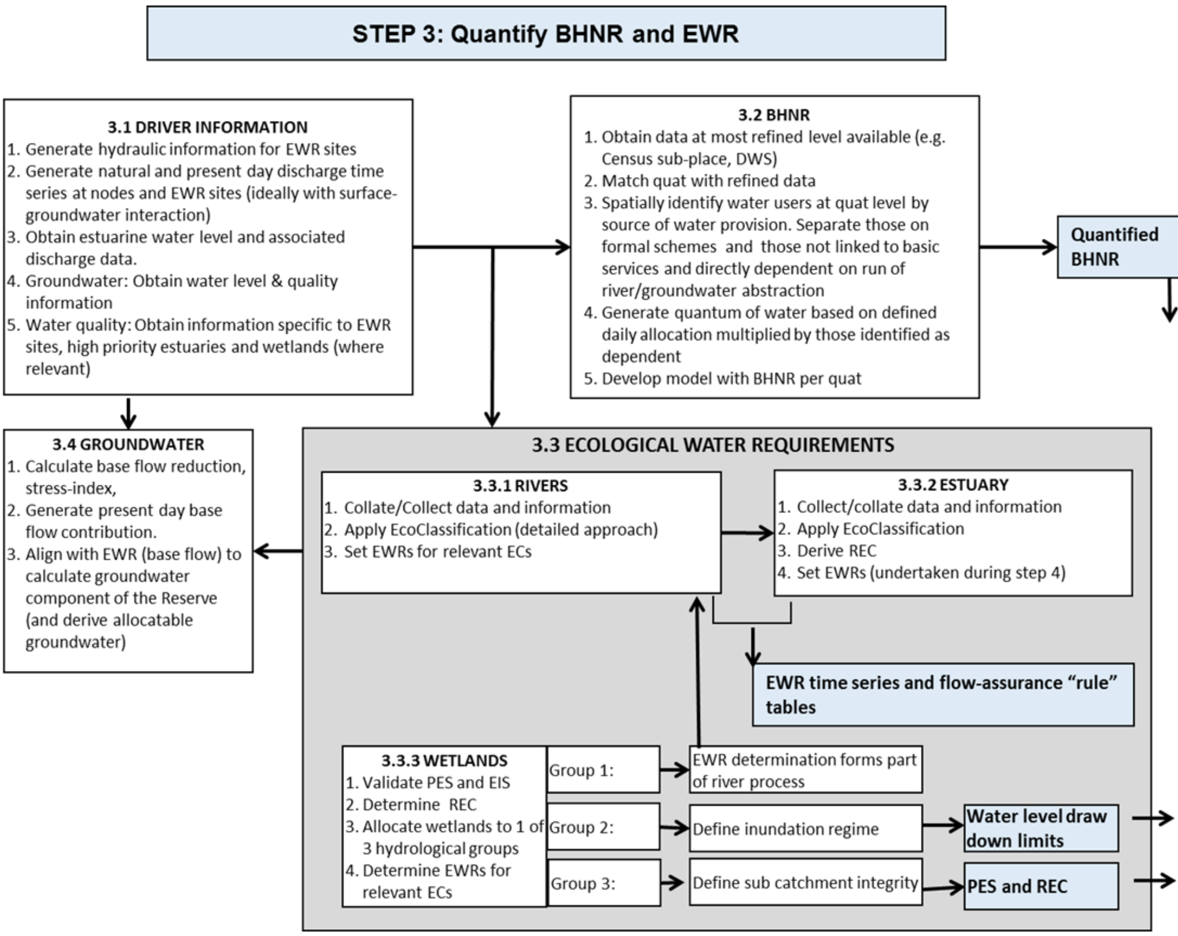

Figure 1-2. Illustration of the sub-steps for Integrated Step 3: Quantify BHNR and EWR.

The wetland component for the EWR step is comprised of 4 sub-tasks: Determine the dominant wetland hydrogeomorphic type (HGM), determine the level of RDM study, assess the ecostatus of high priority wetlands and determine the EWR, or other RDM to achieve the Recommended Ecological Category (REC).

Determine dominant wetland HGM type.

The HGM wetland type dictates the method of RDM study, as there are different types of assessment methods and EWR determination approaches for different types of wetlands (pans and lakes, for example, require different types of expertise and hydrological and hydraulic approaches to those used on floodplains). For the Rapid Reserve methods for wetlands, the DWAF (2007) and Rountree and Batchelor (2013) HGM wetland classification has been followed although the classification system for wetlands developed by Ollis et al. (2013) is being applied more widely as a standard approach to wetland classification throughout South Africa.

Determine appropriate level of RDM study for wetlands.

The document "Guideline for identifying appropriate levels of Resource Protection Measures for Inland Wetlands" (DWA, 2012) provides a framework for selecting the appropriate level of RDM study for wetlands. This approach uses the type of wetland and impact type, or threat being considered to identify an appropriate level of RDM assessment. The RDM assessment may be either a quantitative EWR determination, a qualitative EWR determination or, in the most simple (low risk) situations, the determination of simple conditions to achieve the REC.

- *Quantitative EWR*: Provision of a quantifiable water requirement in terms of volumetric water requirement. This approach would be applied to systems where the primary source of inflows is from a river, such as a floodplain. However, the approach takes into account more than just river inflows and might consider rainfall and evaporation. Outputs may, for example be a time series of river discharge, inflows, outflows and saturation of wetland units.
- *Qualitative EWR:* Provision of a non-volumetric water requirement. This would apply to wetlands where maintenance of inundation levels or extents (defined temporally) would reflect the hydrological functioning of a wetland required for the maintenance of a desired ecological condition. The output could, for example, be a time series of water levels.
- *Conditions for achieving REC:* Provision of simple ecological or site management conditions for the maintenance of wetland integrity to achieve the REC.

Assess EcoStatus of priority wetlands

This is achieved through the following:

- Validating or determining the PES.
- Determining the Ecological Importance and Sensitivity (EIS).
- Determining the REC.

1.2 Objectives of the Study

This project aims to classify and determine the Reserve and Resource Quality Objectives for all significant water resources in the Secondary catchments (A5-A9) of the Limpopo WMA and B9 in the Olifants WMA.

The Scope of Work, as stipulated in the Terms of Reference, calls for the following:

- Coordinate the implementation of the Water Resources Classification System (WRCS), as required in Regulation 810 in Government Gazette 33541, by classifying all significant water resources in the Limpopo WMA (secondary catchments A5-A9) and Olifants WMA (secondary catchment B9).
- Determine the water quantity and quality components of the groundwater and surface water (rivers and wetlands) Reserve.
- Determine Resource Quality Objectives (RQOs) using the Department of Water and Sanitation Procedures to Determine and Implement Resource Quality Objectives.

1.3 Objectives of this document

This document serves as a milestone wetland report for the wetland prioritisation and ecostatus components of the abovementioned study and covers the following areas:

1) Wetland Prioritisation
    a. Approach taken
    b. Results
2) Determination of the PES and REC for high priority wetlands.
    a. Approach taken
    b. Results

2 WETLAND ECOLOGICAL IMPORTANCE AND PRIORITY

2.1 Approach to Prioritise Wetlands

The objective of this step was to identify high-priority wetlands or wetland groups since wetlands are numerous and scattered throughout the study area, and limited resources prevent detailed assessment of all of them. Only the highest priority wetlands are therefore earmarked for further analysis in the process. These high-priority areas were selected based on ecological, socio-cultural and water resource use importance and are often areas of high ecological importance where water resources are stressed or may be stressed in future. A simple 7-step process was followed using the best available data (**Figure 2-1)**:

- Step 1: Determine wetland present ecological state (PES) at sub quaternary catchment scale.
- Step 2: Determine wetland ecological importance (EI) at the same scale as above.
- Step 3: Determine wetland sensitivity (ES) at the same scale as above.
- Step 4: Determine the wetland importance score (IS) by integrating EI, ES and socio-cultural importance (SCI).
- Step 5: Determine the integrated environmental importance of wetland/s (IEI) by integrating IS and PES.
- Step 6: Determine wetland priority by integration of IEI and water resource use importance (WRUI).
- Step 7: Contribute to determining High Priority Areas by integrating with other components.

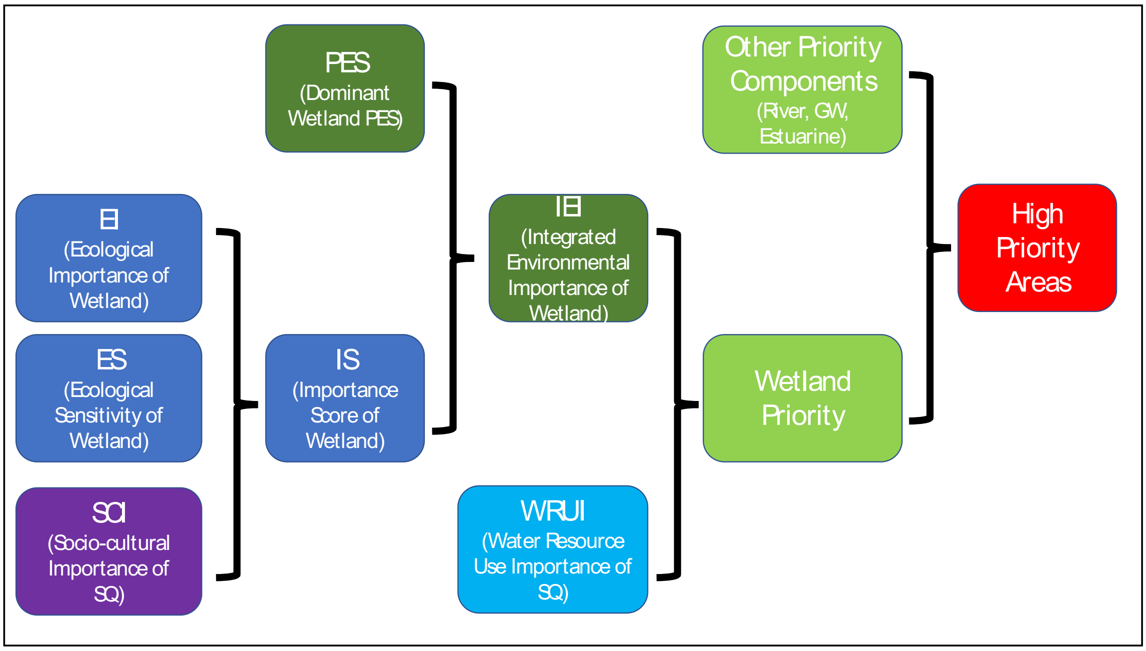

Figure 2-1. Summary of the process to identify high-priority wetlands.

2.1.1 Present Ecological State

The assessment of wetland PES relied on the best available data from mainly three sources:

- The riparian and wetland metrics within the PES/EI/ES database (DWS, 2014).
- The wetland condition metric (WETCON) within the new wetland map (NWM) metadata from the 2018 National Biodiversity Assessment (NBA) (van Deventer *et al.*, 2018).
- The WETCON within the National Freshwater Ecosystem Priority Areas (NFEPA) map metadata (Nel *et al.*, 2011).

Both riparian / wetland metrics rated in the PES/EI/ES database (DWS, 2014) were used as surrogate measures of wetland condition by taking an average of the following two metric scores.

- Riparian / wetland zone modification relates to “modifications that indicate the potential that wetland zones may have been changed from reference [condition] in terms of structure and composition that may influence these zones regarding functioning and processes occurring within these zones” and also refers to these zones as habitats for biota.
- Riparian / wetland zone continuity modification relates to “modifications that indicate the potential that riparian/wetland connectivity may have changed from the reference [condition]”. Physical fragmentation (longitudinal and lateral) is the indicator of wetland continuity. It includes, for example, inundation by weirs and dams, physical removal for farming, mining, overgrazing etc. and the presence of roads or other human structures, e.g. urban areas.

The underlying assumption is that these two metrics incorporate wetlands within each sub-quaternary reach (SQR) and, as such, should provide a useful measure of a more detailed investigation (visual assessment by a specialist using satellite imagery) of the overall ecological state.

The NFEPA project and the NBA produced an estimation of wetland condition and the final ecological condition of inland wetlands modelled from ancillary data (using mainly land use within variously defined buffer zones around wetlands). They have been used here as a measure of the present ecological state. The possible ratings in the NFEPA data are either A/B (natural or good - % natural land cover ≥ 75%), C (moderately modified - % natural land cover 25-75%), D/E/F (heavily to critically modified), Z1 (artificial wetland and excluded from this assessment), Z2 (majority of the wetland classified as artificial and excluded from this assessment) or Z3 (heavily to critically modified - % natural land cover < 25%). Similarly, the possible ratings in the new wetland map (2018) data are either A/B (natural or good - % natural land cover ≥ 75%), C (moderately modified - % natural land cover 25 - 75%), D/E/F (heavily to critically modified), or not assessed. To integrate the WETCON categories with the PES/EI/ES ratings, each was assigned a score as follows: A/B a score of 1, C a score of 2, D/E/F a score of 3.5 and Z3 a score of 5. The average of the PES/EI/ES, NFEPA and NWM scores was taken to represent an integrated PES score presented herein as the final wetland PES for use within prioritisation.

2.1.2 Integrated Environmental Importance

Determining Integrated Environmental Importance (IEI) for wetlands entailed the consideration of PES, EI, ES and SCI. The ecological importance of a wetland is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh *et al.*, 1988; Milner, 1994).

Ecological Importance

The determination of EI considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, 2018)
  - Diversity of wetland hydrogeomorphic (HGMs) within quinary catchment - this is a count of different HGMs within the sub-quaternary (SQ) excluding estuaries.
  - The overall extent of wetlands within a quinary catchment (Ha per SQ).
- NFEPA (2011)
  - RAMSAR status – any wetland designated as a RAMSAR site would automatically be assigned a VERY HIGH EI.
  - Wetland FEPA status – any wetland denoted as a Freshwater Ecosystem Priority Areas (FEPA) wetland was assigned a HIGH EI.
  - Wetland Cluster – does any of the wetlands within the SQ form part of a designated NFEPA wetland cluster?
  - Habitats for rare and endangered species including:
    - Cranes - wetlands (excluding dams) with the majority of its area within a SQ catchment with sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes.
    - Amphibians - wetlands within 500 m of an International Union for Conservation of Nature (IUCN)-threatened frog / toad point locality.
    - Water Birds - wetlands within 500 m of a threatened waterbird point locality.
- PES/EI/ES (DWS, 2014) – EI score (0 - 5) normalised to 4 for integration with other metrics.
- Known important peatland sites.
- Known named National Spatial Biodiversity Assessment (NSBA) wetlands

- Important Birding Areas (2015) - The Important Bird and Biodiversity Areas (IBA) Programme is a BirdLife International Programme to conserve important bird habitats. These areas are defined according to a strict set of guidelines and criteria based on the species in the area. The Important Bird Areas of Southern Africa directory was first published in 1998 and identified within South Africa 122 IBAs. In September 2015, a revised IBA Directory was published by BirdLife South Africa. All these IBAs were objectively determined using established and globally accepted criteria. An IBA is defined by the presence of any of the following bird species in a geographic area: Bird species of global or regional conservation concern, assemblages of restricted-range bird species, assemblages of biome-restricted bird species, and concentrations of numbers of congregatory bird species. If any of the wetlands within the SQR overlap with a designated IBA, then they are rated accordingly (see below).
- Regions / Centres of Plant Endemism (Van Wyk & Smith, 2001) – a wetland that occurs in regions or centres of plant endemism.
- Regional Conservation Plans including (e.g.):
    - Limpopo Conservation Plan, version 2 (2013)
    - KwaZulu Natal - Terrestrial Critical Biodiversity Areas (CBAs) developed in 2010. This is an update to the 2007 terrestrial C-Plan (EKZNW, 2010)
    - Mpumalanga - Mpumalanga Biodiversity Conservation Plan (2006, 2014) comprising the Terrestrial Biodiversity and Freshwater Assessment (Lötter & Ferrar, 2006; Lötter, 2014; MTPA, 2014)

Each criterion was scored according to the system shown in **Table 2-1** and the IEI for each SQR was calculated using the maximum value assigned during this process.

Table 2-1. Determination of EI score: Scoring assigned to assessed criteria based on their state within each SQ. Scoring was from 0 (low / none) to 4 (high / most)

Criteria	State	Score
Wetland diversity	5 or more HGMs	4
	3 or more HGMs	3
	2 HGMs	2
	1 HGM	1
	No wetlands	0
Wetland extent (Ha; total for SQ):	>= 500 Ha	4
	>= 100 Ha	3
	>= 50 Ha	2
	>= 5 Ha	1.5
	< 5 Ha	1
Ramsar Status	Yes	4

Criteria	State	Score
	No	0
Wetland FEPA status	Yes	3
	No	0
NFEPA wetland cluster	Yes	2.5
	No	0
Known important peatland sites	Yes	4
	No	0
Habitat for Cranes	Yes	3
	No	0
Habitat for Amphibians	Yes	3
	No	0
Habitat for Water Birds	Yes	3
	No	0
Important Birding Area	Yes	3
	No	0
Within a region / centre of Plant Endemism	Yes	2.5
	No	0
Critical Biodiversity Area (dominant status of SQ)	CBA 1	3
	CBA 2	2
	CBA 3	1
	ESA 1	2
	ESA 2	1
	Other Natural areas	2
	Highly Significant	3
EI from PES/EI/ES for rip/wet metrics	EI score (normalised to 4)	As stated

Ecological Sensitivity

The determination of ES considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, Van Deventer et al., 2018) -
    - Dominant protection level of wetlands within SQR.
    - Dominant threat status of wetlands within SQR.
- Threatened Ecosystems (SANBI, 2011, the remaining extent of natural vegetation; NBA 2018 Technical Report Volume 1: Terrestrial Realm).
- Threatened Plant Species within SQ (SANBI, 2009).
- PES/EI/ES (DWS, 2014) – ES score (0 - 5) normalised to 4 for integration with other metrics.

Each criterion was scored according to the system shown in **Table 2-2** and the integrated ES for each SQ was calculated using the maximum value assigned during this process.

Table 2-2. Determination of ES score: Scoring assigned to assessed criteria based on their state within each SQ. Scoring was from 0 (low / none) to 4 (high / most).

(CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LC – Least Concern, NT – Not Threatened)

Criteria	State	Score
Dominant wetland protection level within SQR	Not protected	3
	Poorly protected	2
	Moderately protected	1
	Well protected	0
Dominant threat status of wetlands within SQR	Critical	4
	Endangered	3.5
	Vulnerable	3
	Not threatened / not assessed	1
Threatened ecosystems within SQ	CR	4
	EN	3.5
	VU	3
	NT	2
	LC	1
Threatened plant species within SQ	CR listed species in SQ	4
	NE listed species in SQ	3.5
	VU listed species in SQ	3
	NT listed species in SQ	2.5
	Rare species listed in SQ	3
	Declining listed species in SQ	2
	LC listed species in SQ	1
ES from PES/EI/ES for rip/wet metrics	ES score (normalised to 4)	As stated

Socio-cultural Importance (SCI)

The SCI is conducted by a separate specialist team as part of this study. This work is ongoing and will be reported on in the Evaluation of Resource Unit Report. These SCI scores were directly employed as is in the wetland evaluation per quinary catchment.

Integrated Environmental Importance (IEI)

As shown above, in Figure 6.1, the Ecological (EI and ES) and SCI were assessed separately and were then integrated with the PES to determine the IEI of wetlands. The PES forms part of the IEI as wetlands in good condition have importance in their own right. A wetland that is in good condition, but has a low EI, ES, and/or SCI, may still be important from an ecological perspective.

The Importance Score (IS) is calculated from the median of the EI, ES and SCI scores. The IS is then integrated with the PES score to determine the IEI score. This is then called the Integrated Environmental Importance and is defined as VERY HIGH (IEI score = 5), HIGH (IEI score = 4), MODERATE (IEI score = 3), LOW (IEI score = 2) or VERY LOW (IEI score =1) according to the comparison matrix shown in **Table 2-3**).

Table 2-3. Matrix used to determine Wetland Integrated Environmental Importance (IEI) comparing the EI, ES, SCI (IS) and PES scores

IS: EI, ES &SCI	**Very high**	**4**	3	3	3	4	5	5	5	5
	High	**3**	3	3	3	3	4	5	5	5
	Moderate	**2**	2	2	2	3	3	4	5	5
	Low	**1**	1	1	2	2	3	4	4	4
	Very low	**0**	1	1	1	2	2	3	4	4
			D/E to F	**D**	**C/D**	**C**	**B/C**	**B**	**A/B**	**A**
			>3.2	**2.7-3.2**	**2.3-2.6**	**1.7-2.2**	**1.3-1.6**	**0.7-1.2**	**0.3-0.6**	**<0.3**
			PES							

2.1.3 Priority Wetlands

The final prioritisation of wetlands per SQ considers both the IEI (a measure of the ecological and social importance of the wetland) and the WRUI (a measure of demand on or risk to the wetland). The WRUI were directly employed as is in the wetland priority evaluation. The IEI and WRUI were integrated using a matrix of scores (Louw and Huggins, 2007; **Table 2-4**) to determine the final priority rating, which can range from 1 to 4, where 1 is Low and 4 is Very High. RU priority was the maximum SQ priority rating for all SQs within the RU.

Table 2-4. Matrix used to determine wetland priority by comparing the IEI and the WRI for the SQ, where priority can be 1: Low, 2: Moderate, 3: High or 4: Very High

IEI	**Very high**	**5**	2	2	2	2	3	3	4	4	4
	High	**4**	1	2	2	2	2	3	3	4	4
	Moderate	**3**	1	1	1	2	2	2	3	3	3
	Low	**2**	1	1	1	1	1	2	2	2	3
	Very low	**1**	1	1	1	1	1	1	1	2	2
			0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
			Very low	**Low**		**Moderate**		**High**		**Very high**	
			Water Resource Importance								

2.2 Results

2.2.1 Present Ecological State

The results of the preliminary PES assessments are geographically shown in **Figure 2-2** at the sub-quaternary scale, where the SQ carries the dominant PES value and category for all the wetlands within it. The results are also tabulated in **Table 2-5**. Overall, the study area comprises a mixture of PES categories with only 5.9% of them in a category B and 8.1% in a category E. The bulk of the SQs are from B/C to D/E with D the most common (26% of SQs) and the other categories with similar abundance (10.2% are B/C, 22.9% are C, 11.4% are C/D and 14.4% are D/E).

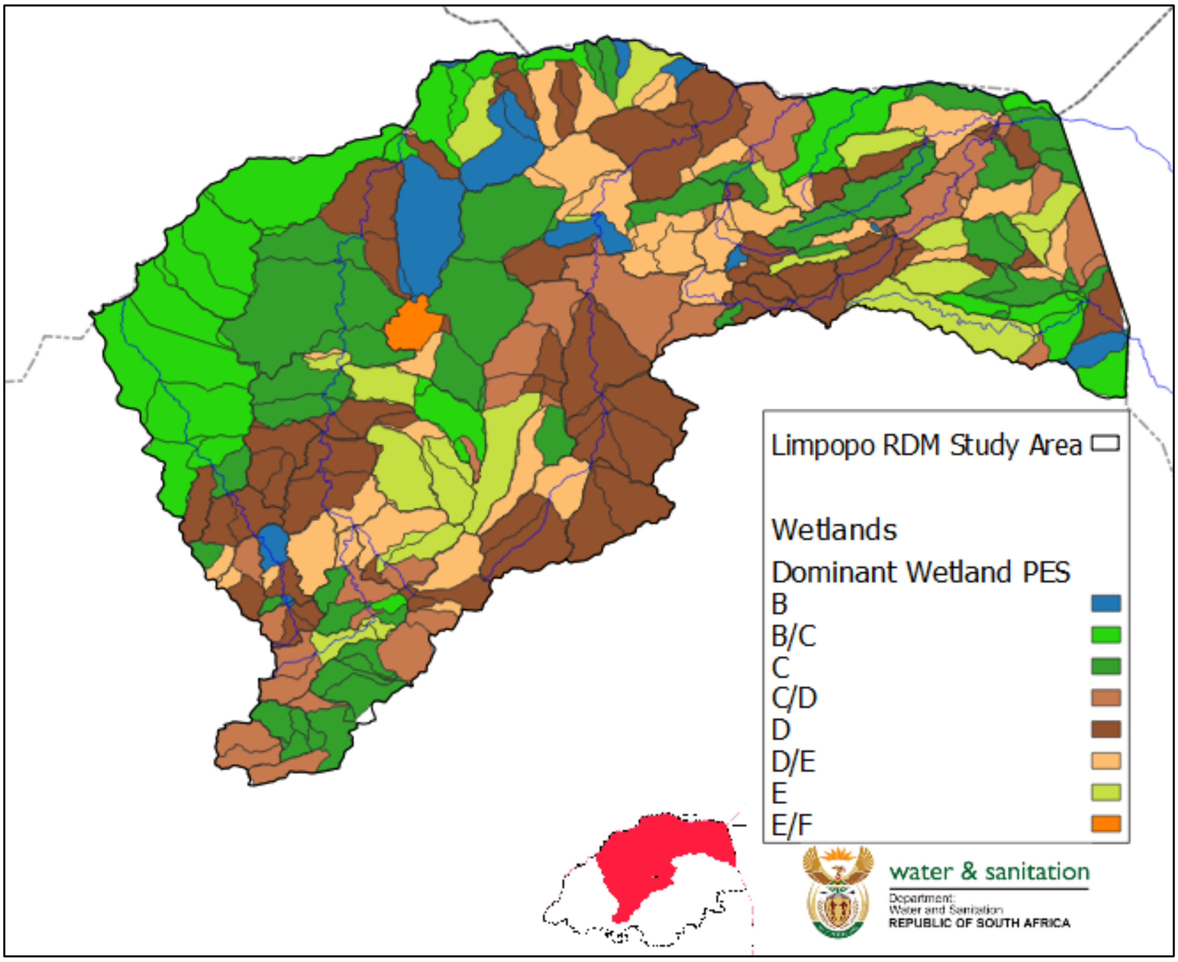

Figure 2-2. Wetland PES (dominant state of each SQ).

2.2.2 Ecological Importance (EI)

The results of the EI assessments are geographically shown in **Figure 2-3** at the sub-quaternary scale, where the SQ carries the dominant EI value and category for all the wetlands within it. The results are also tabulated in **Table 2-5**. Over 50% of the SQs had an ecological importance of Very High and almost 35% of High.

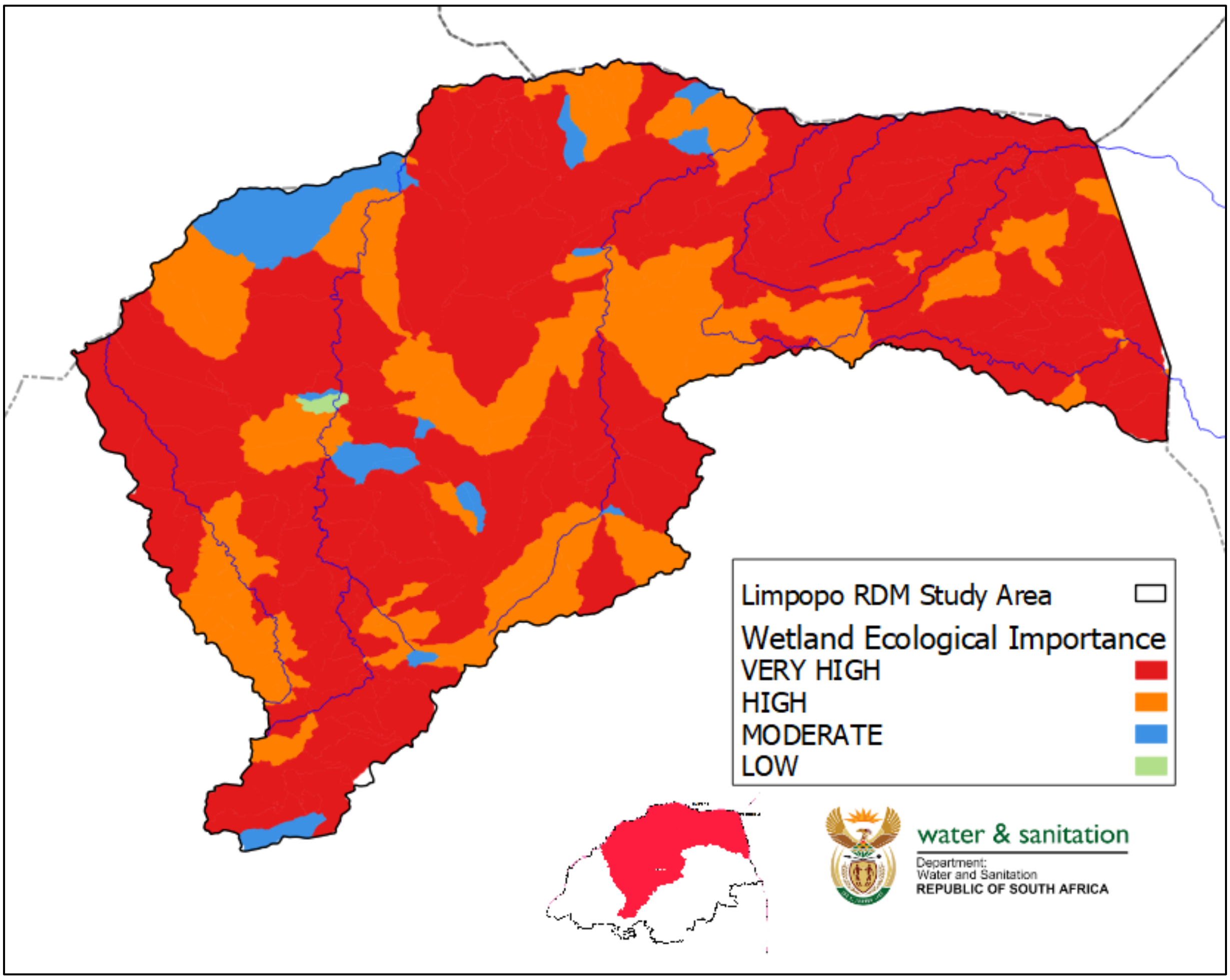

Figure 2-3. Wetland EI (dominant state of the SQ).

2.2.3 Ecological Sensitivity (ES)

The results of the ES assessments are geographically shown in **Figure 2-4** at the sub-quaternary scale, where the SQ carries the dominant ES value and category for all the wetlands within it. The results are also tabulated in **Table 2-5.** Almost 50% of the SQs had an ecological sensitivity of Very High and 10% were High.

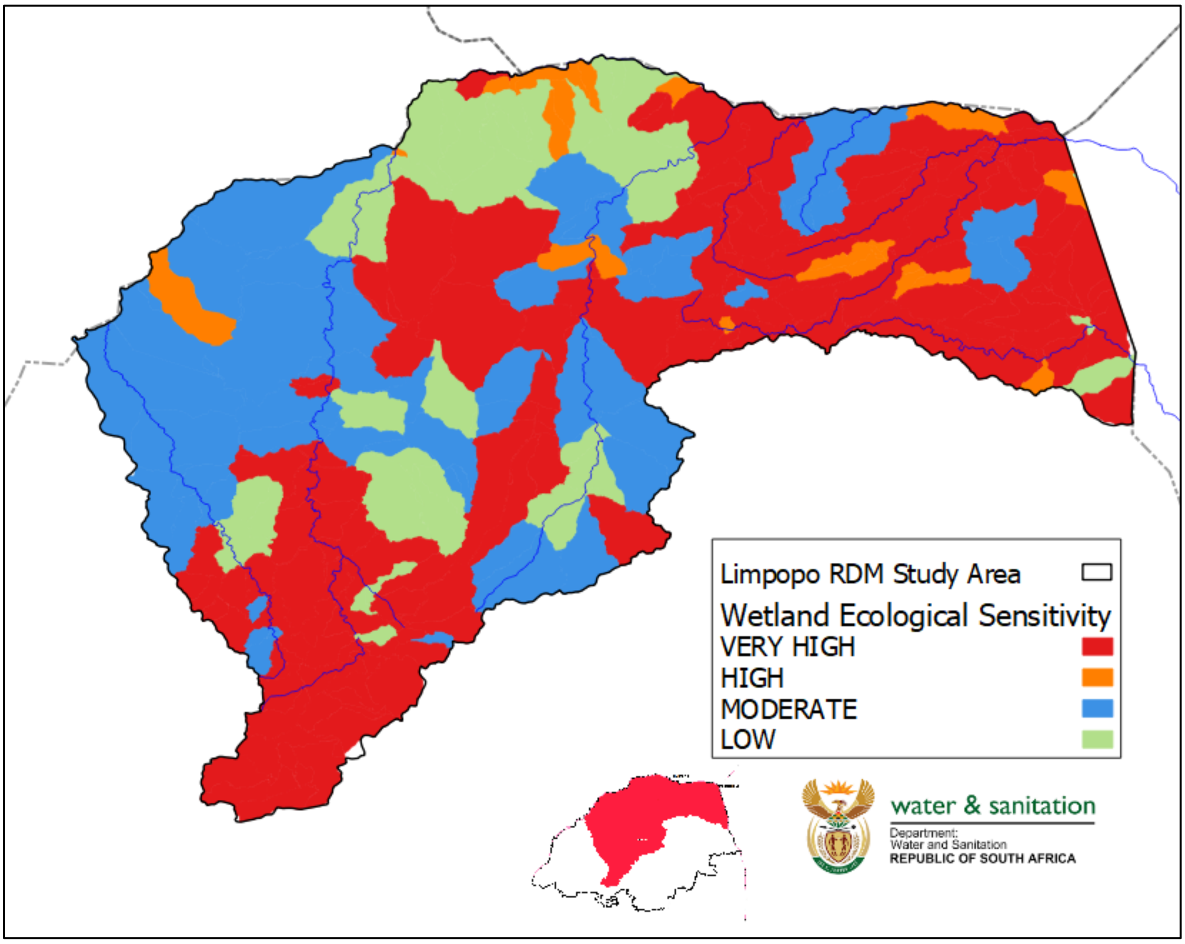

Figure 2-4. Wetland ES (dominant state of the SQ).

2.2.4 Integrated Environmental Importance (IEI)

The results of the IEI assessments are geographically shown in **Figure 2-5** at the sub-quaternary scale, where the SQ carries the dominant IEI value for all the wetlands within it.

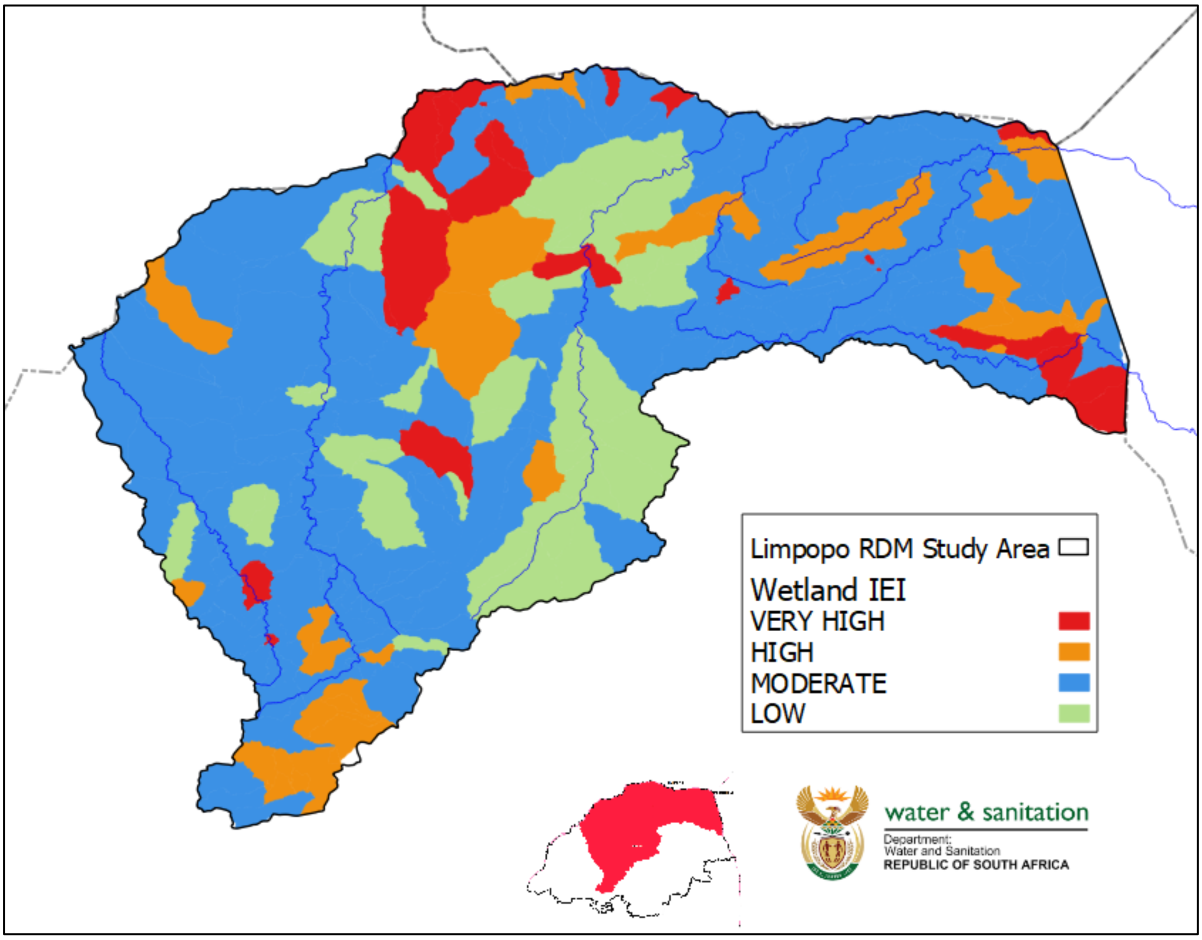

Figure 2-5. Wetland IEI (dominant state of the SQ).

2.2.5 Wetland Priority

The results of wetland prioritisation are geographically shown in **Figure 2-6** at the sub-quaternary scale and are also tabulated in **Table 2-5**. SQs with Very High priority comprised 9.7% of SQs and 37.7% of SQs had a High priority leaving just over 52% of SQs with a Moderate or Low priority.

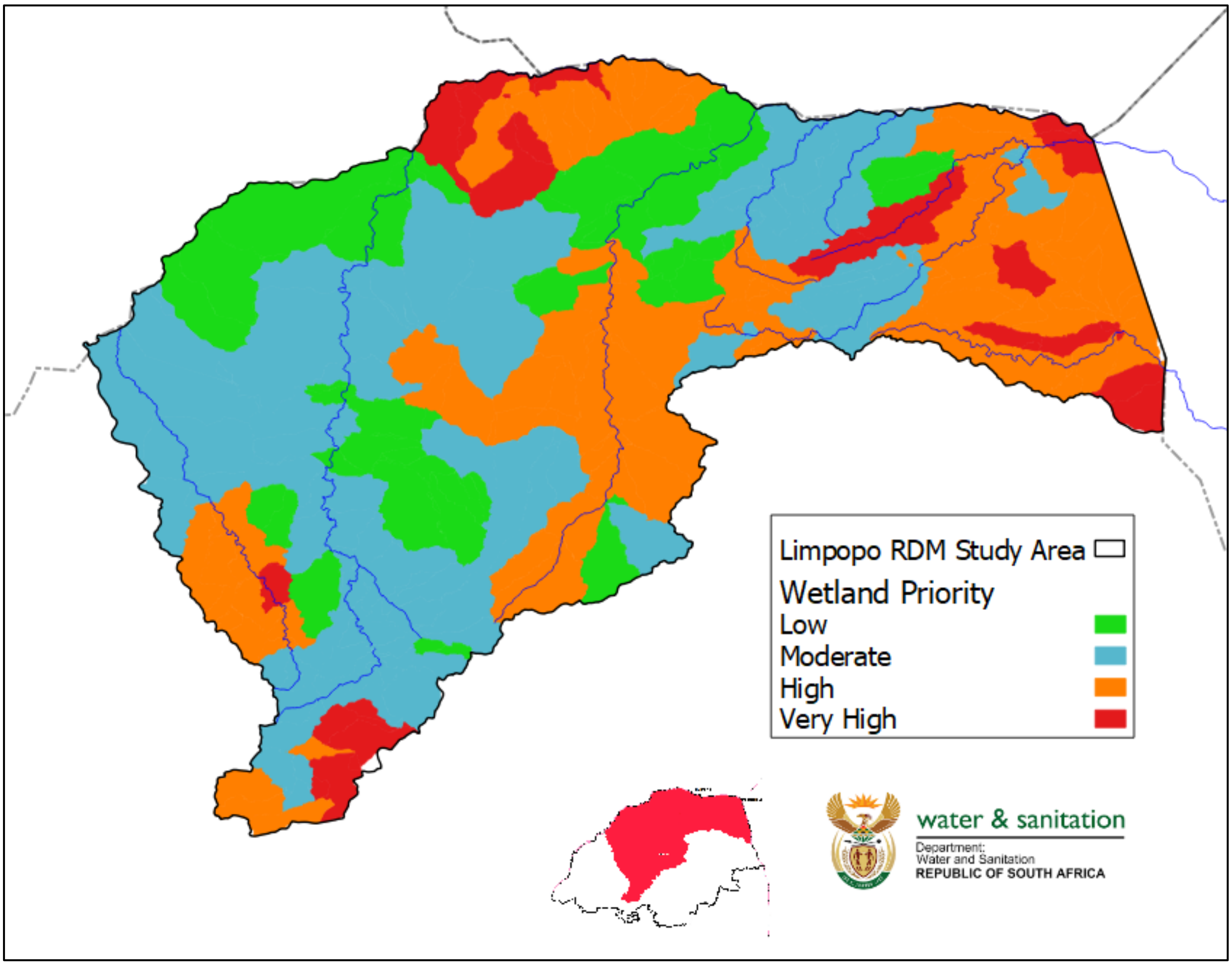

Figure 2-6. Wetland priority per SQ.

2.2.6 Summary

The results of the desktop evaluation of PES, EI, ES and wetland priority are summarised per SQ in **Table 2-5.**

Table 2-5. Summary of wetland properties and priority at the SQ scale. PES, EI and ES categories represent the dominant state of all wetlands within each SQ.

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A50A-00354	Lephalala	B	HIGH	MODERATE	3
A50A-00357	Snyspruit	D	VERY HIGH	VERY HIGH	2
A50A-00370	Rietbokvleispruit	C/D	HIGH	MODERATE	2
A50A-00374	Lephalala	D	HIGH	VERY HIGH	2
A50B-00262	Lephalala	B	VERY HIGH	VERY HIGH	4

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A50B-00298	Lephalala	D	HIGH	VERY HIGH	3
A50B-00303		D/E	HIGH	MODERATE	3
A50B-00344	Lephalala	B	HIGH	MODERATE	3
A50B-00345		C	HIGH	MODERATE	3
A50C-00273	Melk	C/D	HIGH	VERY HIGH	3
A50C-00302		D/E	HIGH	VERY HIGH	3
A50C-00310	Melk	D	HIGH	VERY HIGH	3
A50D-00229	Lephalala	D	HIGH	LOW	3
A50D-00237	Bloklandspruit	D	HIGH	VERY HIGH	3
A50D-00278	Goud	C	HIGH	VERY HIGH	3
A50D-00281	Bloklandspruit	D/E	HIGH	VERY HIGH	3
A50E-00196	Lephalala	C	HIGH	MODERATE	3
A50E-00210	Goud	D	VERY HIGH	MODERATE	3
A50H-00110/Lephalala	Lephalala	B/C	VERY HIGH	MODERATE	2
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A50H-00090	Limpopo	B/C	VERY HIGH	MODERATE	2
A50J-00061		B/C	HIGH	MODERATE	1
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A50J-00073/Kalkpan se Loop	Kalkpan se Loop	B/C	HIGH	HIGH	1
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A61A-00520	Little Nyl	C/D	VERY HIGH	VERY HIGH	3
A61A-00561	Great Nyl	C/D	VERY HIGH	VERY HIGH	3
A61B-00489	Olifantspruit	C	VERY HIGH	VERY HIGH	2
A61B-00503	Middelfonteinspruit	C	VERY HIGH	VERY HIGH	2
A61B-00541	Nyl	C	VERY HIGH	VERY HIGH	2
A61B-00552	Nyl	C	VERY HIGH	VERY HIGH	2
A61C-00484	Badseloop	C/D	VERY HIGH	VERY HIGH	3
A61C-00501	Nyl	C	VERY HIGH	VERY HIGH	4
A61C-00574		C/D	MODERATE	VERY HIGH	3
A61D-00442	Tobiasspruit	C	VERY HIGH	VERY HIGH	4
A61D-00464	Nyl	C	VERY HIGH	VERY HIGH	4
A61E-00386	Nyl	C/D	VERY HIGH	VERY HIGH	2
A61E-00427	Andriesspruit	C	VERY HIGH	VERY HIGH	2
A61E-00465	Nyl	C	VERY HIGH	VERY HIGH	2
A61F-00276	Rooisloot	D/E	VERY HIGH	VERY HIGH	2
A61F-00319	Dorps	D	HIGH	VERY HIGH	2
A61F-00333	Mogalakwena	D	HIGH	VERY HIGH	2
A61F-00353	Mogalakwena	D	MODERATE	VERY HIGH	1
A61F-00371		D/E	HIGH	MODERATE	1

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A61G-00248	Mogalakwena	D/E	VERY HIGH	VERY HIGH	2
A61G-00266	Groot-Sandsloot	E	VERY HIGH	VERY HIGH	2
A61G-00274	Mogalakwena	E	HIGH	LOW	2
A61G-00294		D	HIGH	LOW	2
A61G-00297	Mogalakwena	C/D	HIGH	VERY HIGH	2
A61H-00395	Sterk	E	VERY HIGH	VERY HIGH	2
A61H-00418	Sterk	C/D	VERY HIGH	VERY HIGH	2
A61H-00441		C/D	HIGH	VERY HIGH	2
A61J-00267	Sterk	D/E	VERY HIGH	VERY HIGH	2
A61J-00299	Sterk	C/D	VERY HIGH	VERY HIGH	2
A61J-00306	Klein-Sterk	C	VERY HIGH	VERY HIGH	2
A61J-00349		B/C	HIGH	LOW	2
A61J-00359	Mmadikiri	C	VERY HIGH	VERY HIGH	2
A61J-00369	Sterk	C	HIGH	LOW	2
A61J-00375		C	VERY HIGH	VERY HIGH	2
A61J-00376	Sterk	C/D	VERY HIGH	VERY HIGH	2
A62A-00253	Mokamole	D/E	VERY HIGH	VERY HIGH	1
A62B-00188	Mogalakwena	D	VERY HIGH	VERY HIGH	2
A62B-00223	Mogalakwena	D/E	VERY HIGH	VERY HIGH	2
A62D-00179	Klein Mogolakwena	D	VERY HIGH	VERY HIGH	2
A62D-00198	Klein Mogolakwena	D	VERY HIGH	LOW	1
A62D-00202	Mothlakole	D	VERY HIGH	LOW	1
A62E-00184	Matlala	D/E	VERY HIGH	LOW	1
A62E-00190	Seokeng	E	HIGH	LOW	1
A62E-00191	Matlala	E	VERY HIGH	LOW	1
A62F-00185		E	VERY HIGH	LOW	1
A62G-00167	Matlalane	D	MODERATE	MODERATE	1
A62G-00177	Mogalakwena	D	VERY HIGH	VERY HIGH	1
A62H-00148	Seepabana	E	VERY HIGH	LOW	1
A62H-00155		B/C	MODERATE	MODERATE	1
A62H-00158	Natse	B/C	VERY HIGH	MODERATE	2
A62H-00192	Tshipu	C/D	MODERATE	MODERATE	1
A62H-00195		B/C	MODERATE	MODERATE	1
A62J-00140		D/E	MODERATE	VERY HIGH	1
A62J-00142	Mogalakwena	C	HIGH	MODERATE	2
A62J-00143	Mogalakwena	E	LOW	VERY HIGH	1
A63A-00071	Mogalakwena	C	VERY HIGH	MODERATE	2
A63B-00046	Mogalakwena	D	HIGH	LOW	1
A63B-00077	Leokeng	D	HIGH	VERY HIGH	2

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A63C-00033		B/C	MODERATE	MODERATE	1
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A63D-00034	Mogalakwena	D/E	HIGH	HIGH	1
A63D-00036	Mogalakwena	B/C	MODERATE	LOW	1
A63D-00037	Sonope	D	VERY HIGH	LOW	1
A63D-00044	Sethonoge	B	VERY HIGH	VERY HIGH	2
A63E-00010	Madibohloko	B/C	VERY HIGH	LOW	4
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A63E-00011/Stinkwater	Stinkwater	B/C	VERY HIGH	LOW	4
A63E-00016	Setoka	D	VERY HIGH	LOW	3
A63E-00018	Kolope	B/C	VERY HIGH	LOW	4
A63E-00020	Setonki	E	VERY HIGH	LOW	3
A63E-00021	Kolope	D	VERY HIGH	LOW	3
A63E-00024	Matotwane	B	VERY HIGH	LOW	4
A63E-00025	Kolope	B	VERY HIGH	LOW	4
A63E-00005	Limpopo	B/C	HIGH	HIGH	4
A63E-00007/Kolope	Kolope	B/C	VERY HIGH	VERY HIGH	4
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A63E-00007/Kolope	Kolope	B/C	VERY HIGH	VERY HIGH	4
A63E-00008	Kolope	D	VERY HIGH	HIGH	3
A63E-00009	Limpopo	B	HIGH	LOW	4
A71A-00211	Sand	D/E	HIGH	LOW	3
A71A-00239	Bloed	D	HIGH	MODERATE	3
A71A-00249	Sand	D	HIGH	MODERATE	3
A71B-00214	Diep	D	MODERATE	LOW	1
A71B-00221	Turfloop	D	HIGH	VERY HIGH	2
A71B-00222	Diep	D	VERY HIGH	MODERATE	1
A71C-00156	Dwars	D	VERY HIGH	MODERATE	3
A71C-00172	Sand	D	VERY HIGH	LOW	3
A71C-00181	Koperspruit	D	VERY HIGH	MODERATE	3
A71C-00183	Sand	D	VERY HIGH	LOW	3
A71D-00118	Sand	D	VERY HIGH	MODERATE	3
A71E-00169	Hout	E	VERY HIGH	VERY HIGH	2
A71F-00170	Brakspruit	C/D	VERY HIGH	VERY HIGH	2
A71F-00174		C	VERY HIGH	VERY HIGH	2
A71F-00176	Strydomsloop	D/E	VERY HIGH	VERY HIGH	2
A71G-00107	Hout	C/D	HIGH	VERY HIGH	3
A71G-00129	Mogwatsane	C/D	HIGH	MODERATE	3
A71G-00131	Hout	D	VERY HIGH	VERY HIGH	3

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A71H-00088	Sand	C/D	HIGH	VERY HIGH	3
A71J-00055	Sand	D/E	VERY HIGH	MODERATE	1
A71J-00074	Sand	B	HIGH	HIGH	3
A71J-00076		E	MODERATE	MODERATE	1
A71J-00084	Moleletsane	D	VERY HIGH	MODERATE	1
A71K-00019/SAND	Sand	D	HIGH	VERY HIGH	1
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A71K-00029		D	MODERATE	LOW	1
A71K-00031	Sand	D	VERY HIGH	LOW	1
A71L-00012		D/E	HIGH	LOW	3
A71L-00013	Kongoloop	D	HIGH	HIGH	3
A71L-00014		D/E	VERY HIGH	LOW	3
A71L-00015	Soutsloot	B	MODERATE	HIGH	3
A71L-00017	Kongoloop	D	MODERATE	HIGH	3
A71L-00002		C	HIGH	LOW	3
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A71L-00022	Soutsloot	D/E	HIGH	VERY HIGH	3
A71L-00023		D/E	HIGH	VERY HIGH	3
A71L-00003		B	HIGH	LOW	3
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A71L-00004		C	HIGH	HIGH	3
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	2
A63E-00005	Limpopo	B/C	HIGH	HIGH	3
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A71L-00006		E	VERY HIGH	LOW	3
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A72A-00116	Boshela	E/F	HIGH	VERY HIGH	3
A72A-00123	Brak	D	HIGH	LOW	3
A72A-00133	Ga-Mamasonya	D/E	HIGH	MODERATE	3
A72A-00134	Brak	C	HIGH	LOW	3
A72B-00038	Brak	D/E	VERY HIGH	MODERATE	1
A72B-00052		D/E	VERY HIGH	LOW	1
A72B-00057	Brak	C	VERY HIGH	VERY HIGH	2
A80A-00100	Tshiluvhadi	D	HIGH	MODERATE	3
A80A-00102	Phangani	D/E	HIGH	MODERATE	3
A80A-00089	Nzhelele	D	VERY HIGH	VERY HIGH	3
A80A-00095	Mutshedzi	B	VERY HIGH	VERY HIGH	3
A80B-00069	Nzhelele	D/E	VERY HIGH	VERY HIGH	3
A80C-00068	Mufungudi	D/E	VERY HIGH	VERY HIGH	2

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A80D-00075	Mutamba	D/E	HIGH	MODERATE	1
A80F-00063	Mutamba	C	VERY HIGH	VERY HIGH	2
A80F-00065	Nzhelele	D	VERY HIGH	VERY HIGH	2
A80F-00070		C/D	HIGH	MODERATE	1
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A80G-00026/Nzhelele	Nzhelele	C/D	VERY HIGH	VERY HIGH	2
A80G-00043		D/E	VERY HIGH	VERY HIGH	2
A80G-00048	Nzhelele	C/D	VERY HIGH	VERY HIGH	2
A80G-00053	Nzhelele	C	VERY HIGH	VERY HIGH	2
A80G-00054	Tshishiru	E	VERY HIGH	VERY HIGH	2
A80H-00060	Luphephe	D	VERY HIGH	MODERATE	2
A80H-00064	Nwanedi	D/E	VERY HIGH	MODERATE	2
A50H-00110/Limpopo	Limpopo	C	LOW	LOW	1
A80J-00028/Nwanedi	Nwanedi	B/C	VERY HIGH	MODERATE	2
A91A-00105	Luvuvhu	D/E	HIGH	VERY HIGH	3
A91B-00119	Luvuvhu	D	HIGH	HIGH	2
A91B-00120	Doringspruit	C/D	HIGH	VERY HIGH	2
A91C-00115	Luvuvhu	D	VERY HIGH	VERY HIGH	3
A91C-00122	Mudzwiriti	C	HIGH	VERY HIGH	3
A91D-00108	Latonyanda	D	HIGH	VERY HIGH	2
A91E-00103	Dzindi	D	HIGH	VERY HIGH	2
A91F-00111	Luvuvhu	D	HIGH	VERY HIGH	2
A91F-00093	Luvuvhu	D	VERY HIGH	VERY HIGH	2
A91G-00078	Mukhase	C/D	HIGH	HIGH	2
A91G-00079	Mbwedi	D/E	VERY HIGH	HIGH	2
A91G-00083		B	HIGH	HIGH	3
A91G-00086	Mutshindudi	D	VERY HIGH	VERY HIGH	2
A91G-00087	Mukhase	D	HIGH	HIGH	2
A91G-00091	Mutshindudi	D	VERY HIGH	HIGH	2
A91G-00092	Mutshindudi	B	HIGH	HIGH	3
A91G-00094	Tshinane	C	HIGH	HIGH	2
A91G-00098	Mutshindudi	E	VERY HIGH	VERY HIGH	2
A91H-00045	Luvuvhu	C/D	VERY HIGH	VERY HIGH	3
A91J-00040	Luvuvhu	D	VERY HIGH	VERY HIGH	2
A91J-00050	Matsaringwe	C	VERY HIGH	VERY HIGH	2
A91K-00032	Limpopo	B/C	VERY HIGH	VERY HIGH	4
A91K-00035	Luvuvhu	C	VERY HIGH	VERY HIGH	4
A91K-00039	Luvuvhu	C/D	VERY HIGH	VERY HIGH	3
A91K-00042	Mashikiri	D	VERY HIGH	VERY HIGH	3

SQ	River Named in SQ	Wetland PES	Wetland EI	Wetland ES	SQ Priority based on internal Wetlands
A91K-00056	Saselandonga	C	HIGH	HIGH	3
A91K-00058		C	HIGH	LOW	3
A92B-00051	Mutale	C	VERY HIGH	VERY HIGH	4
A92C-00041	Tshipise	E	VERY HIGH	VERY HIGH	1
A92C-00047	Mutale	D	VERY HIGH	VERY HIGH	1
A92C-00049	Mbodi	D	VERY HIGH	VERY HIGH	1
A92D-00027	Limpopo	C	VERY HIGH	HIGH	3
A92D-00030	Mutale	D/E	VERY HIGH	VERY HIGH	3
B90A-00062		C/D	VERY HIGH	VERY HIGH	3
B90A-00066	Shisha	D/E	HIGH	MODERATE	3
B90B-00080		C	HIGH	MODERATE	3
B90B-00096	Mphongolo	D	HIGH	HIGH	3
B90B-00097		D	HIGH	HIGH	3
B90B-00099		D/E	HIGH	HIGH	3
B90B-00081	Mphongolo	C	VERY HIGH	MODERATE	4
B90B-00082	Mphongolo	E	HIGH	VERY HIGH	3
B90B-00101	Mphongolo	D	VERY HIGH	VERY HIGH	3
B90C-00104	Shihloti	D	VERY HIGH	VERY HIGH	3
B90C-00106	Phugwane	E	VERY HIGH	VERY HIGH	3
B90D-00067	Shisha	E	VERY HIGH	VERY HIGH	3
B90D-00109	Phugwane	C	VERY HIGH	VERY HIGH	3
B90D-00085	Mphongolo	D/E	VERY HIGH	VERY HIGH	3
B90D-00112	Mphongolo	C	VERY HIGH	VERY HIGH	3
B90E-00072	Nkulumbeni	C/D	VERY HIGH	VERY HIGH	3
B90F-00114	Shingwedzi	E	VERY HIGH	VERY HIGH	3
B90G-00121	Bububu	B/C	VERY HIGH	VERY HIGH	4
B90G-00136	Nshenhene	C	VERY HIGH	VERY HIGH	4
B90G-00144	Tshange	C/D	HIGH	HIGH	3
B90G-00125	Bububu	B/C	VERY HIGH	VERY HIGH	4
B90G-00130	Shingwedzi	B/C	VERY HIGH	VERY HIGH	3
B90G-00124	Shingwedzi	B/C	HIGH	LOW	4
B90H-00147	Dzombo	B	VERY HIGH	LOW	4
B90H-00152	Kumba	B/C	VERY HIGH	VERY HIGH	4
B90H-00113	Mphongolo	C	VERY HIGH	VERY HIGH	3
B90H-00117	Shingwedzi	D	VERY HIGH	VERY HIGH	3
B90H-00145	Shingwedzi	C	HIGH	LOW	3

3 WETLAND ECOSTATUS

Chapter 2 outlines the desktop assessment of PES of wetlands per SQ. This is done in order to prioritise wetlands because only the highest priority wetlands receive additional and more detailed assessment. Hence, the following high priority wetlands were assessed in the field for (higher confidence) PES:

- Luvuvhu Floodplain (Makuleke)
- Nyl River Floodplain
- Wonderkrater
- Nyl Pans
- Maloutswa Floodplain (Mapungubwe)
- Kolope Wetlands
- Lake Fundudzi
- Mutale Wetlands
- Mokamole wetlands – a tributary of the Mogalakwena River
- Malahlapanga (Peat dome)
- Bububu wetlands – a tributary of the Shingwedzi River

3.1 Methods

Collection of Field Data:

Qfield was used to collect coordinate data for use in ground truthing both Bing and Google Earth © imagery within QGIS, and included the following fields:

- Unique ID
- Date
- Latitude
- Longitude
- Landform
  - MCB, bank, pool, backwater, flood channel, backflood, channel, floodplain, oxbow, pan, riverine wetland, depression, seep, CVB, UCVB, Lake, flat, sodic, sodic ecotine, flood bench, bar, terrace, other.
- Lifeform
  - Bare, water, sand, rock, cobble/boulder, aquatic, creeping grass, tufted grass, sedge, reed, emergent, herbaceous, weed, shrub, tree, tall tree, other.
- Dominant species
- Common species
- Important species
- Landuse

Assessment of Wetland PES:

The assessment of the ecostatus of high priority wetlands was achieved through the following:

- Validation of the PES
- Determination of the EIS
- Determination of the REC

Both the WetHealth Level 1 and the Wetland Habitat Integrity (Wetland IHI) were used within the framework of the DWS Decision Support Protocol (DSP; Ollis et al., 2014) to determine the wetland Present Ecological Status (PES). The DSP is specifically for the rapid assessment of Wetland PES, in the form of a series of electronic spreadsheets compiled in a Microsoft Excel (.xls) format and integrates both the WETHealth and IHI tools.

WET-Health is a tool designed to assess the health or integrity of a wetland (Macfarlane et al., 2006). Wetland health is defined as a measure of the deviation of wetland structure and function from its natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health. It is a modular approach that uses:

- An impact-based approach for those activities that do not produce clearly visible responses in wetland structure and function. The impact of irrigation or afforestation in the catchment, for example, produces invisible impacts on water inputs. This is the main approach used in the hydrological assessment.
- An indicator-based approach for activities that produce clearly visible responses in wetland structure and function such as the presence of gullies or alien species. This approach is mainly used in the assessment of geomorphological and vegetation health.

The Wetland Habitat Integrity model is designed for the RAPID assessment of floodplain and channelled valley bottom wetland types, for the purposes of determining an index of WETLAND-IHI for reporting on the Present Ecological state (PES) of the wetland system in question. It includes a water quality module that augments the WetHealth Level 1 within the DSP.

The EIS will be assessed using the Rountree and Kotze (2013) approach for wetlands, and REC can be determined according to the guideline in the Rapid Reserve Manual for Wetlands (Rountree et al., 2013).

3.2 Results

3.2.1 Makuleke

The wetland complex known as the Makuleke Ramsar site comprises the Luvuvhu River and its floodplain, portion of the Limpopo River and its floodplain and the 31 pans within this area (**Figure 3-1**). On a broad scale the Luvuvhu River floodplain comprises the main channel which conveys the perennial Luvuvhu River and left and right bank paleo-channels, or flood channels under extreme events, that link depressional areas that form pans, mostly seasonal or intermittent with Mwambi as an important perennial pan (only drying out in extreme and infrequent drought periods; **Figure 3-2**). Field data collection for the Makuleke wetlands assessment was conducted from 16 to 22 Oct 2022 with 25 pans and over 600 hand-held XYZ points being surveyed in order to:

- Ground truth the DTM, capture trig beacon and historic flood levels.
- Survey floodplain and pan topography, especially at important points such as the edge of the floodplain, edge of the pan, pan full supply level, flood breach points, vegetation types, and pan water level.
- Survey dominant vegetation lifeforms and species.
- Survey water depth in pans with open water.
- Delineate floodplain (this delineation was then the area of assessment for the PES).
- Provide information for the PES assessment.

Survey points, contours and ecological notes were used to delineate the floodplain, both Luvuvhu and the Limpopo right bank (**Figure 3-3**).

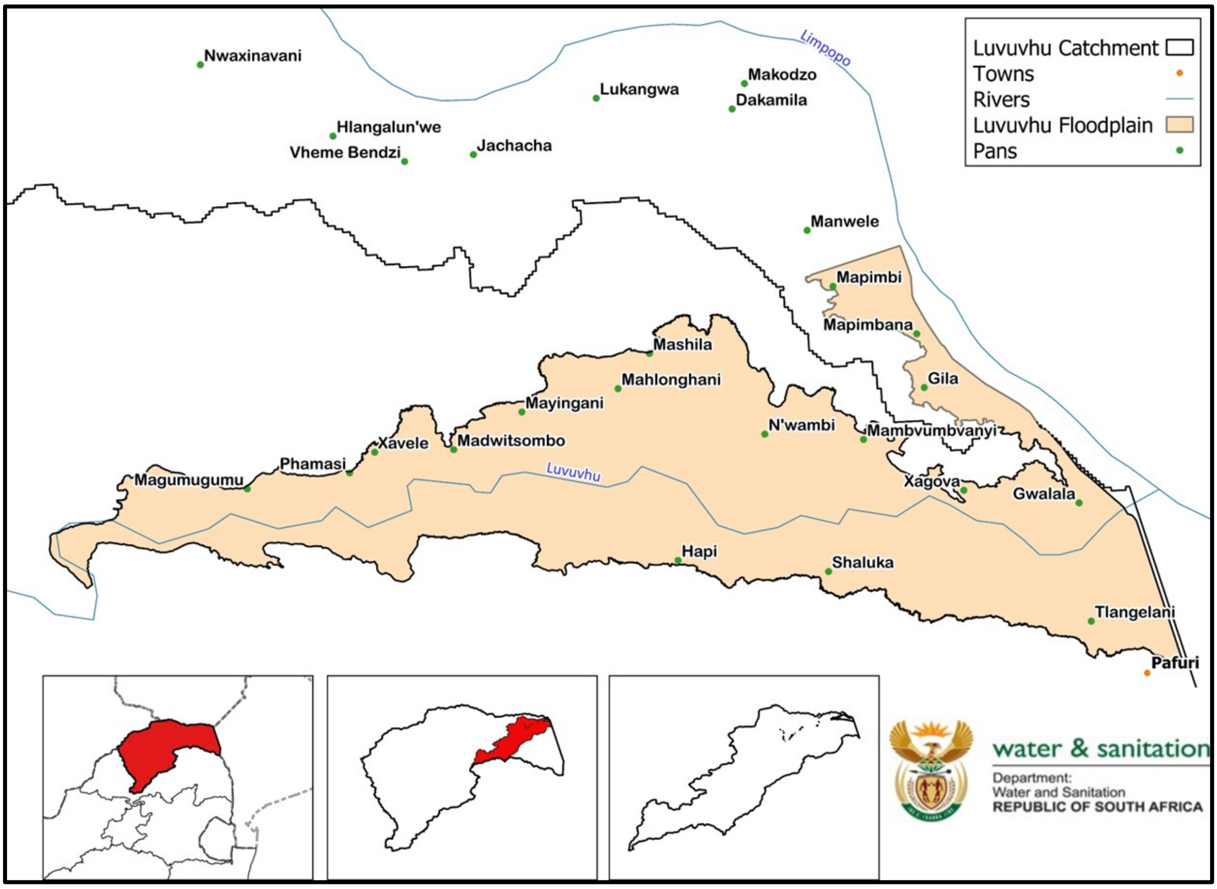

Figure 3-1. Map showing the pans along the Luvuvhu and Limpopo rivers that are included in the Makuleke Ramsar site, as well as the floodplain delineation for the area.

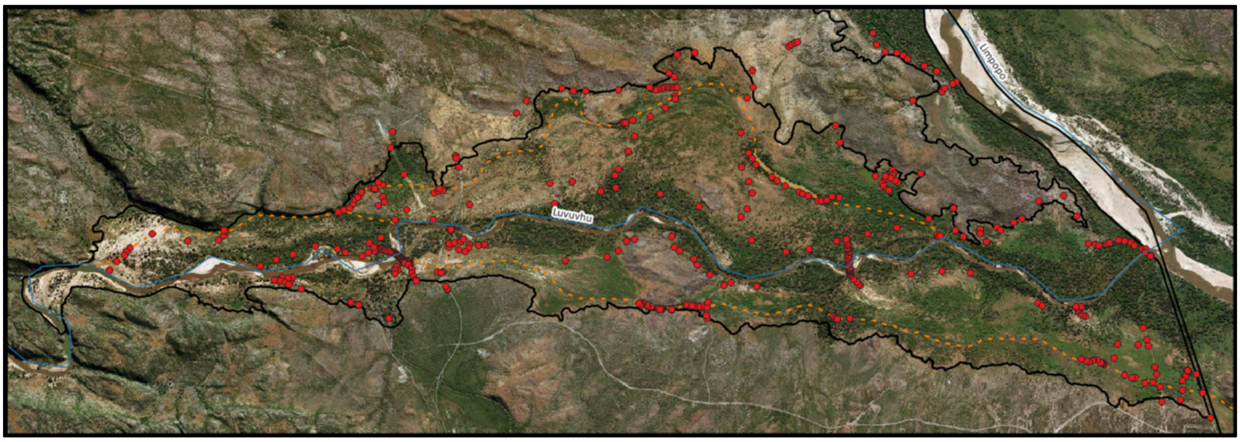

Figure 3-2. Bing aerial image showing the Luvuvhu floodplain delineation (black outline), main Luvuvhu and Limpopo rivers (blue lines), paleo-channels along the Luvuvhu floodplain (dotted orange lines) and field sample points (red points).

Figure 3-3. Floodplain delineation of the Luvuvhu and Limpopo floodplains (right bank only) that form part of the Makuleke wetlands.

PES of the Luvuvhu Floodplain:

The Luvuvhu River catchment upstream of the floodplain as shown in **Figure 3-2** is comprised predominantly of agricultural activities with at least 75% used for crops of various kinds or old fields, and includes several urban centres or large towns such as Thohoyandou, as well as some large dams quite far upstream from the floodplain (**Table 3-1**). Land use within the floodplain, including a 200m buffer, is however mostly natural, as one would expect for a wetland system within Kruger National Park (KNP; **Table 3-2**). A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Luvuvhu River floodplain.

Table 3-1. Land cover classes (NLC, 2020) in the Luvuvhu River catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Cover (%)
43		Fallow Land & Old Fields (Bush)	52.1
40		Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	12.4
38		Commercial Annuals Pivot Irrigated	11.5
39		Commercial Annuals Non-Pivot Irrigated	3.1
20		Artificial Sewage Ponds	2.8
22		Herbaceous Wetlands (currently mapped)	2.8
61		Urban Recreational Fields (Tree)	2.7
6		Open & Sparse Planted Forest	2.3
19		Artificial Dams (incl. canals)	1.1

No.	Legend Colour	2020 NLC Class Name	Cover (%)
1		Contiguous (indigenous) Forest (combined very high, high, medium)	1.0
41		Subsistence / Small-Scale Annual Crops	1.0
63		Urban Recreational Fields (Grass)	0.7
56		Village Dense (bare only)	0.6
68		Mines: Surface Infrastructure	0.6

Table 3-2. Land cover classes (NLC, 2020) in the Luvuvhu River floodplain, expressed as a percentage of the floodplain area, including 200m buffer (Only top 10 classes are shown).

Floodplain: (2020 NLC Class Name)	Cover (% wetland area)
Open Woodland (10 - 35% cc)	40.3
Natural Grassland	23.3
Contiguous (indigenous) Forest (combined very high, high, medium)	18.8
Dense Forest & Woodland (35 - 75% cc)	12.1
Natural Rivers	2.5
Herbaceous Wetlands (currently mapped)	1.0
Bare Riverbed Material	0.6
Contiguous Low Forest & Thicket (combined classes)	0.5
Artificial Dams (incl. canals)	0.4
Natural Pans (flooded @ obsv time)	0.3

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 70% (C). The rating, reasons and results are shown in **Table 3-3**, **Table 3-4** and **Table 3-5.**

Table 3-3. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Luvuvhu River floodplain.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-2	The Vondo dam on the Mutshindudi River and the Nandoni dam on the Luvuvhu River are both some distance upstream of the floodplain but will likely cause flow reductions and some reduced flood peaks, while the Mutale River remains undammed. There are	High

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
		also likely to be abstractions along the Mutale River, with some mining and informal agriculture. In addition, intense informal agriculture has deteriorated the condition of extensive wetlands along the Mutale, which may promote runoff rather than infiltration. Similarly, the Mushindudi and Luvuvhu rivers have areas with high informal occupancy and agriculture.	
Increase in flows (water inputs)	0	No net effect, increased catchment hardening offset by abstraction upstream of floodplain	Medium
Combined impact Score	-2		
Change in flood patterns (peaks)	-1.5	Flood peaks are likely reduced by large upstream dams, Nandoni and Vondo.	High
Magnitude of impact Score	2.5		

Table 3-4. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Luvuvhu floodplain).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	0	0	0	None, the HGM is within KNP	High
Modifications to existing channels	0	0	0	None, the HGM is within KNP	High
Reduced roughness	0	0	0	None, the HGM is within KNP	High
Impeding features (e.g. dams) – upstream effects	1	6	0.06	Road with culverts built across the floodplain.	High
Impeding features – downstream effects	0	0	0	None, the HGM is within KNP	High
Increased on-site water use	0	0	0	None, the HGM is within KNP	High

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Deposition/infilling or excavation	0	0	0	None, the HGM is within KNP	High
Combined impact Score			0.1		

Table 3-5. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	0.1
Changes to Water Input characteristics	2.5
Combined Hydrology Impact Score	**3.0**
Hydrology PES% Score	**70%**
Hydrology PES Category	**C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 90% (A/B). The rating, reasons and results are shown in **Table 3-6**.

Table 3-6. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Luvuvhu River floodplain.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Conf
Diagnostic component						
(1) Upstream dams	Floodplain	100	1	1.0	Vondo and Nandoni dams are a distance upstream so the intensity of impact on geomorphology of the HGM is low.	Medium
(2) Stream diversion/ shortening	Floodplain, Channeled VB	0	0	0.0	No stream shortening or diversions	High
(3) Infilling	Floodplain, Channeled VB	1	2	0.0	Road from Luvuvhu bridge across the floodplain but affects	High

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Conf
					a small proportion of the HGM.	
(4) Increased runoff	Non-floodplain HGMs	0	0	0.0	N/A	
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	0	0	0.0	N/A	
(6) Depositional features	All non-floodplain HGMs	0	0	0.0	N/A	
(6) Loss of organic matter	All non-floodplain HGMs with peat	0	0	0.0	N/A	
Combined Impact Score based on a sum of all magnitude scores				1.0		
Geomorphology PES% Score				90%		
Geomorphology PES Category				A/B		

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 71% (C). The rating, reasons and results are shown in **Table 3-7.**

Table 3-7. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Luvuvhu River floodplain.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	1	3
	Salts	1.0.01	1	3
	Nutrients	1.0	1	3
	Water Temp.	0.0	1	3
	Turbidity	1.542	100	3
	Oxygen	-0.5	1	2
	Toxics	1.0	1	2
Water Quality: overall scores				
Rating:		1.4	*Confidence:*	*3.0*
Percentage:		71.0		
PES Category:		C		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 87% (B). The rating, reasons and results are shown in **Table 3-8**.

Table 3-8. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Luvuvhu River floodplain).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	3	10	10	0.3	Gravel and tar roads, airstrip	High
Deep flooding by dams	0	10	10	0.0		
Shallow flooding by dams	0	4 - 8	6	0.0		
Crop lands	0	8 - 10	9	0.0		
Commercial plantations	0	7 - 10	9	0.0		
Annual pastures	0	9 -10	9	0.0		
Perennial pastures	0	4 -10	8	0.0		
Dense Alien vegetation patches.	5	5 - 10	7	0.4	No dense patches but AIP are present and there's a fulltime team constantly busy with removal	High
Sports fields	0	7 - 10	9	0.0		
Gardens	0	6 - 10	8	0.0		
Areas of sediment deposition/ infilling & excavation	1	4-10	8	0.1	Raised road from bridge over the Luvuvhu across the floodplain	High
Eroded areas	0	3 - 9	7	0.0		
Old / abandoned lands (Recent)	0	7 - 9	7	0.0		
Old / abandoned lands (Old)	0	3 - 8	5	0.0		
Overgrazing	20	1 - 5	3	0.6	Contentious, but the floodplain is heavily utilised and damage by	High

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes		Confidence rating
					elephants, which is extensive and notable.		
Untransformed areas	0	0 - 3	1	0.0			
Overall weighted impact score				1.3			
Vegetation PES% Score				87%			
Vegetation PES Category				B			

Summary and Overall PES:

The summary and overall PES for the Luvuvhu River floodplain is 80% (B/C), and is shown in **Table 3-9.** The primary drivers of change were an altered flow regime, invasive alien plant species and pressure from megaherbivores.

Table 3-9. Summary PES results for the Luvuvhu River floodplain.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	70 %	C
Geomorphology PES	WET-Health Geomorph Module	90 %	A/B
Water quality PES	Wetland-IHI WQ Module	71 %	C
Vegetation PES	WET-Health Veg Module	87 %	B
Overall Wetland PES	WET-Health default weightings	80 %	B/C

3.2.2 Nyl River Floodplain

The Nyl floodplain comprises a meandering channel within a long and narrow (roughly 75km long by 2-6 km wide) floodplain, dominated by floodplain grasses (notably Leersia hexandra and Oryza longistaminata, a vulnerable species in SA), surrounded mostly by savanna, mostly fine-leaved savanna, often comprising sodic sites, and with surrounding back flooded areas here and there dominated by hydromorphic grasslands. The Nyl floodplain was surveyed from 16 to 20 January 2023 with over 300 hand-held points with the following aims (**Figure 3-2)**:

- Ground truth the vegetation units to tie in with the DTM and existing hydraulic model.
- Survey important floodplain points, such as the edge of the floodplain.
- Survey dominant vegetation lifeforms (for example, see **Figure 3-5)** and species.
- Survey dominant landforms, e.g. floodplain, channel, sodic site, hydrogeomorphic grassland.
- Survey dominant land use.
- Provide information for the PES assessment.

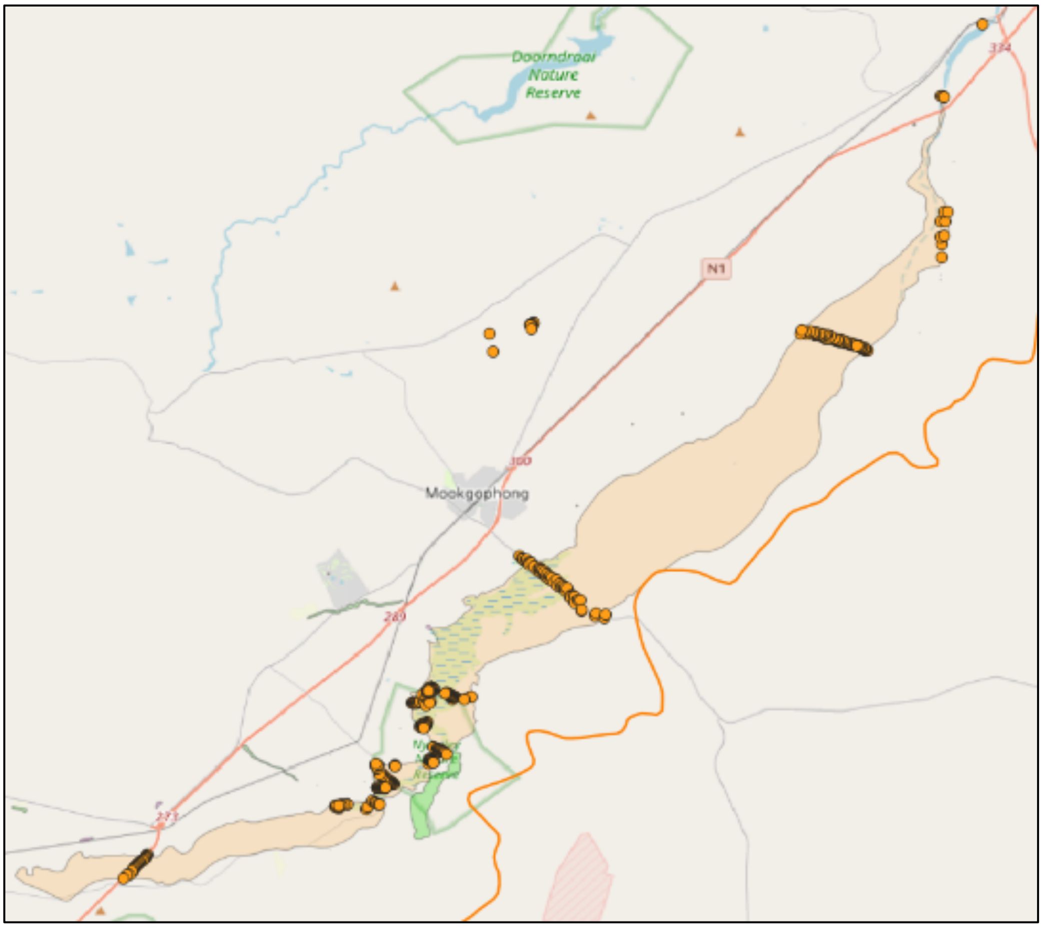

Figure 3-4. Map showing the Nyl floodplain as well as hand held survey points taken along the floodplain and Wonderkrater (orange points) during January 2023.

Figure 3-5. Example of waypoints showing dominant lifeform information across the Nyl floodplain.

PES of the Nyl Floodplain:

The Nyl River catchment upstream of and surrounding the floodplain is comprised predominantly of open or dense woodland and agricultural activities with at least 30% used for crops of various kinds or old fields, and includes the towns of Modimolle and Mookgopong, as well as Donkerpoort and Deelkraal dams (**Figure 3-6; Table 3-10**). Land use within the floodplain, including a 200m buffer, is mostly open or dense woodland, natural grassland or wetland, but includes at least 20% agricultural crops of various kinds (**Table 3-11**). Much of the floodplain is used for grazing or mixed grazing with wildlife preservation/ hunting and a small portion forms the Nylsvei Nature Reserve (which comprises the Ramsar site, which is important for the floodplain grasses but also birds and roan antelope). Historical aerial photographs show that the floodplain has been similarly used for a long time and photographs from 1939 also show farming and channel manipulation within the floodplain (**Figure 3-7)**. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Nyl River floodplain:

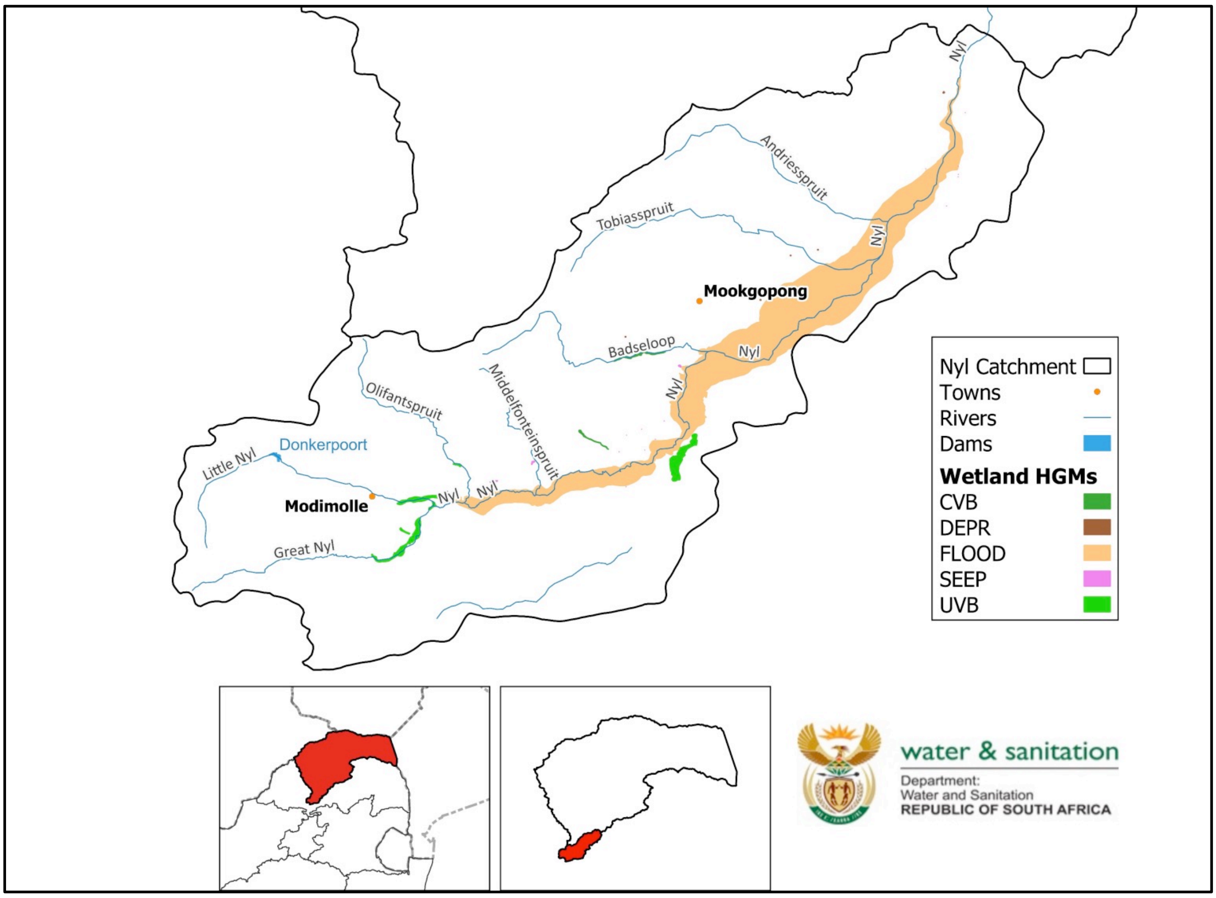

Figure 3-6. Map showing the Nyl floodplain in relation to its catchment area.

Figure 3-7. Comparison of an historical aerial photograph taken on Dec 31, 1939 (left) to present day satellite imagery from May 2022 (right). The red dot indicates the Vogelfontein Rd (D925).

Table 3-10. Land cover classes (NLC, 2020) in the Nyl River catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Cover (%)
4		Open Woodland (10 - 35% cc)	47.0
40		Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	15.9
3		Dense Forest & Woodland (35 - 75% cc)	14.5
43		Fallow Land & Old Fields (Bush)	10.2
13		Natural Grassland	5.0
42		Fallow Land & Old Fields (Trees)	1.3
38		Commercial Annuals Pivot Irrigated	0.9
58		Smallholdings (Bush)	0.7
44		Fallow Land & Old Fields (Grass)	0.6
48		Residential Formal (Bush)	0.5
32		Cultivated Commercial Permanent Orchards	0.4
23		Herbaceous Wetlands (previous mapped extent)	0.3

Table 3-11. Land cover classes (NLC, 2020) in the Nyl River floodplain, expressed as a percentage of the floodplain area, including 200m buffer (Only top 10 classes are shown).

Floodplain: (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Open Woodland (10 - 35% cc)	54.7
Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	15.3
Natural Grassland	10.5
Herbaceous Wetlands (currently mapped)	6.5
Dense Forest & Woodland (35 - 75% cc)	4.7
Fallow Land & Old Fields (Bush)	4.4
Herbaceous Wetlands (previous mapped extent)	2.6
Fallow Land & Old Fields (Grass)	0.5
Fallow Land & Old Fields (Trees)	0.3
Fallow Land & Old Fields (wetlands)	0.2

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 65% (C). The rating, reasons and results are shown in **Table 3-12, Table 3-13** and **Table 3-14**.

Table 3-12. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Nyl River floodplain.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-1.5	The Donkerpoort Dam on the Little Nyl River upstream of the floodplain will likely cause some flow reductions and reduced flood peaks. There are also likely to be abstractions along all tributaries leading to the floodplain with intense agriculture in places, and some centre pivots, which may promote runoff rather than infiltration.	High
Increase in flows (water inputs)	0.5	The WWTW at Modimolle is dysfunctional and decants directly into the Little Nyl River. This is likely to elevate flows and cause water quality deterioration for some way downstream but only likely to affect the upper portion of the floodplain.	High
Combined impact Score	-1		

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Change in flood patterns (peaks)	-2	Flood peaks are likely reduced by Donkerpoort Dam, and although the Great Nyl doesn't have large dams there are several farm dams / weirs upstream of the floodplain e.g. Deelkraal.	High
Magnitude of impact Score	2.5	.	

Table 3-13. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Nyl floodplain).

Nature of alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	1	3	0.03	There is at least 1 canal traversing portion of the floodplain	High
Modifications to existing channels	5	7	0.35	Further downstream from the Nylsvley Reserve the main channel appears to have been constrained to its current position cf historical aerial photographs from 1939. Upstream of Deelkraal, near the N1 there is moderate but notable channel straightening.	High
Reduced roughness	0	0	0		
Impeding features (e.g. dams) – upstream effects	5	3	0.15	Several berms cut across the floodplain at various points and appear to be designed to retain post-flood water	High
Impeding features – downstream effects	5	3	0.15	Various farm damming areas and also Deelkraal Dam	High
Increased on-site water use	0	0	0		
Deposition/infilling or excavation	10	3	0.3	Various, scattered, designed to channel flood flow and drain grazing areas	High
Combined impact Score			1.0		

Table 3-14. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	**1.0**
Changes to Water Input characteristics	**2.5**
Combined Hydrology Impact Score	**3.5**
Hydrology PES% Score	**65%**
Hydrology PES Category	**C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 73% (C). The rating, reasons and results are shown in **Table 3-15**.

Table 3-15. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Nyl River floodplain.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Conf
Diagnostic component						
(1) Upstream dams	Floodplain	100	2	2.0	Donkerpoort Dam upstream of the floodplain, farm weirs upstream of all contributing tributaries and Deelkraal dam	High
(2) Stream diversion/ shortening	Floodplain, Channeled VB	10	3	0.3	Further downstream from the Nylsvley Reserve the main channel appears to have been constrained to its current position cf historical aerial photographs from 1939. Upstream of Deelkraal, near the N1 there is moderate but	High

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Conf
					notable channel straightening.	
(3) Infilling	Floodplain, Channeled VB	10	4	0.4	Criss-cross berms designed to retain flood waters	High
(4) Increased runoff	Non-floodplain HGMs			0.0		
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	0	0	0.0	N/A	
(6) Depositional features	All non-floodplain HGMs	0	0	0.0	N/A	
(6) Loss of organic matter	All non-floodplain HGMs with peat	0	0	0.0	N/A	

Combined Impact Score based on a sum of all magnitude scores	2.7
Geomorphology PES% Score	73%
Geomorphology PES Category	C

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 79% (B/C). The rating, reasons and results are shown in **Table 3-16.**

Table 3-16. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Nyl River floodplain.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	2
	Salts	1.0	20	3
	Nutrients	2.0	40	4
	Water Temp.	1.0	10	3
	Turbidity	1.0	100	4
	Oxygen	0.0	20	3
	Toxics	1.0	5	2
Water Quality: overall scores				
Rating:		1.0	*Confidence:*	*3.6*
Percentage:		79.0		
PES Category:		B/C		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 58% (C/D). The rating, reasons and results are shown in **Table 3-17**.

Table 3-17. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Nyl River floodplain).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	0.05	10	10	0.0	Calculated from NLC 2020	High
Deep flooding by dams	0.12	10	10	0.0		
Shallow flooding by dams	2	4 - 8	8	0.2		
Crop lands	15.36	8 - 10	10	1.5		
Commercial plantations	0.01	7 - 10	10	0.0		
Annual pastures	5	9 -10	9	0.5		
Perennial pastures	10	4 -10	8	0.8		
Dense Alien vegetation patches.	5	5 - 10	10	0.5		
Sports fields	0	7 - 10	9	0.0		
Gardens	0.06	6 - 10	8	0.0		

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Areas of sediment deposition/ infilling & excavation	3	4-10	8	0.2		
Eroded areas	0.05	3 - 9	8	0.0		
Old / abandoned lands (Recent)	2	7 - 9	7	0.1		
Old / abandoned lands (Old)	2	3 - 8	5	0.1		
Seepage below dams	0.5	1 - 5	7	0.0		
Untransformed areas	5	0 - 3	4	0.2		
Overall weighted impact score				**4.2**		
Vegetation PES% Score				**58%**		
Vegetation PES Category				**C/D**		

Summary and Overall PES:

The summary and overall PES for The Nyl River floodplain is 65% (C), and is shown in **Table 3-18.** The primary drivers of change are agricultural activities within the floodplain, floodplain disturbance including berms for water retention, channel re-routing and canalisation, and an altered flow regime.

Table 3-18. Summary PES results for the Nyl River floodplain.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	65 %	**C**
Geomorphology PES	WET-Health Geomorph Module	73 %	**C**
Water quality PES	Wetland-IHI WQ Module	79 %	**B/C**
Vegetation PES	WET-Health Veg Module	58 %	**C/D**
Overall Wetland PES	WET-Health default weightings	65 %	**C**

3.2.3 Wonderkrater

Wonderkrater is a spring mound consisting entirely of peat up to 8m thick (McCarthy et al., 2010) and is delineated in the NWM5 as a valley bottom wetland without a channel. According to the farmer on whose property the mound is to be found (**Figure 3-8**), the wetland area receives additional water input from the nearby ephemeral drainage channel, and surrounding landscape, but the spring is the main source of wetness and has been instrumental in its development. Wonderkrater was surveyed on the 20th January, 2023 (**Figure 3-9)**.

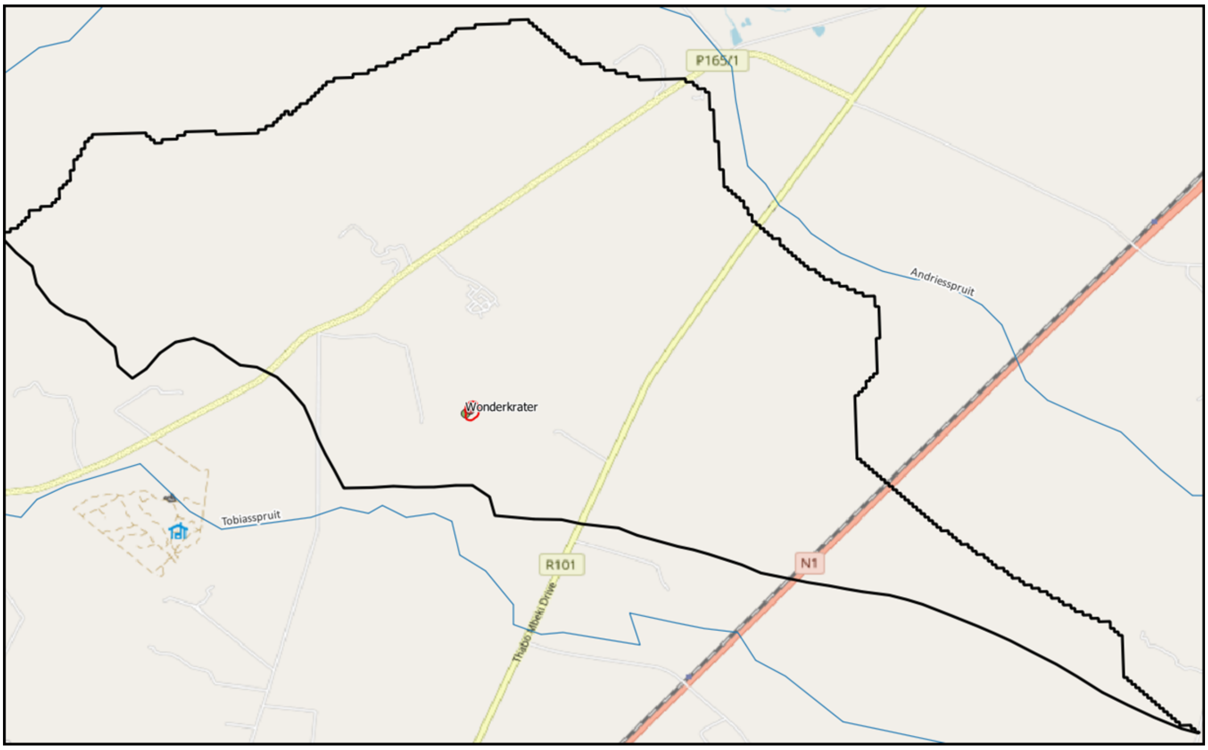

Figure 3-8. Map showing Wonderkrater and its catchment area.

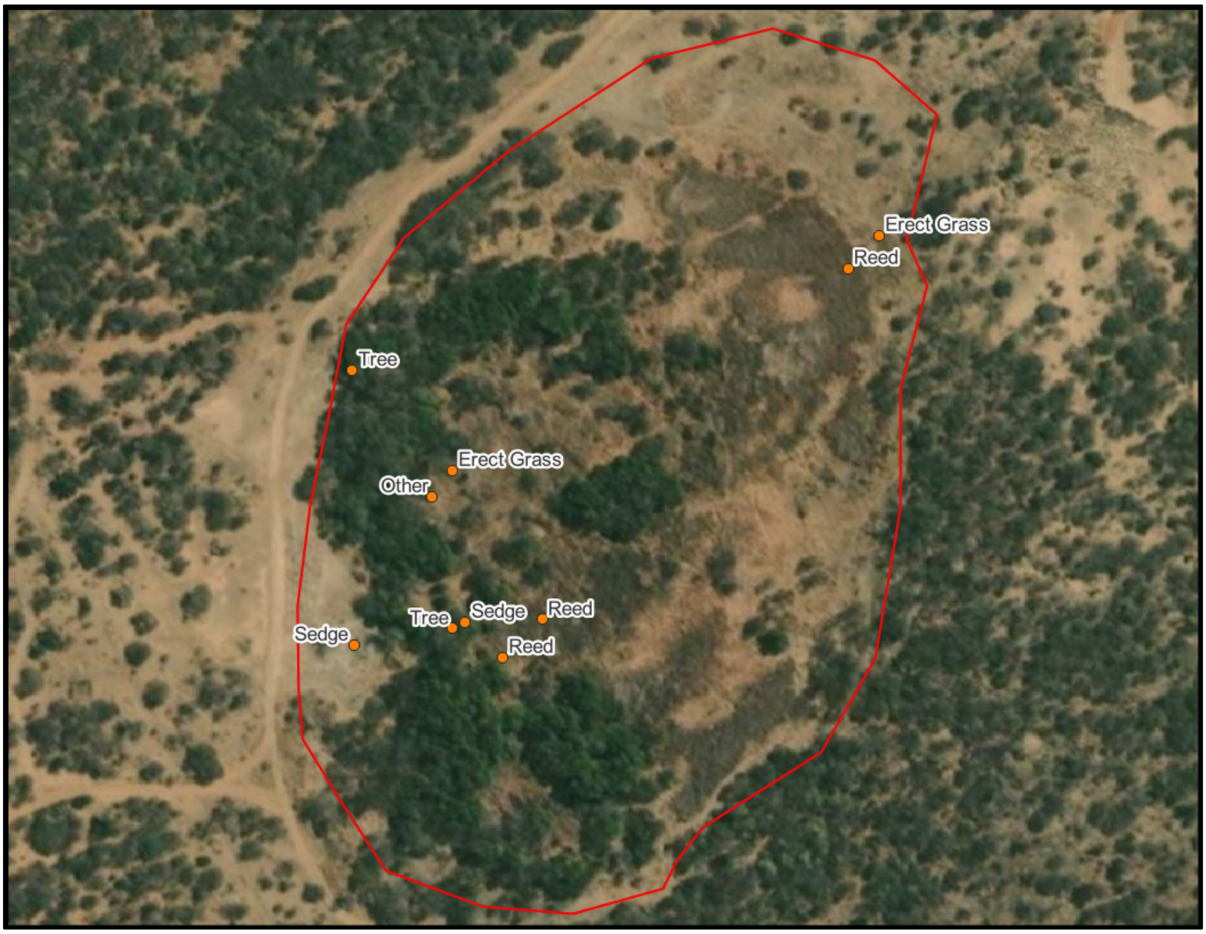

Figure 3-9. Example of waypoints showing lifeform information around Wonderkrater, taken on 20th January 2023.

PES of Wonderkrater:

Wonderkrater, about 4.5Ha, occurs entirely within private property which is used for mixed livestock farming / wildlife preservation / lodge purposes and as such enjoys some level of protection. In addition, the owners are fully aware of the importance of the wetland, are more than willing to grant access for assessment and have also allowed wetland rehabilitation measures to take place (**Figure 3-10**). In tandem with these rehabilitation measures, grazing pressure in the area has been reduced in an attempt to promote vegetation establishment around the wetland. The catchment area surrounding Wonderkrater occurs between Tobiasspruit and Andriesspruit (**Figure 3-8**) and is comprised mostly of open and dense woodland with some natural grassland and about 30% being cultivated areas (**Table 3-19)**. Land cover classes (NLC, 2020) surrounding and within Wonderkrater comprise mainly open woodland with some natural grassland (**Table 3-20)**. Since the WetHealth and Wetland IHI are not designed to deal with this type of wetland (functionally more depressional or flat in type rather than unchanneled valley bottom), the DSP provides the option of using the RDM-99 method to determine the Overall PES, the results of which follow for Wonderkrater:

Figure 3-10. Photograph showing wetland rehabilitation surrounding Wonderkrater to promote pooling and vegetation recovery with reduced delivery of sediments to the mound area.

Table 3-19. Land cover classes (NLC, 2020) in the Wonderkrater catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
4		Open Woodland (10 - 35% cc)	2849.4	45.1
3		Dense Forest & Woodland (35 - 75% cc)	1318.7	20.9
43		Fallow Land & Old Fields (Bush)	1046.1	16.6
40		Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	614.5	9.7
13		Natural Grassland	216.3	3.4
42		Fallow Land & Old Fields (Trees)	92.7	1.5
44		Fallow Land & Old Fields (Grass)	50.4	0.8
32		Cultivated Commercial Permanent Orchards	37.3	0.6
38		Commercial Annuals Pivot Irrigated	19.3	0.3
67		Roads & Rail (Major Linear)	14.8	0.2

Table 3-20. Land cover classes (NLC, 2020) surrounding and within Wonderkrater, expressed as a percentage of the wetland area, including 200m buffer (Only top 10 classes are shown).

Depression (includes Pans): (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Open Woodland (10 - 35% cc)	95.59
Natural Grassland	3.95
Dense Forest & Woodland (35 - 75% cc)	0.42
Other Bare	0.03
Contiguous (indigenous) Forest (combined very high, high, medium)	0.00
Contiguous Low Forest & Thicket (combined classes)	0.00
Contiguous & Dense Planted Forest (combined classes)	0.00
Open & Sparse Planted Forest	0.00
Temporary Unplanted Forest	0.00
Low Shrubland (other regions)	0.00

Summary and Overall PES using the RDM-99 method:

The PES for Wonderkrater using the RDM-99 methodology within the DWS DSP is 80% (B) and is shown in **Table 3-21**. The main drivers of change are invasive alien plant species and high grazing and trampling pressure, although the latter appears to be remnant of past pressure.

Table 3-21. PES results for the Wonderkrater using the RDM-99 methodology.

Criteria	Relevance	Score	Confidence
Hydrological			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	4.5	3
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	3.5	3
Water quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements	5	3

Criteria	Relevance	Score	Confidence
	and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	4	3
Hydraulic / Geomorphological			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	5	3
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.	3	3
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	4	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	4.5	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	2	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	5	3
Overutilisation of biota	Overgrazing, over-fishing, etc.	3.5	3
MEAN SCORE		4.0	3.3
MINIMUM SCORE		2	
Overall PES% Score (without "override")		80%	
Overall PES Category (without "override")		B	

3.2.4 Nyl Pans (The Nyl Dam and Lakes Sekgagapeng and Lekalakala)

The Nyl Pans form a complex of open water and associated wetland habitat, essentially depressional wetlands (lakes) within the Nyl channel at the outlet of the Nyl floodplain and the start of the Mogalakwena River (**Figure 3-11**). The first depressional wetland has been dammed (The Nyl Dam), the second is called Lake Sekgagapeng and the third is called lake Lekalakala (pictured at right; **Figure 3-12**). The Nyl pans were surveyed as part of the Nyl floodplain survey from 16 to 20 January 2023 and Lake Lekalakala was surveyed on the 17th April, 2023.

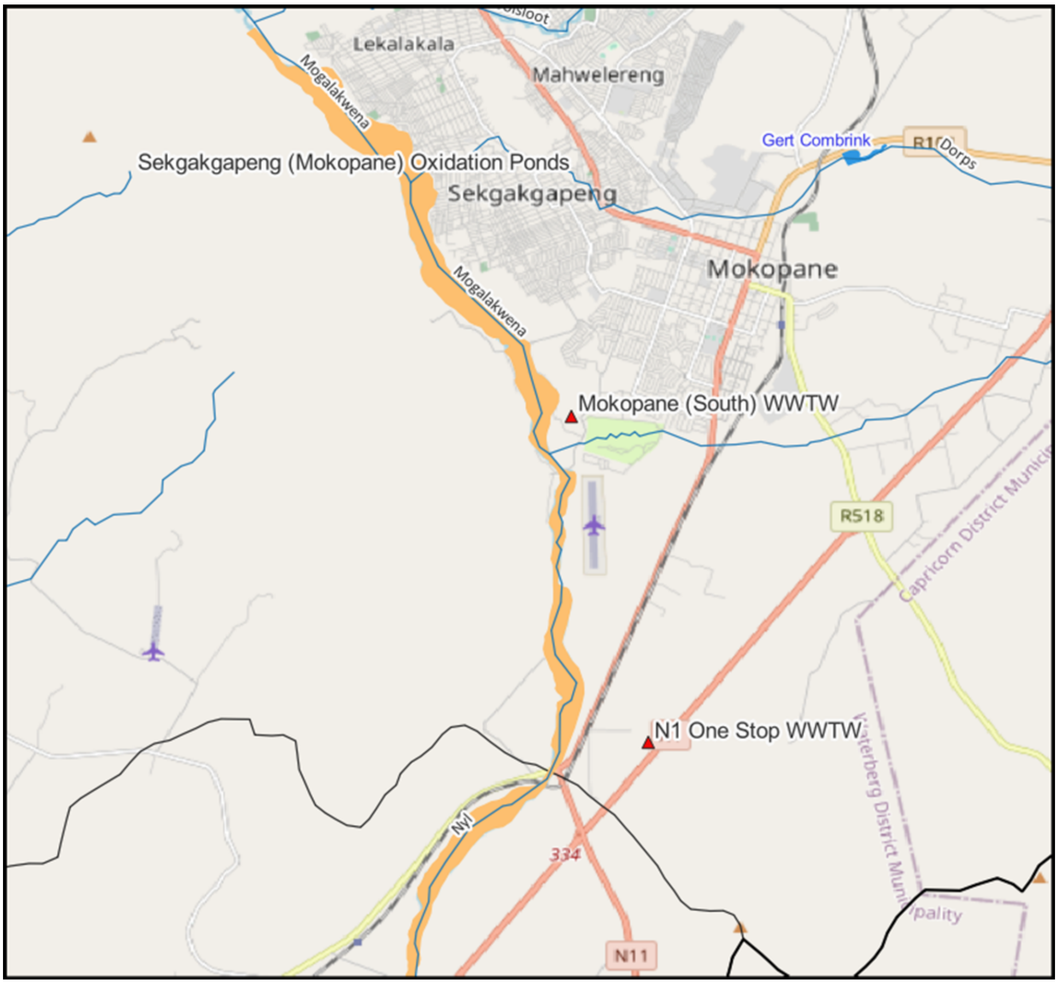

Figure 3-11. Map showing an extension of the Nyl floodplain to include the Nyl pans.

Figure 3-12. Example of waypoints showing species information around Lake Lekalakala, taken on 17th April 2023.

PES of the Nyl Pans:

Historically these depressional areas likely represented important biodiversity habitat, but more recently have been considerably modified due to treated sewage and urban stormwater inputs and have become wetter. Sedimentation and water quality are important considerations. They are therefore now more likely to be important functionally (from a water quality and related perspective), and as the hydrological regime has changed from more temporarily inundated habitat to more seasonally to permanently wet habitat, they will likely provide a refuge for biota, possibly even some not normally expected in the area. Historical aerial photographs from 1953 show the first depressional wetland before it was dammed, as well as the extent of urbanisation of surrounding areas (Mokopane) since then (**Figure 3-13)**. The catchment area upstream of the Nyl pans is similar to that of the Nyl floodplain with the important addition of the town of Mokopane, its urban sprawl and its non-functional WWTWs (North and South), with evidence of untreated water entering the system directly. Land use along the channel and depressional wetlands, including a 200m buffer, is mostly natural wooded and grassland areas, fallow lands, old fields and temporary crops, wetlands, artificial water bodies and residential areas. (**Table 3-22**). Wetlands between depressional lakes and surrounding them are heavily grazed by domestic livestock including cattle, goats, donkeys, horses, pigs and chickens, but still maintain abundant populations of indigenous water and wetland birds. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Nyl pans.

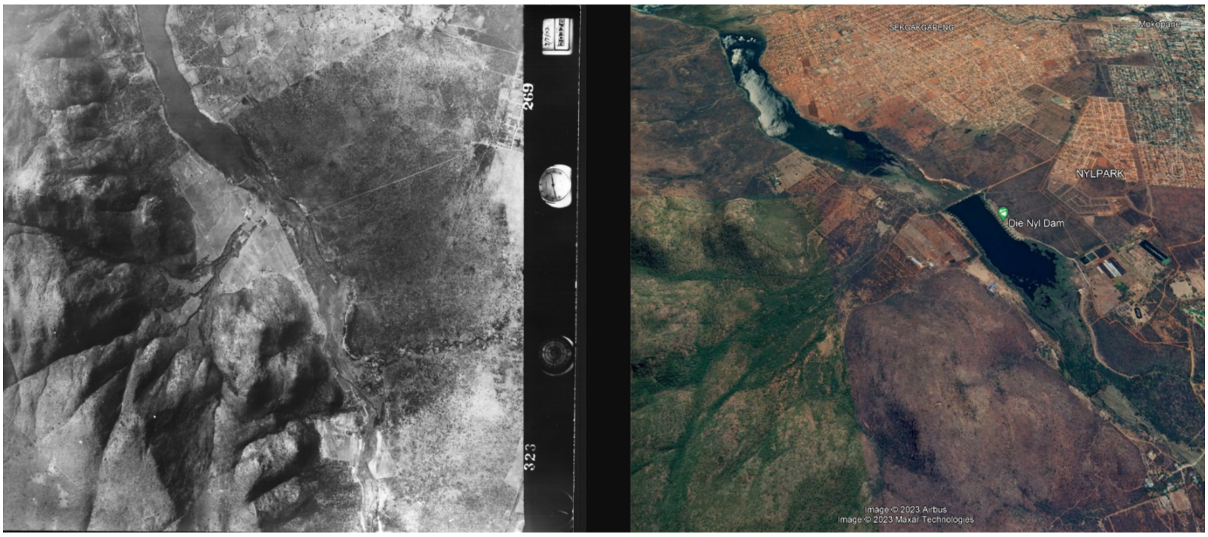

Figure 3-13. Comparison of an historical aerial photograph taken on Jul 1, 1953 (left) to present day satellite imagery from May 2022 (right) showing the current Nyl Dam, the second lake and the extent of urban development since then.

Table 3-22. Land cover classes (NLC, 2020) along the Nyl Pans, expressed as a percentage of the floodplain area, including 200m buffer (Only top 10 classes are shown).

(2020 NLC Class Name - Level 2)	Cover (% wetland area)
Natural Wooded Land	51.5
Natural Grassland	11.7
Fallow Lands & Old Fields	10.6
Artificial Water bodies	9.6
Temporal Crops	8.0
Herbaceous Wetlands	4.6
Residential	3.3
Transport	0.2
Unconsolidated	0.2
Planted Forest	0.1

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 65% (C). The rating, reasons and results are shown in **Table 3-23, Table 3-24** and **Table 3-25**.

Table 3-23. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Nyl pans.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-1.5	The Donkerpoort Dam on the Little Nyl River upstream of the floodplain will likely cause some flow reductions and reduced flood peaks. There are also likely to be abstractions along all tributaries leading the floodplain with intense agriculture in places, and some centre pivots, which may promote runoff rather than infiltration. Direct abstraction from the lakes also occurs.	High
Increase in flows (water inputs)	3	The WWTW at Modimolle is dysfunctional and decants directly into the Little Nyl River. This is likely to elevate flows and cause water quality deterioration for some way downstream but only likely to affect the upper portion of the floodplain. More importantly the Mokopane WWTW (North and South) decant directly into the lakes and due to surrounding catchment hardening and denudation, runoff is increased.	High
Combined impact Score	1.5		
Change in flood patterns (peaks)	3	Flood peaks are likely reduced by Donkerpoort Dam, and although the Great Nyl doesn't have large dams there are several farm dams / weirs upstream of the floodplain. More importantly, runoff from surrounding areas will likely increase flashiness and peaks.	High
Magnitude of impact Score	1.0		

Table 3-24. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Nyl pans).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	10	4	0.4	Several gullies and artificial inflow from the urbanised surroundings	High
Modifications to existing channels	30	3	0.9	Conversion of the first depressional area into the Nyl Dam	High

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduced roughness	30	2	0.6	Overgrazing to form "lawns" of vegetated wetland habitats	High
Impeding features (e.g. dams) – upstream effects	5	2	0.1	Some berms into the wetland areas for water abstraction points	High
Impeding features – downstream effects	30	3	0.9	Conversion of the first depressional area into the Nyl Dam	High
Increased on-site water use	5	2	0.1	Direct water abstraction from lakes.	High
Deposition/infilling or excavation	2	2	0.04	Some berms into the wetland areas for water abstraction points	High
Combined impact Score			3.0		

Table 3-25. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	**3.0**
Changes to Water Input characteristics	**1.0**
Combined Hydrology Impact Score	**3.5**
Hydrology PES% Score	**65%**
Hydrology PES Category	**C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 43% (D). The rating, reasons and results are shown in **Table 3-26**.

Table 3-26. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Nyl pans.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
(1) Upstream dams	Floodplain	100	2	2.0	The Nyl dam	High
(2) Stream diversion/shortening	Floodplain, Channeled VB	2	1	0.0	Diverted around the side of the Nyl dam.	Medium
(3) Infilling	Floodplain, Channeled VB	5	1	0.1	Several berms installed into the wetland area, appear for abstraction or may not be working.	High
(4) Increased runoff	Non-floodplain HGMs	100	3	3.0	WWTWs from Mokopane and storm water runoff from surrounding urban development	High
(5) Erosional features	All non-floodplain HGMs			0.0		
(6) Depositional features	All non-floodplain HGMs			0.0		
(6) Loss of organic matter	All non-floodplain HGMs with peat	30	2	0.6	Overgrazing	High
Combined Impact Score based on a sum of all magnitude scores	5.7					
Geomorphology PES% Score	43%					
Geomorphology PES Category	D					

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 73.3% (C). The rating, reasons and results are shown in **Table 3-27**.

Table 3-27. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Nyl River floodplain.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	1.0	10	2
	Salts	1.0	40	2
	Nutrients	2.5	100	3
	Water Temp.	0.0	60	3
	Turbidity	1.5	90	3
	Oxygen	-1.0	80	2
	Toxics	1.0	20	2
Water Quality: overall scores				
Rating:		1.3	*Confidence:*	*2.6*
Percentage:		73.3		
PES Category:		C		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 60% (C/D). The rating, reasons and results are shown in **Table 3-28**.

Table 3-28. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Nyl River floodplain).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	0.5	10	10	0.1	Estimated from NLC, 2020 and verified in the field in 2023	High
Deep flooding by dams	20	10	10	2.0		
Shallow flooding by dams	0	4 - 8	8	0.0		
Crop lands	5	8 - 10	6	0.3		
Commercial plantations	0	7 - 10	10	0.0		
Annual pastures	5	9 -10	9	0.5		

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Perennial pastures	20	4 -10	4	0.8		
Dense Alien vegetation patches.	2	5 - 10	10	0.2		
Sports fields	0	7 - 10	9	0.0		
Gardens	0	6 - 10	8	0.0		
Areas of sediment deposition/ infilling & excavation	1	4-10	6	0.1		
Eroded areas	2	3 - 9	6	0.1		
Old / abandoned lands (Recent)	0	7 - 9	7	0.0		
Old / abandoned lands (Old)	0	3 - 8	5	0.0		
Seepage below dams	0.5	1 - 5	7	0.0		
Untransformed areas	0	0 - 3	4	0.0		
Overall weighted impact score				**4.0**		
Vegetation PES% Score				**60%**		
Vegetation PES Category				**C/D**		

Summary and Overall PES:

The summary and overall PES for the Nyl Pans and surrounding wetlands is 57% (D), and is shown in

Table 3-29. The main drivers of change are channel diversions and damming, deterioration of water quality, altered flow regime and agricultural encroachment.

Table 3-29. Summary PES results for the Nyl pans.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	65 %	**C**
Geomorphology PES	WET-Health Geomorph Module	43 %	**D**
Water quality PES	Wetland-IHI WQ Module	73 %	**C**
Vegetation PES	WET-Health Veg Module	60 %	**C/D**

Overall Wetland PES	WET-Health default weightings	57 %	**D**

3.2.5 Maloutswa Floodplain

The Maloutswa floodplain comprises a wide floodplain area affected by the Limpopo, Maloutswa and Kolope rivers. The Malotswa River flows along its full length and is part of the floodplain, while the Kolope River confluences with the Malotswa River about halfway along its course and provides additional input into the floodplain until it meets the Limpopo (**Figure 3-14**). It is also likely that the Limpopo River floods the floodplain directly at high extreme events. The Maloutswa floodplain was surveyed on the 22nd of January 2023 and hand-held points taken, with the same aims as before (**Figure 3-15)**.

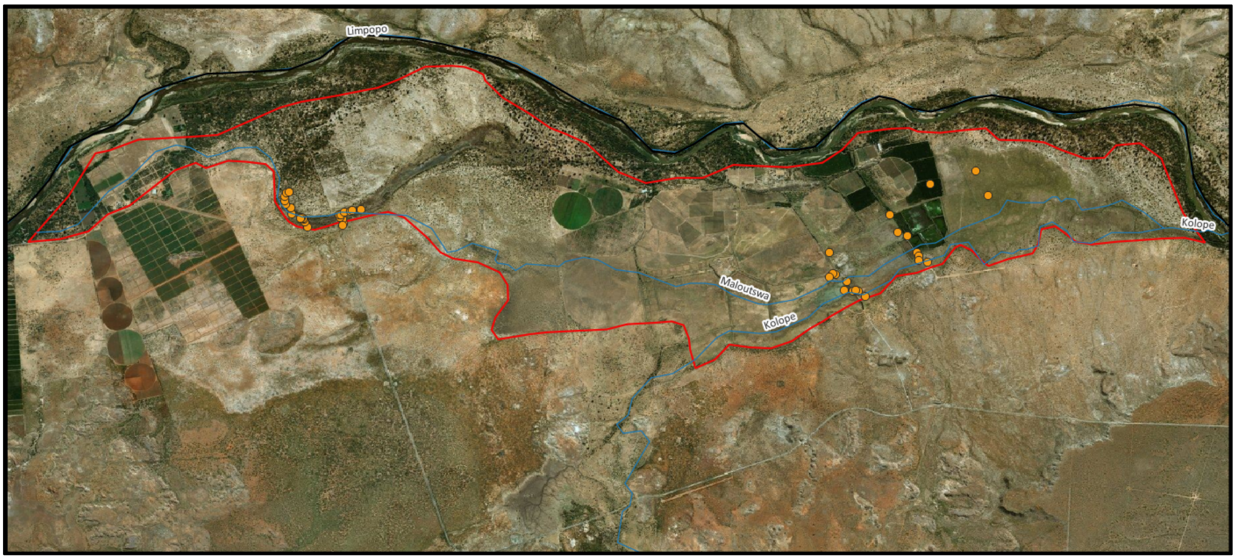

Figure 3-14. Map showing the Maloutswa floodplain as (red) well as hand held survey points taken along the floodplain during January 2023 (orange points).

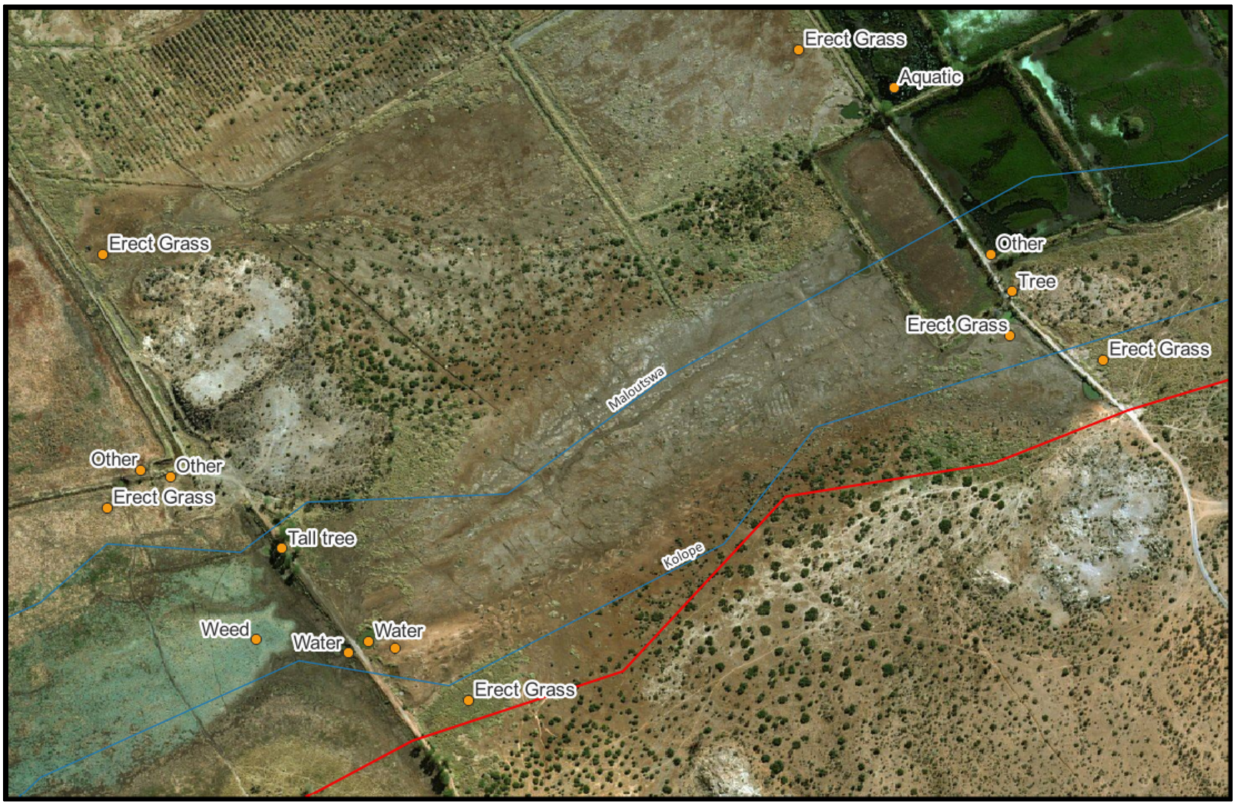

Figure 3-15. Example of waypoints showing dominant lifeform information across the Maloutswa floodplain.

PES of the Maloutswa Floodplain:

The Maloutswa floodplain occurs within the Mapungubwe National Park along the Limpopo River which affords conservative protection to about two thirds of the floodplain. The large central portion, while still within Mapungubwe is prone to mixed conservation / farming with access roads, centre pivots, annual and permanent crops, elevated storage dams for irrigation and an offtake canal extracting water from the Limpopo River for irrigation along the floodplain. Almost 20% of the floodplain comprises crops of some kind (**Table 3-30**). Woody alien species have been removed within the park area and some wetland rehabilitation is evident. The floodplain is grass dominated, mostly Agrostis lachnantha, and is heavily utilised by wildlife, and livestock in places. Due to the proximity of farming activities annual weed plant species are abundant, especially in association with infilling or damming on the floodplain. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Maloutswa floodplain:

Table 3-30. Land cover classes (NLC, 2020) in the Maloutswa floodplain, expressed as a percentage of the floodplain area, including 200m buffer (Only top 10 classes are shown).

Floodplain: (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Natural Grassland	33.8
Open Woodland (10 - 35% cc)	27.6
Other Bare	9.3
Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	7.5
Commercial Annuals Pivot Irrigated	6.1
Dense Forest & Woodland (35 - 75% cc)	5.6
Cultivated Commercial Permanent Orchards	2.7
Fallow Land & Old Fields (Bush)	1.6
Fallow Land & Old Fields (Grass)	1.2
Commercial Annuals Non-Pivot Irrigated	1.1

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 60% (C/D). The rating, reasons and results are shown in **Table 3-31, Table 3-32** and **Table 3-33**.

Table 3-31. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Maloutswa floodplain.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-3	No flow reductions from the Maloutswa or Kolope Rivers, but the Limpopo River which also influences the floodplain has high levels of abstraction	Medium
Increase in flows (water inputs)	1	Return flows from irrigation within the central portion of the floodplain as well as canal offtake from the Limpopo to fill storage dams on the floodplain.	High
Combined impact Score	-2		
Change in flood patterns (peaks)	-1.5	Flood peak reduction along the Limpopo River, which is likely the most important source of floodplain inundation.	Medium

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Magnitude of impact Score	3.0		

Table 3-32. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Maloutswa floodplain).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	1	2	0.02	All associated with area being farmed with various crops	Medium
Modifications to existing channels	5	4	0.2	Road crossings through the floodplain and these also serve as moderately sized dams on the floodplain	High
Reduced roughness	0	2	0		
Impeding features (e.g. dams) – upstream effects	20	6	1.2	Road crossings through the floodplain and these also serve as moderately sized dams on the floodplain	High
Impeding features – downstream effects	5	3	0.15	Some erosion below road crossings and dams	High
Increased on-site water use	10	2	0.2	Irrigation of the central portion of the floodplain	High
Deposition/infilling or excavation	10	4	0.4	Raised storage dams for irrigation provision	High
Combined impact Score			**2.2**		

Table 3-33. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	**2.2**
Changes to Water Input characteristics	**3.0**
Combined Hydrology Impact Score	**4.0**
Hydrology PES% Score	**60%**
Hydrology PES Category	**C/D**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 77% (C). The rating, reasons and results are shown in **Table 3-34**.

Table 3-34. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Maloutswa floodplain.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	20	8	1.6	Dammed areas along road crossing with high level culverts	High
(2) Stream diversion/shortening	Floodplain, Channeled VB	0	1	0.0		
(3) Infilling	Floodplain, Channeled VB	5	6	0.3	Road crossings and additional berms to store flood water	High
(4) Increased runoff	Non-floodplain HGMs	10	4	0.4	Return flows from irrigation	High
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs			0.0		
(6) Depositional features	All non-floodplain HGMs			0.0		
(6) Loss of organic matter	All non-floodplain HGMs with peat			0.0		

Combined Impact Score based on a sum of all magnitude scores	2.3
Geomorphology PES% Score	77%
Geomorphology PES Category	C

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 82.3% (B). The rating, reasons and results are shown in **Table 3-35**.

Table 3-35. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Maloutswa floodplain.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.5	10	2
	Salts	1.0	40	2
	Nutrients	1.5	100	3
	Water Temp.	1.0	20	2
	Turbidity	1.0	90	3
	Oxygen	0.0	80	2
	Toxics	0.5	10	2
Water Quality: overall scores				
Rating:		0.9	Confidence:	*2.5*
Percentage:		82.3		
PES Category:		B		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 64% (C). The rating, reasons and results are shown in **Table 3-36.**

Table 3-36. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Maloutswa floodplain).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	1	10	10	0.1	Estimated from NLC, 2020 and ground truthed in 2023	High
Deep flooding by dams	8	10	10	0.8		
Shallow flooding by dams	2	4 - 8	8	0.2		
Crop lands	20	8 - 10	6	1.2		
Commercial plantations	0	7 - 10	10	0.0		
Annual pastures	0	9 -10	9	0.0		

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes		Confidence rating
Perennial pastures	0	4 -10	4	0.0			
Dense Alien vegetation patches.	5	5 - 10	10	0.5			
Sports fields	0	7 - 10	9	0.0			
Gardens	2	6 - 10	8	0.2			
Areas of sediment deposition/ infilling & excavation	8	4-10	6	0.5			
Eroded areas	1	3 - 9	6	0.1			
Old / abandoned lands (Recent)	0	7 - 9	7	0.0			
Old / abandoned lands (Old)	0	3 - 8	5	0.0			
Seepage below dams	2	1 - 5	7	0.1			
Untransformed areas	0	0 - 3	4	0.0			
Overall weighted impact score				**3.6**			
Vegetation PES% Score				**64%**			
Vegetation PES Category				**C**			

Summary and Overall PES:

The summary and overall PES for the Maloutswa floodplain is 66% (C), and is shown in **Table 3-37**. The main drivers of change are agricultural activities within the floodplain, channel diversion/constriction, altered wetting regime and farm dams within the floodplain, and alien plant species in some areas. These drivers of change are mostly applicable to the areas of floodplain where conservation is not the landuse.

Table 3-37. Summary PES results for the Maloutswa floodplain.

Components	**Method used for assessment**	**PES% Score**	**Ecological Category**
Hydrology PES	WET-Health Hydro Module	60 %	**C/D**
Geomorphology PES	WET-Health Geomorph Module	77 %	**C**
Water quality PES	Wetland-IHI WQ Module	82 %	**B**
Vegetation PES	WET-Health Veg Module	64 %	**C**
Overall Wetland PES	WET-Health default weightings	66 %	**C**

3.2.6 Kolope Wetlands

The wetlands that occur along the dry Kolope, Setoka, Setonki and Matotwane rivers have been typed as riverine wetlands in the NWM5 and are extensive in the region (**Figure 3-16**). The bulk of these wetlands occur within privately owned property such as the De Beers Venetia diamond mine and Nature Reserve and access was not granted for an assessment. The assessment was therefore limited to the portion of the Kolope River within the Mapungubwe National Park. These wetlands were surveyed on the 22nd April 2023 and **Figure 3-17** shows the waypoints that were taken as part of the data gathered.

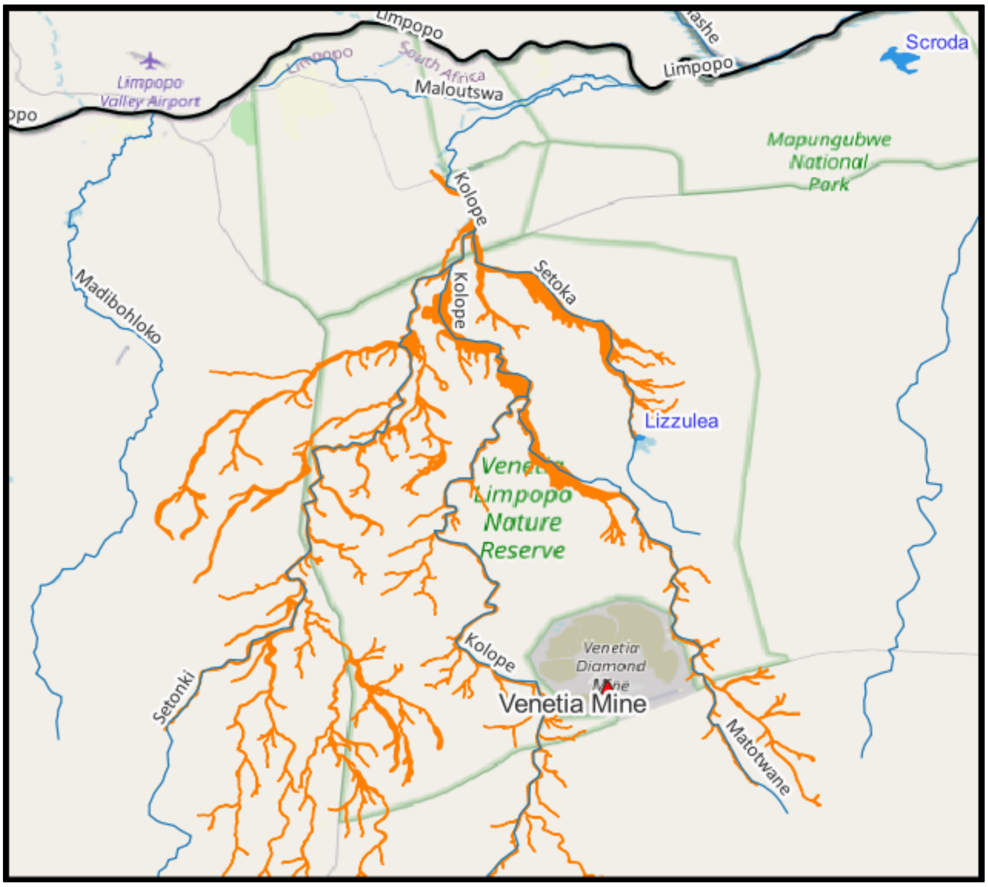

Figure 3-16. Map showing riverine wetlands (orange) associated with the dry river systems of the Kolope, Setoka, Setoki and Matotwane rivers.

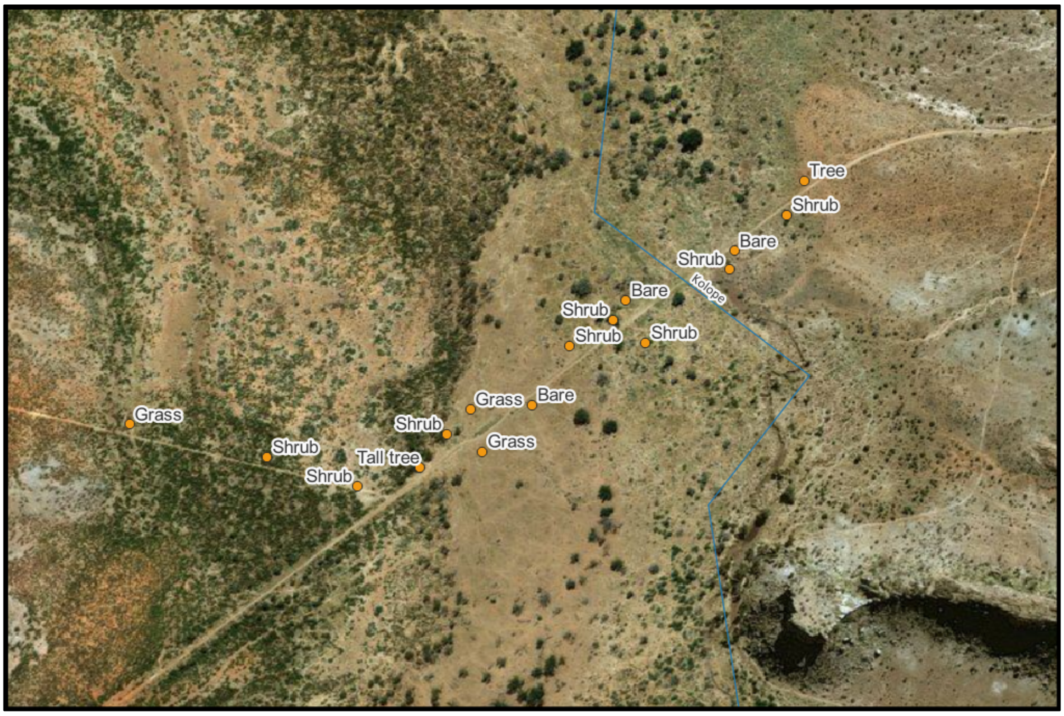

Figure 3-17. Example of waypoints showing dominant lifeform information across the riverine wetlands along the Kolope River within Mapungubwe National Park (April, 2023).

PES of Kolope wetlands

The catchment of the Kolope riverine wetlands is comprised predominantly of open woodland (76%) and natural grassland (16%), with some eroded and bare lands and about 2% coverage by the Venetian diamond mining activities (**Table 3-38**). Land use surrounding the riverine wetlands, including a 200m buffer, is also mostly open woodland (notably Mopane) and natural grassland with almost 10% being eroded or bare areas (**Table 3-39)**. The bulk of the wetlands occur within conservation areas, notably the Mapungubwe National Park and the Venetia Limpopo Nature Reserve and while impacts are low the area is highly erodible. A few small dams exist. These wetland systems are intermittent to ephemeral with a high degree of flashiness during rainfall events, but also with a myriad of small pans both off-channel and within the broader channel that have high levels of clay and clearly hold water for some time (a few weeks at most). Leeupan, which is connected to the Kolope River (and which has been targeted for wetland rehabilitation to prevent and rectify incision) is a notable exception and is vital for its importance to biodiversity in the area (see inset to the right). A combination of WetHealth Level 1 and the Wetland IHI was used within

the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for riverine wetlands along these systems.

Table 3-38. Land cover classes (NLC, 2020) in the Kolope wetlands catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
4		Open Woodland (10 - 35% cc)	78866.6	76.5
13		Natural Grassland	17182.3	16.7
27		Eroded Lands	1783.2	1.7
31		Other Bare	1527.3	1.5
71		Mines: Waste (Tailings) & Resource Dumps	1246.1	1.2
43		Fallow Land & Old Fields (Bush)	746.0	0.7
40		Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	473.4	0.5
69		Mines: Extraction Sites: Open Cast & Quarries combined	391.8	0.4
44		Fallow Land & Old Fields (Grass)	165.0	0.2
21		Artificial Flooded Mine Pits	154.4	0.1

Table 3-39. Land cover classes (NLC, 2020) surrounding the Kolope wetlands, expressed as a percentage of area, including 200m buffer (Only top 10 classes are shown).

Valley-bottom with a channel : (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Open Woodland (10 - 35% cc)	60.8
Natural Grassland	28.3
Eroded Lands	5.7
Other Bare	3.1
Dense Forest & Woodland (35 - 75% cc)	0.6
Fallow Land & Old Fields (Bush)	0.3
Natural Rock Surfaces	0.3
Bare Riverbed Material	0.2
Artificial Dams (incl. canals)	0.1
Fallow Land & Old Fields (Grass)	0.1

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 90% (A/B). The rating, reasons and results are shown in **Table 3-40, Table 3-41** and **Table 3-42.**

Table 3-40. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Kolope riverine wetlands.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-1	A few small farm-style dams upstream	High
Increase in flows (water inputs)	0	Venetia diamond mine appear to store groundwater in off-channel dams and do not decant into the Kolope system	Medium
Combined impact Score	-1		
Change in flood patterns (peaks)	0	None	Medium
Magnitude of impact Score	1.0		

Table 3-41. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Kolope riverine wetlands).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	2	4	0.08	Potential erosion of access roads	Medium
Modifications to existing channels	0	0	0	None	Medium
Reduced roughness	0	0	0	None	Medium
Impeding features (e.g. dams) – upstream effects	2	8	0.16	A few in-channel small dams	High
Impeding features – downstream effects	2	3	0.06	A few in-channel small dams	High
Increased on-site water use	0	0	0	None, only at the mine but it does not appear to decant water into the system	Low
Deposition/infilling or excavation	0	0	0	None	Medium
Combined impact Score			**0.3**		

Table 3-42. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	0.3
Changes to Water Input characteristics	1.0
Combined Hydrology Impact Score	1.0
Hydrology PES% Score	**90%**
Hydrology PES Category	**A/B**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 89% (A/B). The rating, reasons and results are shown in **Table 3-43.**

Table 3-43. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Kolope riverine wetlands.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	5	3	0.2	A few small farm-style dams upstream	High
(2) Stream diversion/shortening	Floodplain, Channeled VB	0	0	0.0	None	Medium
(3) Infilling	Floodplain, Channeled VB	0	0	0.0	None	Medium
(4) Increased runoff	Non-floodplain HGMs	10	6	0.6	Storm water runoff from roads and potential inputs from the mine	Low
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	10	4	0.4	The area is prone to erosion and incision e.g. Leeupan, but access roads and low-level crossings exacerbates erosion	Medium
(6) Depositional features	All non-floodplain HGMs	0	0	0.0	None	Medium
(6) Loss of organic matter	All non-floodplain HGMs with peat	0	0	0.0	None	High
Combined Impact Score based on a sum of all magnitude scores				1.2		

Geomorphology PES% Score	89%
Geomorphology PES Category	A/B

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 88.3% (A/B). The rating, reasons and results are shown in **Table 3-44**.

Table 3-44. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Kolope wetlands.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	3
	Salts	0.0	20	3
	Nutrients	0.0	90	3
	Water Temp.	0.0	10	3
	Turbidity	1.5	100	3
	Oxygen	0.0	40	3
	Toxics	1.0	20	3
Water Quality: overall scores				
Rating:		**0.6**	**Confidence:**	***3.0***
Percentage:		**88.3**		
PES Category:		**A/B**		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 90% (A/B). The rating, reasons and results are shown in **Table 3-45**.

Table 3-45. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Kolope wetlands).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	2	10	10	0.2	Few access roads and low-level crossings	High
Deep flooding by dams	0	10	10	0.0	None	High

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes		Confidence rating
Shallow flooding by dams	1	4 - 8	8	0.1	A few small dams in-channel		High
Crop lands	0.2	8 - 10	8	0.0	Measured from NLC 2020		High
Commercial plantations	0	7 - 10	10	0.0	None		High
Annual pastures	0	9 -10	9	0.0	None		High
Perennial pastures	0.3	4 -10	4	0.0	Measured from NLC 2020		High
Dense Alien vegetation patches.	0	5 - 10	7	0.0	None		High
Sports fields	0	7 - 10	9	0.0	None		High
Gardens	0	6 - 10	8	0.0	None		High
Areas of sediment deposition/ infilling & excavation	0	4-10	8	0.0	None		High
Eroded areas	9	3 - 9	7	0.6	Measured from NLC 2020		High
Old / abandoned lands (Recent)	0	7 - 9	7	0.0	None		High
Old / abandoned lands (Old)	0	3 - 8	5	0.0	None		High
Seepage below dams	1	1 - 5	3	0.0	A few small dams in-channel		High
Untransformed areas	0	0 - 3	1	0.0	None		High
Overall weighted impact score				**1.0**			
Vegetation PES% Score				**90%**			
Vegetation PES Category				**A/B**			

Summary and Overall PES:

The summary and overall PES for the Kolope riverine wetlands is 90% (A/B), and is shown in **Table 3-46**.

Table 3-46. Summary PES results for the Kolope wetlands.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	90 %	**A/B**
Geomorphology PES	WET-Health Geomorph Module	89 %	**A/B**
Water quality PES	Wetland-IHI WQ Module	88 %	**A/B**
Vegetation PES	WET-Health Veg Module	90 %	**A/B**
Overall Wetland PES	WET-Health default weightings	90 %	**A/B**

3.2.7 Lake Fundudzi

Lake Fundudzi, a depressional wetland that is also seen as the start of the Mutale River is unique in that it was created by a natural landslide and has cultural value as a sacred site to the surrounding people, and as such is afforded protection from the royal house. The lake itself is surrounded by steep well wooded slopes and channelled valley bottom wetlands upstream of the lake that have already been the focus of rehabilitation with installed gabions to rectify and prevent channel incision (**Figure 3-18**). These wetlands were surveyed on the 20th April 2023 and **Figure 3-19** shows the waypoints that were taken as part of the data gathered.

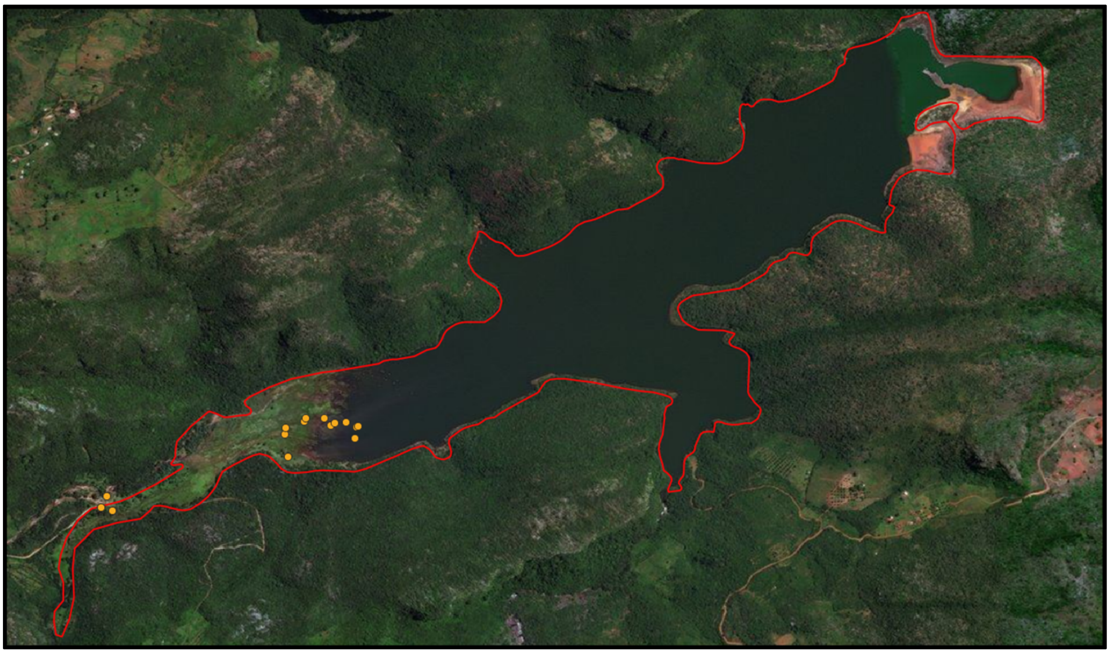

Figure 3-18. Bing aerial image showing Lake Fundudzi and the channelled valley bottom wetlands leading into it, as well as hand held survey points within the wetland (orange points) during April 2023.

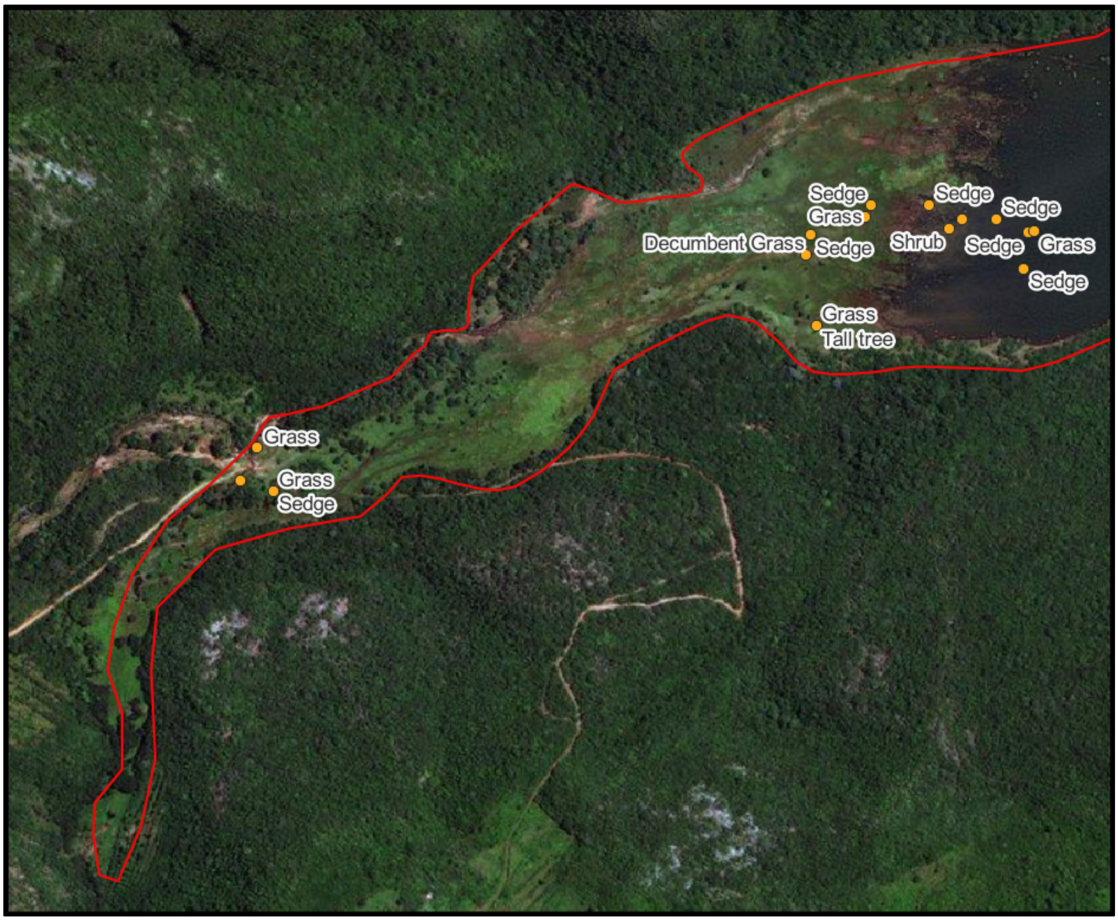

Figure 3-19. Example of waypoints showing dominant lifeform information across the Lake Fundudzi upstream channelled valley bottom wetlands.

PES of Lake Fundudzi and the upstream channelled valley bottom wetlands:

The catchment upstream of Lake Fundudzi is comprised predominantly of cultivation of some kind and informal and formal residential areas (**Table 3-47**). Land use surrounding the lake and channelled valley bottom wetlands, including a 200m buffer, is mostly herbaceous wetlands, dense forest, woodland or thicket and natural lakes (**Table 3-48**). The lake is used for fishing by locals although poaching is on the increase (pers com, Royal house) and is also important for sacred rituals. The access roads to the lake and upstream wetlands are steep, gravel and erosion is extreme, delivering sediments and increased flood flashiness to the system. Borrow pits for the road surfacing are also eroding. Channelled valley bottom wetlands are dominated by grasses (*Ishaemum faciculatum*, *Arundinella napalensis*) and sedges (*Cypers dives*, *Kylinga sp*, *Juncus lomatophyllus*), but with invasion by indigenous and alien shrubs, and are used for grazing localised livestock with grazing and trampling pressure being high. These wetlands are also heavily invaded by both annual and perennial alien plant species, notably *Senna didymobotrya*. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for Lake Fundudzi and the upstream channelled valley bottom wetlands.

Table 3-47. Land cover classes (NLC, 2020) in the Lake Fundudzi catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Cover (%)
32		Cultivated Commercial Permanent Orchards	62.8
50		Residential Formal (Bare)	10.8
2		Contiguous Low Forest & Thicket (*combined classes*)	5.1
73		Fallow Land & Old Fields (wetlands)	4.7
23		Herbaceous Wetlands (previous mapped extent)	3.8
22		Herbaceous Wetlands (currently mapped)	3.5
67		Roads & Rail (Major Linear)	1.2
3		Dense Forest & Woodland (35 - 75% cc)	0.9
4		Open Woodland (10 - 35% cc)	0.9
5		Contiguous & Dense Planted Forest (*combined classes*)	0.9
52		Residential Informal (Bush)	0.9
65		Commercial	0.9

Table 3-48. Land cover classes (NLC, 2020) surrounding Lake Fundudzi, expressed as a percentage of the lake and wetlands area, including 200m buffer (Only top 10 classes are shown).

Valley-bottom with a channel; lake : (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Herbaceous Wetlands (currently mapped)	30.1
Contiguous Low Forest & Thicket (combined classes)	23.6
Dense Forest & Woodland (35 - 75% cc)	23.5
Natural Lakes	18.6
Dry Pans	1.2
Natural Grassland	1.2
Open Woodland (10 - 35% cc)	0.9
Fallow Land & Old Fields (Trees)	0.5
Cultivated Commercial Permanent Orchards	0.2
Herbaceous Wetlands (previous mapped extent)	0.1

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 80% (B/C). The rating, reasons and results are shown in **Table 3-49, Table 3-50** and **Table 3-51**.

Table 3-49. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of Lake Fundudzi.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	0		
Increase in flows (water inputs)	1	Catchment is steep so hardening increases flows and flashiness, fields and access roads, roof areas.	High
Combined impact Score	1		
Change in flood patterns (peaks)	2	Catchment is steep so hardening increases flows and flashiness, fields and access roads, roof areas.	High
Magnitude of impact Score	1.0		

Table 3-50. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Lake Fundudzi & surrounding wetlands).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	4	10	0.4	Gullies have eroded along steep gravel access roads.	High
Modifications to existing channels	1	4	0.04	Low level crossing	
Reduced roughness	10	6	0.6	Cleared areas for roads, borrow pits, wood removal	
Impeding features (e.g. dams) – upstream effects	0	6	0		
Impeding features – downstream effects	1	4	0.04	Low level crossing, negligible	High
Increased on-site water use	0	2	0		
Deposition/infilling or excavation	0	4	0		
Combined impact Score			**1.1**		

Table 3-51. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	**1.1**
Changes to Water Input characteristics	**1.0**
Combined Hydrology Impact Score	**2.0**
Hydrology PES% Score	**80%**
Hydrology PES Category	**B/C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 82% (B). The rating, reasons and results are shown in **Table 3-52**.

Table 3-52. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for Lake Fundudzi & surrounding wetlands.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	0	8	0.0		
(2) Stream diversion/shortening	Floodplain, Channeled VB	0	1	0.0		
(3) Infilling	Floodplain, Channeled VB	0	6	0.0		
(4) Increased runoff	Non-floodplain HGMs	20	8	1.6	Storm water off steep, gravel access roads and livestock paths.	High
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	5	4	0.2	Parts of the channel have incised due to storm water erosion, evidence of wetland rehabilitation structures in place.	High
(6) Depositional features	All non-floodplain HGMs			0.0		
(6) Loss of organic matter	All non-floodplain HGMs with peat			0.0		
Combined Impact Score based on a sum of all magnitude scores		1.8				
Geomorphology PES% Score		82%				
Geomorphology PES Category		B				

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 82.9% (B). The rating, reasons and results are shown in **Table 3-53**.

Table 3-53. Water quality module (Wetland IHI within DSP): Consider water quality impacts for Lake Fundudzi & surrounding wetlands.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	2
	Salts	0.5	40	2
	Nutrients	1.0	100	3
	Water Temp.	0.0	20	3
	Turbidity	1.5	90	3
	Oxygen	0.5	80	2
	Toxics	0.5	10	3
Water Quality: overall scores				
Rating:		**0.9**	**Confidence:**	***2.6***
Percentage:		**82.9**		
PES Category:		**B**		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 72% (C). The rating, reasons and results are shown in **Table 3-54.**

Table 3-54. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class, and integrate these for the overall wetland (Lake Fundudzi & surrounding wetlands).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	0.5	10	10	0.1	Measured from NLC, 2020 and ground truthed in 2023	High
Deep flooding by dams	0	10	10	0.0		
Shallow flooding by dams	0	4 - 8	8	0.0		
Crop lands	5	8 - 10	6	0.3		
Commercial plantations	5	7 - 10	10	0.5		
Annual pastures	0	9 -10	9	0.0		
Perennial pastures	0	4 -10	4	0.0		
Dense Alien vegetation patches.	15	5 - 10	10	1.5		
Sports fields	0	7 - 10	9	0.0		
Gardens	0	6 - 10	8	0.0		

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Areas of sediment deposition/ infilling & excavation	2	4-10	6	0.1		
Eroded areas	5	3 - 9	6	0.3		
Old / abandoned lands (Recent)	0	7 - 9	7	0.0		
Old / abandoned lands (Old)	0	3 - 8	5	0.0		
Seepage below dams	0	1 - 5	7	0.0		
Untransformed areas	0	0 - 3	4	0.0		
Overall weighted impact score				**2.8**		
Vegetation PES% Score				**72%**		
Vegetation PES Category				**C**		

Summary and Overall PES:

The summary and overall PES for Lake Fundudzi's surrounding channelled valley bottom wetlands is 78% (B/C), and is shown in **Table 3-55.** The main drivers of change are agricultural encroachment, grazing pressure within wetlands, invasive alien plant species and altered flooding patterns from runoff, mostly gravel roads, increasing flashiness and sediment delivery.

Table 3-55. Summary PES results for Lake Fundudzi & surrounding wetlands.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	80 %	**B/C**
Geomorphology PES	WET-Health Geomorph Module	82 %	**B**
Water quality PES	Wetland-IHI WQ Module	83 %	**B**
Vegetation PES	WET-Health Veg Module	72 %	**C**
Overall Wetland PES	WET-Health default weightings	78 %	**B/C**

3.2.8 Mutale Wetlands

The Mutale wetlands that were assessed comprise seepage, channelled valley bottom and unchanneled valley bottom wetlands in excess of 3500 Ha that form a major contribution to the Mutale River main channel (**Figure 3-20**). The area is well utilized by the surrounding population and their livestock, and wetlands are mostly freely accessible. Some of the channelled valley bottom wetlands upstream of the Mutale River confluence have already been the focus of rehabilitation with installed gabions to rectify and prevent channel incision. These wetlands were surveyed on the 21st April 2023 and **Figure 3-21** shows some of the waypoints that were taken as part of the data gathered.

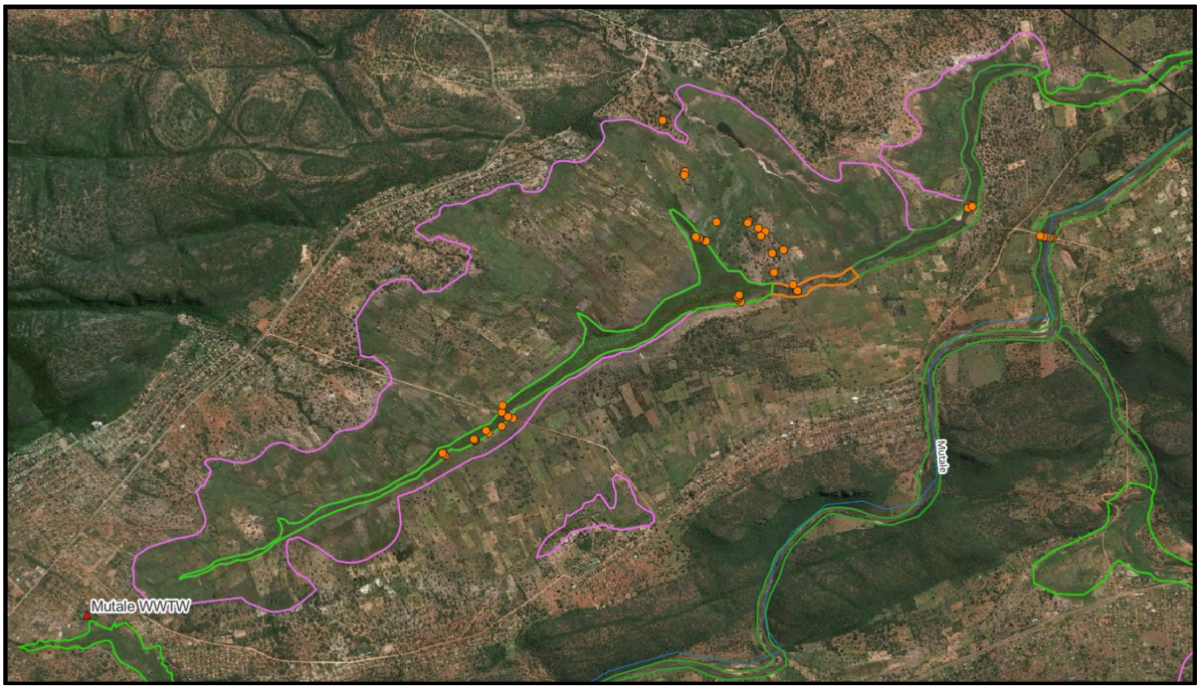

Figure 3-20. Bing aerial image showing the Mutale wetlands (channelled and unchanneled valley bottom and seepage wetlands), as well as hand held survey points within the wetland (orange points) during April 2023.

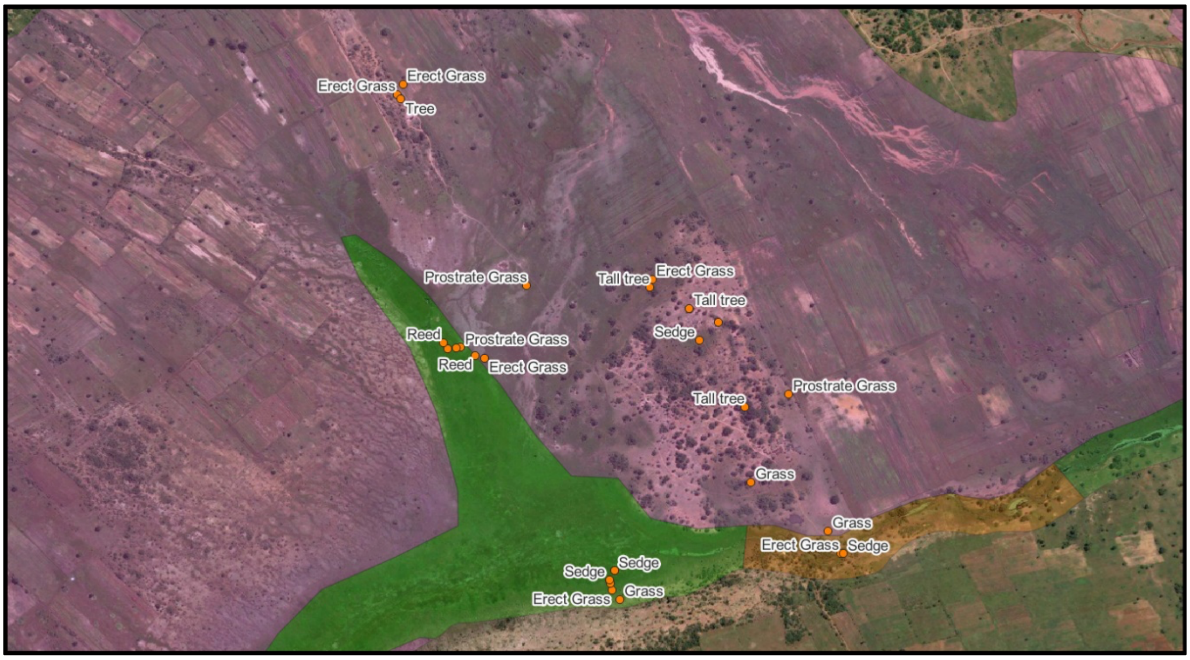

Figure 3-21. Example of waypoints showing dominant lifeform information across the Mutale wetlands.

PES of Mutale wetlands:

The catchment upstream and surrounding the Mutale wetlands is comprised predominantly of dense or open forest woodland or thicket (almost 77%), with 11 and 10% comprising cultivated and built-up areas respectively (**Table 3-56)**. Land use within the wetlands, including a 200m buffer, is also predominantly dense or open woodland but also comprises cultivated areas for about 13% of the area (**Table 3-57)**. The channelled and unchanneled valley bottom wetlands are utilised predominantly for the grazing of livestock, although plant material, notable giant sedges, is also collected. There is widespread evidence of high grazing and trampling pressure, some of which has caused erosion of the main channel. Grazing pressure is extended to the seepage wetlands, but this area is extensively used for cultivation and intense sand mining. Sand mining is to depths of 2,5m or more in places and has resulted in localised artificial depressional wetland habitats dispersed across seepage wetland areas. Wood removal is also widespread. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Mutale wetlands:

Table 3-56. Land cover classes (NLC, 2020) in the Mutale wetlands catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
3		Dense Forest & Woodland (35 - 75% cc)	21687.4	34.2
2		Contiguous Low Forest & Thicket (*combined classes*)	17462.5	27.5
4		Open Woodland (10 - 35% cc)	5999.1	9.4
42		Fallow Land & Old Fields (Trees)	3899.5	6.1
48		Residential Formal (Bush)	3439.8	5.4
5		Contiguous & Dense Planted Forest (*combined classes*)	3314.5	5.2
47		Residential Formal (Tree)	2814.3	4.4
41		Subsistence / Small-Scale Annual Crops	2593.5	4.1
43		Fallow Land & Old Fields (Bush)	495.5	0.8
32		Cultivated Commercial Permanent Orchards	387.5	0.6
6		Open & Sparse Planted Forest	332.4	0.5
50		Residential Formal (Bare)	329.8	0.5

Table 3-57. Land cover classes (NLC, 2020) within the Mutale wetlands, expressed as a percentage of wetland area, including 200m buffer (Only top 10 classes are shown).

2020 NLC Class Name - Full Level	Cover (% wetland area)
Dense Forest & Woodland (35 - 75% cc)	42.4
Open Woodland (10 - 35% cc)	33.1
Subsistence / Small-Scale Annual Crops	10.2
Contiguous Low Forest & Thicket (combined classes)	8.1
Fallow Land & Old Fields (Trees)	2.0
Herbaceous Wetlands (currently mapped)	1.4
Fallow Land & Old Fields (Bush)	0.8
Residential Formal (Bush)	0.6
Residential Formal (Tree)	0.3
Bare Riverbed Material	0.3

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 70% (C). The rating, reasons and results are shown in **Table 3-58, Table 3-59** and **Table 3-60**.

Table 3-58. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Mutale wetlands.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-2	Some evergreen crops and alien vegetation, some diversion by access routes, small farm-style dams	High
Increase in flows (water inputs)	2	Catchment denudation, loss of vegetation cover and gravel road infrastructure	High
Combined impact Score	0		
Change in flood patterns (peaks)	1	Catchment denudation, loss of vegetation cover and gravel road infrastructure	High
Magnitude of impact Score	0.0		

Table 3-59. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Mutale wetlands).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	2	8	0.16	Eroded gravel access roads that traverse the wetland	High
Modifications to existing channels			0		
Reduced roughness	80	2	1.6	Vegetation clearing for agriculture, and overgrazing combined with trampling pressure	High
Impeding features (e.g. dams) – upstream effects	5	6	0.3	Small farm-style dams	Medium
Impeding features – downstream effects			0		
Increased on-site water use			0		
Deposition/infilling or excavation	20	9	1.8	Intense localised sand mining	High
Combined impact Score			**3.9**		

Table 3-60. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	3.9
Changes to Water Input characteristics	0.0
Combined Hydrology Impact Score	3.0
Hydrology PES% Score	**70%**
Hydrology PES Category	**C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 69% (C). The rating, reasons and results are shown in **Table 3-61**.

Table 3-61. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Mutale wetlands.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	5	6	0.3	Small farm-style dams	Medium
(2) Stream diversion/shortening	Floodplain, Channeled VB			0.0		
(3) Infilling	Floodplain, Channeled VB			0.0		
(4) Increased runoff	Non-floodplain HGMs	10	8	0.8	Catchment denudation, loss of vegetation cover and gravel road infrastructure	High
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	20	10	2.0	Intense localised sand mining	High

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
(6) Depositional features	All non-floodplain HGMs			0.0		
(6) Loss of organic matter	All non-floodplain HGMs with peat			0.0		
Combined Impact Score based on a sum of all magnitude scores				3.1		
Geomorphology PES% Score				69%		
Geomorphology PES Category				C		

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 76.3% (C). The rating, reasons and results are shown in **Table 3-62**.

Table 3-62. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Mutale wetlands.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	2
	Salts	1.0	40	2
	Nutrients	1.5	100	3
	Water Temp.	0.0	20	3
	Turbidity	2.0	90	3
	Oxygen	-0.5	80	2
	Toxics	0.5	10	3
Water Quality: overall scores				
Rating:		**1.2**	**Confidence:**	***2.6***
Percentage:		**76.3**		
PES Category:		**C**		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 43% (D). The rating, reasons and results are shown in **Table 3-63**.

Table 3-63. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class and integrate these for the overall wetland (Mutale wetlands).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude
Infrastructure	5	10	10	0.5
Deep flooding by dams		10	10	0.0
Shallow flooding by dams	5	4 - 8	8	0.4
Crop lands	15	8 - 10	8	1.2
Commercial plantations		7 - 10	10	0.0
Annual pastures		9 -10	9	0.0
Perennial pastures	10	4 -10	4	0.4
Dense Alien vegetation patches.	5	5 - 10	10	0.5
Sports fields		7 - 10	9	0.0
Gardens		6 - 10	8	0.0
Areas of sediment deposition/ infilling & excavation	20	4-10	10	2.0
Eroded areas	2	3 - 9	6	0.1
Old / abandoned lands (Recent)	5	7 - 9	7	0.4
Old / abandoned lands (Old)	5	3 - 8	5	0.3
Seepage below dams		1 - 5	7	0.0
Untransformed areas		0 - 3	4	0.0
Overall weighted impact score				**5.7**
Vegetation PES% Score				**43%**
Vegetation PES Category				**D**

Summary and Overall PES:

The summary and overall PES for the Mutale wetlands is 62% (C/D), and is shown in **Table 3-64**. The main drivers of change are agricultural activities within wetlands, sand mining within wetlands, invasive alien plant species and high grazing pressure within and around wetlands potentially altering runoff patterns.

Table 3-64. Summary PES results for the Mutale wetlands.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	70 %	**C**
Geomorphology PES	WET-Health Geomorph Module	69 %	**C**
Water quality PES	Wetland-IHI WQ Module	76 %	**C**
Vegetation PES	WET-Health Veg Module	43 %	**D**
Overall Wetland PES	WET-Health default weightings	62 %	**C/D**

3.2.9 Mokamole Wetlands - Tributary of Mogalakwena

These wetlands occur in a headwater tributary of the Mokamole River, which is a tributary of the Mogalakwena River, just upstream and downstream of the R518 (**Figure 3-22**). The NWM5 map indicates the typing as seepage and riverine wetlands, but the field assessment has found that they comprise valley bottom wetlands, mostly without a channel upstream of the R518, with the channel becoming more prominent downstream of the R518. Such large systems at the base of the Waterberg are relatively uncommon (Marneweck, pers com). In the context of the broader region these wetlands are important from a biodiversity perspective. The area is utilized by livestock and has access roads, some of which traverse the wetlands. These wetlands were surveyed on the 23rd April 2023 and

Figure 3-23 shows some of the waypoints that were taken as part of the data gathered.

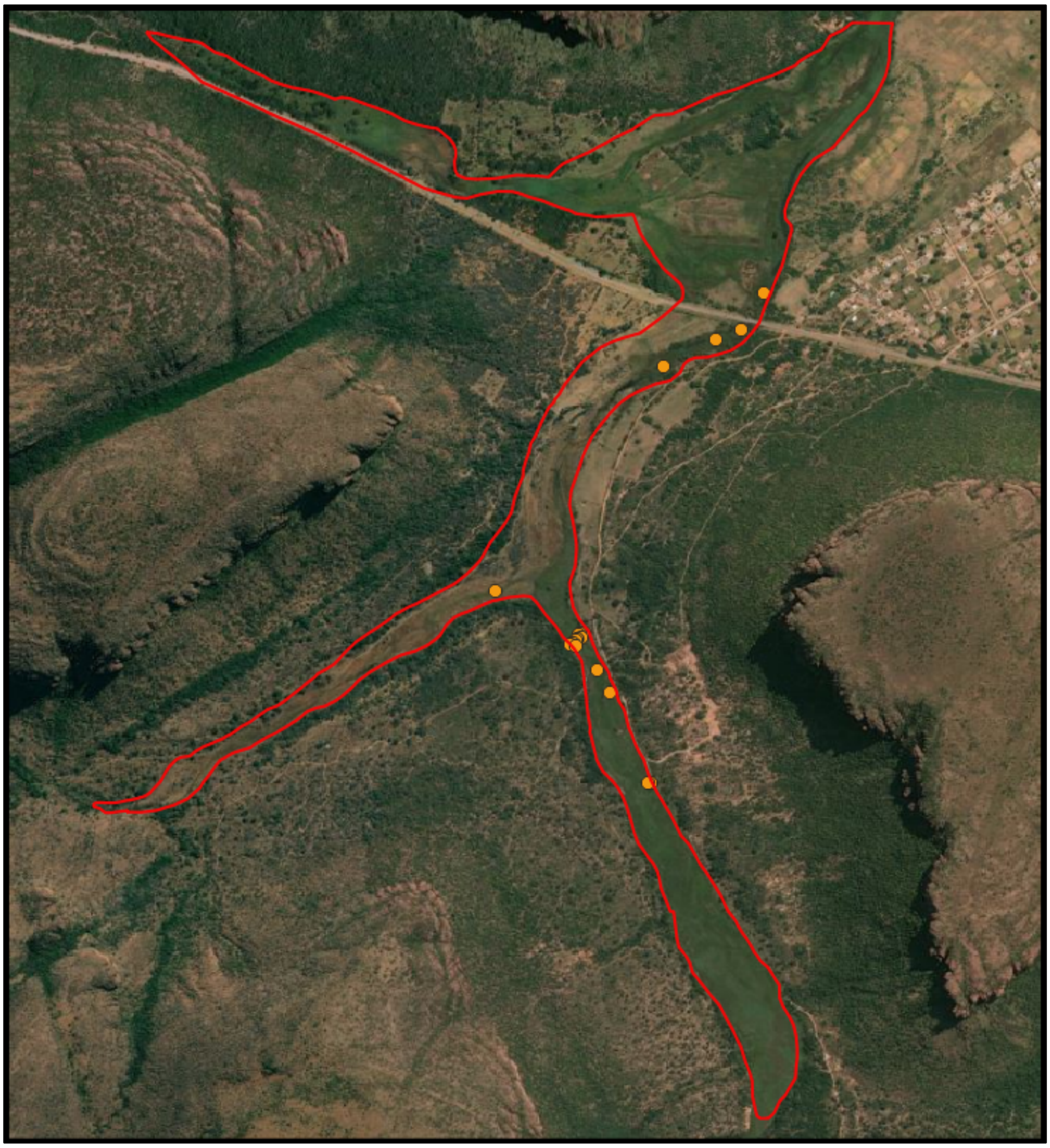

Figure 3-22. Bing aerial image showing the Mokamole wetlands, as well as handheld survey points within the wetland (orange points) taken during April 2023.

Figure 3-23. Example of waypoints showing dominant lifeform information across the Mokamole wetlands.

PES of the Mokamole wetlands:

The catchment upstream and surrounding the Mokamole wetlands is comprised predominantly of dense or open forest woodland or thicket (more than 90%), with some natural grassland and cultivated areas (**Table 3-65**). Land use within the wetlands, including a 200m buffer, is also predominantly dense or open woodland but also comprises cultivated areas for about 9% of the area (**Table 3-66**). The channelled and unchanneled valley bottom wetlands are utilised predominantly for the grazing of livestock and access to upstream valleys. Wood removal also occurs and some agricultural activities downstream of the R518 bridge. A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Mokamole wetlands:

Table 3-65. Land cover classes (NLC, 2020) in the Mokamole wetlands catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
4		Open Woodland (10 - 35% cc)	8044.0	45.6
3		Dense Forest & Woodland (35 - 75% cc)	7845.1	44.5
13		Natural Grassland	633.6	3.6
2		Contiguous Low Forest & Thicket (combined classes)	469.8	2.7
43		Fallow Land & Old Fields (Bush)	328.8	1.9
42		Fallow Land & Old Fields (Trees)	103.5	0.6
25		Natural Rock Surfaces	93.6	0.5
12		Sparsely Wooded Grassland (5 - 10% cc)	43.6	0.2
48		Residential Formal (Bush)	14.0	0.1
23		Herbaceous Wetlands (previous mapped extent)	13.6	0.1

Table 3-66. Land cover classes (NLC, 2020) within the Mokamole wetlands, expressed as a percentage of wetland area, including 200m buffer (Only top 10 classes are shown).

Valley-bottom without a channel: (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Dense Forest & Woodland (35 - 75% cc)	62.4
Contiguous Low Forest & Thicket (combined classes)	14.6
Subsistence / Small-Scale Annual Crops	9.1
Open Woodland (10 - 35% cc)	5.3
Herbaceous Wetlands (previous mapped extent)	2.4
Natural Grassland	2.1
Fallow Land & Old Fields (Trees)	2.1
Residential Formal (Tree)	0.5
Fallow Land & Old Fields (Bush)	0.4
Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	0.3

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 80% (B/C). The rating, reasons and results are shown in **Table 3-67, Table 3-68** and **Table 3-69**.

Table 3-67. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Mokamole wetlands.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	-1	Several small farm-style dams upstream	High
Increase in flows (water inputs)	0		
Combined impact Score	-1		
Change in flood patterns (peaks)	-1	Several small farm-style dams upstream	High
Magnitude of impact Score	1.0		

Table 3-68. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Mokamole wetlands).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	2	4	0.08	Potential erosion of access roads	Medium
Modifications to existing channels	0	0	0	none	Medium
Reduced roughness	10	5	0.5	Grazing pressure and clearing for agriculture	Medium
Impeding features (e.g. dams) – upstream effects	5	5	0.25	Some damming associated with the bridge structure	High
Impeding features – downstream effects	5	3	0.15	Some damming associated with the bridge structure	High
Increased on-site water use	0	0	0	none	Medium
Deposition/infilling or excavation	0	0	0	none	Medium
Combined impact Score			1.0		

Table 3-69. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	1.0
Changes to Water Input characteristics	1.0
Combined Hydrology Impact Score	2.0
Hydrology PES% Score	**80%**
Hydrology PES Category	**B/C**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 84% (B). The rating, reasons and results are shown in **Table 3-70**.

Table 3-70. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Mokamole wetlands.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	100	1	1.0	Several small farm-style dams upstream	High
(2) Stream diversion/shortening	Floodplain, Channeled VB	0	0	0.0	None	High
(3) Infilling	Floodplain, Channeled VB	0	0	0.0	None	High
(4) Increased runoff	Non-floodplain HGMs	20	3	0.6	Potential lateral inputs from residential areas	Medium
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	0	0	0.0	None	High

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
(6) Depositional features	All non-floodplain HGMs	0	0	0.0	None	High
(6) Loss of organic matter	All non-floodplain HGMs with peat	0	0	0.0	None	High
Combined Impact Score based on a sum of all magnitude scores				1.6		
Geomorphology PES% Score				84%		
Geomorphology PES Category				B		

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 88.6% (A/B). The rating, reasons and results are shown in **Table 3-71.**

Table 3-71. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Mokamole wetlands.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	2
	Salts	0.5	20	3
	Nutrients	0.5	90	3
	Water Temp.	0.0	10	3
	Turbidity	1.0	100	3
	Oxygen	0.0	40	2
	Toxics	0.5	20	2
Water Quality: overall scores				
Rating:		0.6	*Confidence:*	*2.8*
Percentage:		88.6		
PES Category:		A/B		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 75% (C). The rating, reasons and results are shown in Table 3-72.

Table 3-72. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class and integrate these for the overall wetland (Mokamole wetlands).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes		Confidence rating
Infrastructure	0.5	10	10	0.1	Few access and cross roads		High
Deep flooding by dams	0	10	10	0.0	None		High
Shallow flooding by dams	1	4 - 8	8	0.1	Associated with the bridge		High
Crop lands	11.9	8 - 10	8	1.0	Measured from NLC 2020		High
Commercial plantations	0	7 - 10	10	0.0	None		High
Annual pastures	0	9 -10	9	0.0	None		High
Perennial pastures	30	4 -10	4	1.2	Free range livestock grazing		High
Dense Alien vegetation patches.	2	5 - 10	7	0.1	Some Wattle		High
Sports fields	0	7 - 10	9	0.0	None		High
Gardens	0	6 - 10	8	0.0	None		High
Areas of sediment deposition/ infilling & excavation	0	4-10	8	0.0	None		High
Eroded areas	0.5	3 - 9	7	0.0	Access road erosion		High
Old / abandoned lands (Recent)	0	7 - 9	7	0.0	None		High
Old / abandoned lands (Old)	0	3 - 8	5	0.0	None		High
Seepage below dams	0	1 - 5	3	0.0	None		High
Untransformed areas	0	0 - 3	1	0.0	None		High
Overall weighted impact score				**2.5**			
Vegetation PES% Score				**75%**			
Vegetation PES Category				**C**			

Summary and Overall PES:

The summary and overall PES for the Mokamole wetlands is 80% (B/C), and is shown in **Table 3-73**. The main drivers of change are crop lands and perennial pastures and small farm dams.

Table 3-73. Summary PES results for the Mokamole wetlands.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	80 %	**B/C**
Geomorphology PES	WET-Health Geomorph Module	84 %	**B**
Water quality PES	Wetland-IHI WQ Module	89 %	**A/B**
Vegetation PES	WET-Health Veg Module	75 %	**C**
Overall Wetland PES	WET-Health default weightings	80 %	**B/C**

3.2.10 Malahlapanga

The Malahlapanga peatland is about 9 Ha and contains several thermal springs and spring mires and four small peat domes (cupolas; Grundling et al. 2017) and is linked to an ephemeral drainage channel that is a tributary to the Mphongolo River (**Figure 3-24**). The mounds are referred to as percolation mounds which occur as a result of large and consistent water supply evenly distributed throughout the year, and in this case the water supply is groundwater based (Joosten & Clarke, 2002). Malahlapanga was surveyed on the 19th of April, 2023 and **Figure 3-25** shows the waypoints taken as part of the data collected for the assessment.

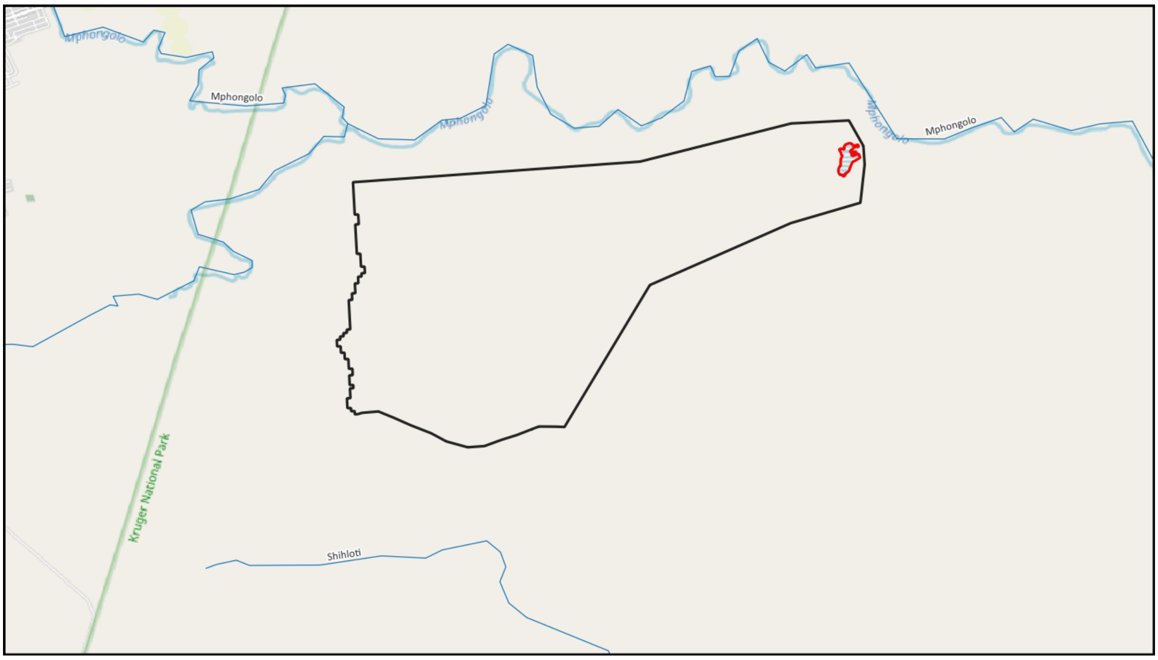

Figure 3-24. Map showing Malahlapanga (red) and its catchment area (black) within KNP.

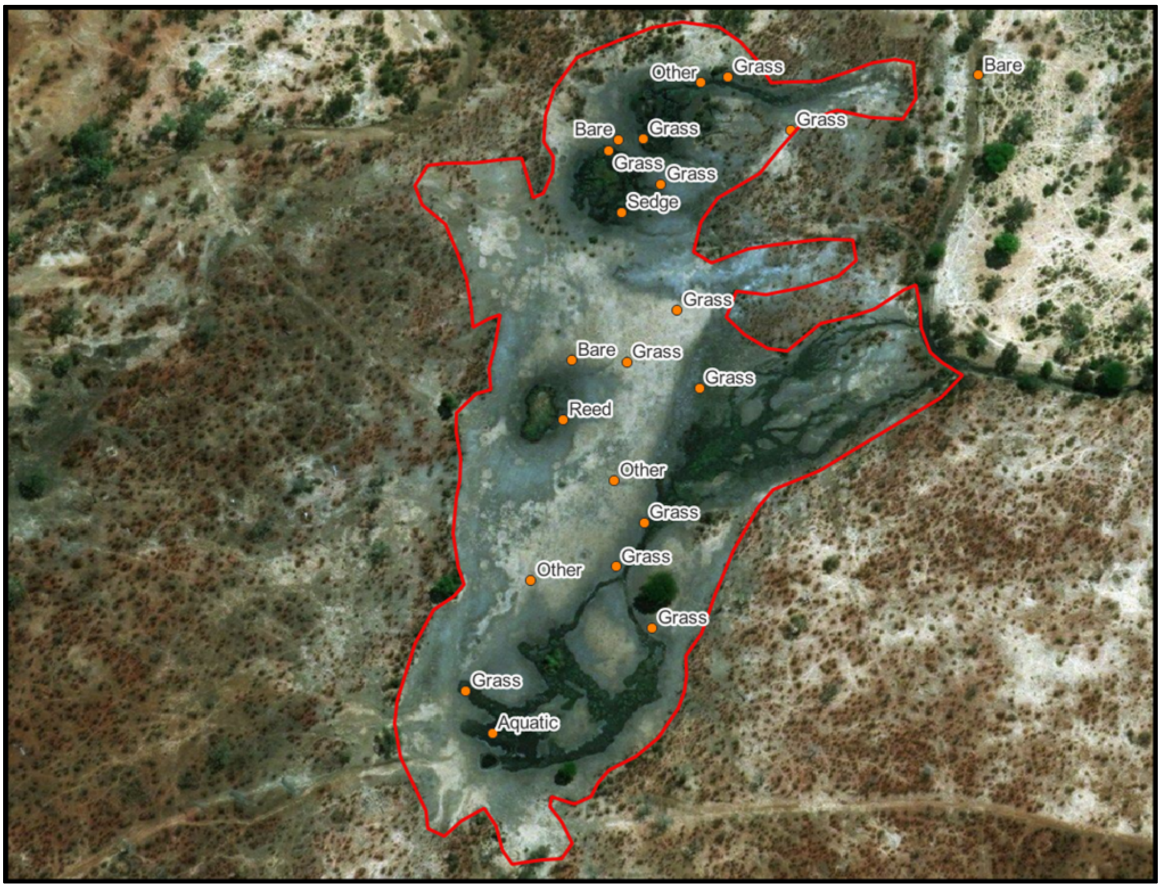

Figure 3-25. Example of waypoints showing lifeform information around Malahlapanga, taken on 19th April 2023. The red area indicates the delineation of the wetland complex.

PES of Malahlapanga:

A detailed change analysis of Malahlapanga showed that the wetland has degraded over time which is thought to be exacerbated by the effects of climate change (Olwoch, 2011). It has also been suggested that some of the spring mounds in the Malahlapanga wetland have been trampled by large game over the years, specifically elephants (Grootjans et al., 2010), but also buffalo, making the issue of elephant populations and numbers of artificial boreholes relevant to the overall health of Malahlapanga. Many of the mounds have been shown to be reducing in height as a result of trampling pressure by megaherbivores and several wetland rehabilitation measures have been put in place, mainly earthen berms, to promote pooling and wetland vegetation recovery (**Figure 3-26**). The catchment area surrounding Malahlapanga occurs completely with KNP (Figure 3-24) and is therefore mostly natural, comprised mostly of open and dense woodland with some natural grassland (**Table 3-74**). Land cover classes (NLC, 2020) surrounding and within Malahlapanga comprise mainly open or dense woodland and natural grassland (**Table 3-75**). Since the WetHealth and Wetland IHI are not designed to deal with this type of wetland (functionally more depressional or flat in type), the DSP provides the option of using the RDM-99 method to determine the Overall PES, the results of which follow for Malahlapanga:

Figure 3-26. Photograph showing wetland rehabilitation earthen berms at Malahlapanga to promote pooling and wetland vegetation recovery.

Table 3-74. Land cover classes (NLC, 2020) in the Malahlapanga catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
4		Open Woodland (10 - 35% cc)	1383.0	62.78
3		Dense Forest & Woodland (35 - 75% cc)	792.6	35.98
13		Natural Grassland	26.1	1.19
27		Eroded Lands	0.6	0.03
22		Herbaceous Wetlands (currently mapped)	0.6	0.03
31		Other Bare	0.0	0.00
1		Contiguous (indigenous) Forest (combined very high, high, medium)	0.0	0.00
2		Contiguous Low Forest & Thicket (combined classes)	0.0	0.00
5		Contiguous & Dense Planted Forest (combined classes)	0.0	0.00
6		Open & Sparse Planted Forest	0.0	0.00

Table 3-75. Land cover classes (NLC, 2020) surrounding and within Malahlapanga, expressed as a percentage of the wetland area, including 200m buffer (Only top 10 classes are shown).

2020 NLC Class Name - Full Level	Cover (% wetland area)
Open Woodland (10 - 35% cc)	83.61
Natural Grassland	9.51
Dense Forest & Woodland (35 - 75% cc)	5.54
Herbaceous Wetlands (currently mapped)	1.25
Eroded Lands	0.08
Contiguous (indigenous) Forest (combined very high, high, medium)	0.00
Contiguous Low Forest & Thicket (combined classes)	0.00
Contiguous & Dense Planted Forest (combined classes)	0.00
Open & Sparse Planted Forest	0.00
Temporary Unplanted Forest	0.00

Summary and Overall PES using the RDM-99 method:

The PES for Malahlapanga using the RDM-99 methodology within the DWS DSP is 78% (B in RDM-99 scoring but B/C in the WetHealth scoring) and is shown in **Table 3-76**. Main drivers of change are annual alien plant species and high grazing and trampling pressure from megaherbivores.

Table 3-76. PES results for the Malahlapanga using the RDM-99 methodology.

Criteria	Relevance	Score	Confidence
Hydrological			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	5	3
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	4	3
Water quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements	5	3

Criteria	Relevance	Score	Confidence
	and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	4	3
Hydraulic / Geomorphological			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	5	3
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.	1	3
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	5	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	2.5	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	3	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	5	3
Overutilisation of biota	Overgrazing, over-fishing, etc.	3.5	3
MEAN SCORE		3.9	3.3
MINIMUM SCORE		1	
Overall PES% Score (without "override")		78%	3
Overall PES Category (without "override")		B	3

3.2.11 Bububu Wetlands (Tributary to the Shingwedzi)

These wetlands have been delineated as channelled valley bottoms along the Bububu River, which is a tributary of the Shingwedzi River (**Figure 3-27**). The NWM5 map indicates the typing as channelled valley bottom wetlands although they were not previously indicated in the NFEPA coverage. Field assessment however has found that they are more typical of riparian zones along an ephemeral channel with associated sodic sites and scattered small pans in the landscape. Riverine wetlands would be a more fitting type. These wetlands were surveyed on the 18th April 2023 and **Figure 3-28** shows some of the waypoints that were taken as part of the data gathered.

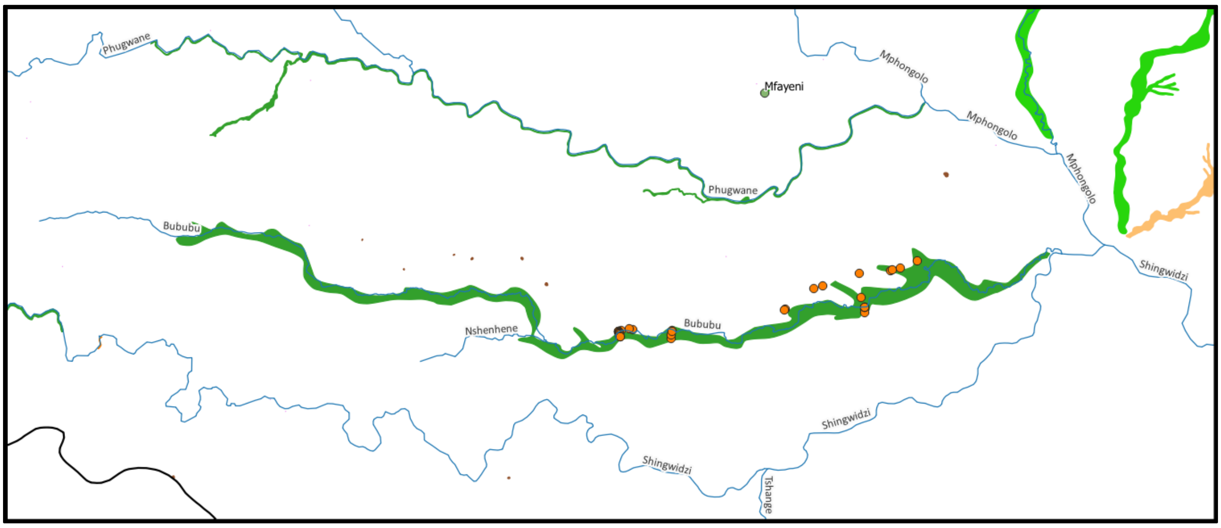

Figure 3-27. Map showing the riverine wetlands along the Bububu River, as well as hand held survey points within the wetland (orange points) taken during April 2023.

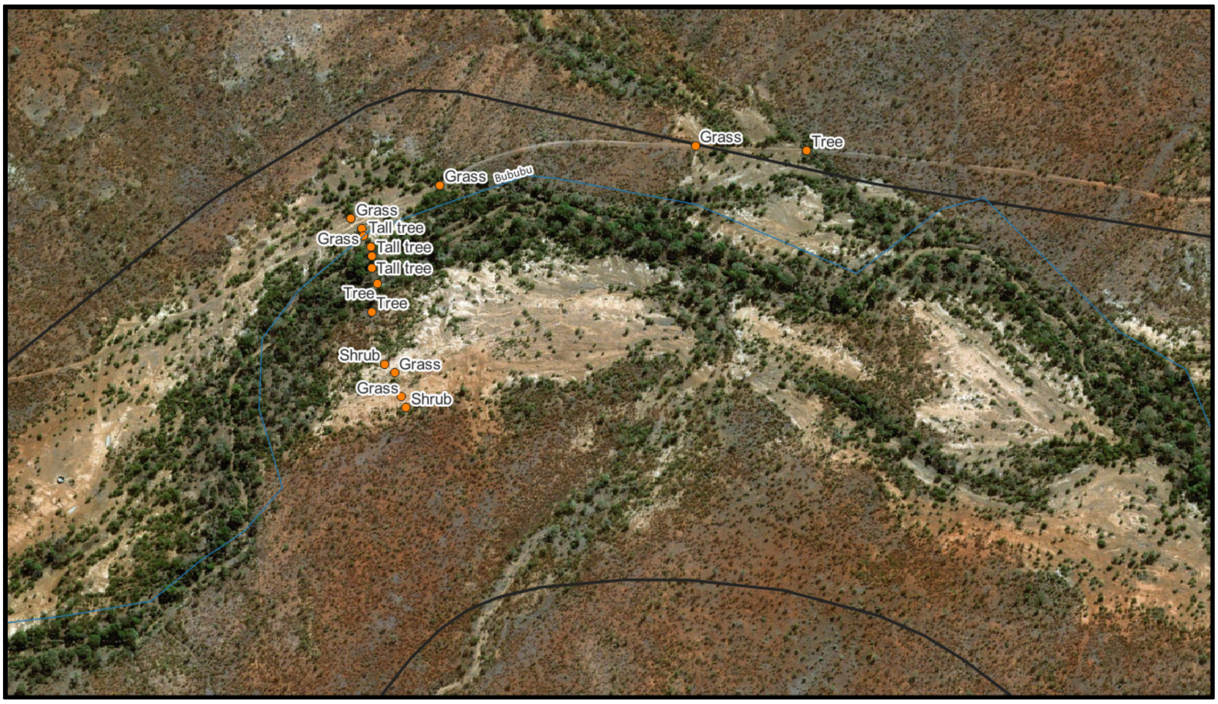

Figure 3-28. Example of waypoints showing dominant lifeform information across the Bububu wetlands.

PES of the Bububu wetlands:

The catchment upstream and surrounding the Bububu wetlands is almost completely within the KNP and not surprisingly is comprised predominantly of open or dense woodland (more than 90%), with some natural grassland and less than 1% cultivated areas outside the Park (**Table 3-77**). Land use within the wetlands, including a 200m buffer, is also predominantly dense or open woodland and natural grassland but also comprises bare areas, some of which has been found to be sodic in nature (**Table 3-78)**. The entire system is well conserved within the KNP mantra and as such remains natural (reference condition). A combination of WetHealth Level 1 and the Wetland IHI was used within the DWS DSP to assess the hydrology, geomorphology, water quality and vegetation modules, the results of which follow for the Bububu wetlands:

Table 3-77. Land cover classes (NLC, 2020) in the Bububu wetlands catchment area, expressed as a percentage of the catchment area (Only top 10 classes are shown).

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
4		Open Woodland (10 - 35% cc)	27090.7	94.68
3		Dense Forest & Woodland (35 - 75% cc)	766.66	2.679
13		Natural Grassland	409.81	1.432
41		Subsistence / Small-Scale Annual Crops	130.06	0.455
48		Residential Formal (Bush)	104.04	0.364

No.	Legend Colour	2020 NLC Class Name	Area (Ha)	Cover (%)
49		Residential Formal (low veg / grass)	64.96	0.227
50		Residential Formal (Bare)	12.08	0.042
22		Herbaceous Wetlands (currently mapped)	10.64	0.037
43		Fallow Land & Old Fields (Bush)	10.4	0.036
44		Fallow Land & Old Fields (Grass)	3.85	0.013

Table 3-78. Land cover classes (NLC, 2020) within the Bububu wetlands, expressed as a percentage of wetland area, including 200m buffer (Only top 10 classes are shown).

Valley-bottom with a channel : (2020 NLC Class Name - Full Level)	Cover (% wetland area)
Open Woodland (10 - 35% cc)	75.21
Natural Grassland	12.72
Dense Forest & Woodland (35 - 75% cc)	9.94
Other Bare	1.83
Eroded Lands	0.28
Bare Riverbed Material	0.02
Contiguous Low Forest & Thicket (combined classes)	0.00
Artificial Dams (incl. canals)	0.00
Contiguous (indigenous) Forest (combined very high, high, medium)	0.00
Contiguous & Dense Planted Forest (combined classes)	0.00

Hydrology Module:

The hydrology module was assessed using WetHealth Level 1, with an outcome of 100% (A). The rating, reasons and results are shown in **Table 3-79, Table 3-80** and **Table 3-81.**

Table 3-79. Hydrology module (WetHealth Level 1 within DSP): Step 2A - evaluate changes to water input characteristics from the catchment of the Bububu wetlands.

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	0	Almost completely within KNP and no outside influence	High
Increase in flows (water inputs)	0	Almost completely within KNP and no outside influence	High
Combined impact Score	0		

Nature of Alteration	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Change in flood patterns (peaks)	0	Almost completely within KNP and no outside influence	High
Magnitude of impact Score	0.0		

Table 3-80. Hydrology module (WetHealth Level 1 within DSP): Step 2B - evaluate changes to water distribution & retention patterns within the wetland (Bububu wetlands).

Nature of Alteration	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Gullies and artificial drainage channels	0	0	0	None	High
Modifications to existing channels	0	0	0	None	High
Reduced roughness	0	0	0	None	High
Impeding features (e.g. dams) – upstream effects	2	8	0.16	Localised backup at low-level crossings	High
Impeding features – downstream effects	2	3	0.06	Localised backup at low-level crossings	High
Increased on-site water use	0	0	0	None	High
Deposition/infilling or excavation	0	0	0	None	High
Combined impact Score			**0.2**		

Table 3-81. Hydrology module (WetHealth Level 1 within DSP): Step 2C - determine the overall hydrological impact score of the HGM unit based on integrating the assessments from steps 2A and 2B.

Changes to water distribution & retention patterns	**0.2**
Changes to Water Input characteristics	**0.0**
Combined Hydrology Impact Score	**0.0**
Hydrology PES% Score	**100%**
Hydrology PES Category	**A**

Geomorphology Module:

The geomorphology module was assessed using WetHealth Level 1, with an outcome of 96% (A). The rating, reasons and results are shown in **Table 3-82**.

Table 3-82. Geomorphology module (WetHealth Level 1 within DSP): Step 3A - determine the present geomorphic state of individual HGM units for the Bububu wetlands.

Impact type	Applicability to HGM type	Extent (%)	Intensity (0 - 10)	Magnitude	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Diagnostic component						
(1) Upstream dams	Floodplain	0	0	0.0	None	High
(2) Stream diversion/shortening	Floodplain, Channeled VB	0	0	0.0	None	High
(3) Infilling	Floodplain, Channeled VB	2	6	0.1	Localised low-level crossings	High
(4) Increased runoff	Non-floodplain HGMs	2	6	0.1	Tourist roads	High
Indicator-based component						
(5) Erosional features	All non-floodplain HGMs	2	8	0.2	Localised at low-level crossings	High
(6) Depositional features	All non-floodplain HGMs	0	0	0.0	None	High
(6) Loss of organic matter	All non-floodplain HGMs with peat	0	0	0.0	None	High
Combined Impact Score based on a sum of all magnitude scores				0.4		
Geomorphology PES% Score				96%		
Geomorphology PES Category				A		

Water Quality Module:

The water quality module was assessed using the Wetland IHI, with an outcome of 93.1% (A). The rating, reasons and results are shown in **Table 3-83**.

Table 3-83. Water quality module (Wetland IHI within DSP): Consider water quality impacts for the Bububu wetlands.

		RATING	Weighting	Confidence (1-5)
Water Quality	pH	0.0	10	3
	Salts	0.0	20	3
	Nutrients	0.0	90	3
	Water Temp.	0.0	10	3
	Turbidity	1.0	100	3
	Oxygen	0.0	40	3
	Toxics	0.0	20	3
Water Quality: overall scores				
Rating:		0.3	*Confidence:*	*3.0*
Percentage:		93.1		
PES Category:		A		

Vegetation Module:

The vegetation module was assessed using WetHealth Level 1, with an outcome of 95% (A). The rating, reasons and results are shown in **Table 3-84**.

Table 3-84. Vegetation module (WetHealth Level 1 within DSP): Step 4c - assess the changes to vegetation composition in each class and integrate these for the overall wetland (Bububu wetlands).

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes	Confidence rating
Infrastructure	2	10	10	0.2	Few access roads and low-level crossings	High
Deep flooding by dams	0	10	10	0.0	None	High
Shallow flooding by dams	2	4 - 8	8	0.2	At low-level crossings	High
Crop lands	0	8 - 10	8	0.0	None	High

Disturbance Class	Extent (%)	Typical intensity	Intensity (0 - 10)	Magnitude	Additional Notes		Confidence rating
Commercial plantations	0	7 - 10	10	0.0	None		High
Annual pastures	0	9 -10	9	0.0	None		High
Perennial pastures	0	4 -10	4	0.0	None		High
Dense Alien vegetation patches.	0	5 - 10	7	0.0	None		High
Sports fields	0	7 - 10	9	0.0	None		High
Gardens	0	6 - 10	8	0.0	None		High
Areas of sediment deposition/ infilling & excavation	2	4-10	8	0.2	At low-level crossings		High
Eroded areas	0	3 - 9	7	0.0	None		High
Old / abandoned lands (Recent)	0	7 - 9	7	0.0	None		High
Old / abandoned lands (Old)	0	3 - 8	5	0.0	None		High
Seepage below dams	0	1 - 5	3	0.0	None		High
Untransformed areas	0	0 - 3	1	0.0	None		High
Overall weighted impact score				**0.5**			
Vegetation PES% Score				**95%**			
Vegetation PES Category				**A**			

Summary and Overall PES:

The summary and overall PES for the Bububu wetlands is 97% (A), and is shown in **Table 3-85**. The system is in a natural state.

Table 3-85. Summary PES results for the Bububu wetlands.

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	100 %	A
Geomorphology PES	WET-Health Geomorph Module	96 %	A
Water quality PES	Wetland-IHI WQ Module	93 %	A
Vegetation PES	WET-Health Veg Module	95 %	A
Overall Wetland PES	WET-Health default weightings	97 %	A

3.2.12 Summary

A summary of the PES scores and categories, EI, ES, REC and how to achieve the REC for all assessed high priority wetlands is shown in **Table 3-86**.

Table 3-86. Summary of the PES score and category, the EI and ES and the REC for all wetlands that were assessed.

High Priority Wetland	PES Score	PES Category	EI	ES	REC	How to achieve the REC
Luvuvhu Floodplain (Makuleke)	80.0	**B/C**	Very High	Very High	**B/C**	Maintain PES
Nyl River Floodplain	65.0	**C**	Very High	Very High	**C**	Maintain PES
Wonderkrater	80.0	**B/C**	Very High	High	**B/C**	Maintain PES
Nyl Pans	57.0	**D**	High	Very High	**C/D**	Improve water quality
Maloutswa Floodplain	66.0	**C**	Very High	Very High	**C**	Maintain PES
Kolope Wetlands	90.0	**A/B**	Very High	Low	**A/B**	Maintain PES
Lake Fundudzi	78.0	**B/C**	Very High	Very High	**B/C**	Maintain PES
Mutale Wetlands	62.0	**C/D**	Very High	Very High	**C/D**	Maintain PES
Mokamole (tributary of the Mogalakwena)	80.0	**B/C**	High	High	**B/C**	Maintain PES
Malahlapanga	78.0	**B/C**	Very High	Moderate	**B**	Reduce trampling pressure from megaherbivores
Bububu wetlands (tributary of the Shingwedzi)	97.0	**A**	Very High	High	**A**	Maintain PES

4 CONCLUSIONS & RECOMMENDATIONS

Chapter 2 of this report explores all existing data for all the wetlands within the study area in a desktop assessment to determine the PES, EI and ES of delineated wetlands (according to the new SANBI wetland map 5; van Deventer *et al*., 2018). This information is then utilised, together with socio-cultural values and water resource use importance (potential or real demand) to prioritise wetlands so that the highest priority wetlands may be assessed in more detail. This is the content of chapter 3 where high priority wetlands are assessed for PES and REC via field verification using existing wetland assessment tools (WET-Health and Wetland IHI). PES scores and categories determined in chapter 3 surpass those outlined in chapter 2. The wetlands that were highlighted as priority wetlands, together with their PES and main drivers of change, included:

- Luvuvhu Floodplain (Makuleke) – B/C (flow regime change, alien plants, impacts of megaherbivores)
- Nyl River Floodplain – C (Agriculture, floodplain manipulation & disturbance, channel alteration)
- Wonderkrater – B/C (trampling & grazing pressure, alien plants)
- Nyl Pans – D (WWTW failure and other water quality problems, grazing pressure)
- Maloutswa Floodplain (Mapungubwe) – C (agriculture, channel constriction)
- Kolope Wetlands – A/B (near natural, minimal impacts)
- Lake Fundudzi – B/C (grazing pressure, alien plants, increased runoff with high sediment loads)
- Mutale Wetlands – C/D (agriculture, grazing and trampling pressure)
- Mokamole wetlands – a tributary of the Mogalakwena River – B/C (alien plants, vegetation removal, small farm dams)
- Malahlapanga (Peat dome) – B/C (trampling pressure by megaherbivores)
- Bububu wetlands – a tributary of the Shingwedzi River – A (natural)

The following recommendations are made:

- All wetland delineations were taken from the new wetland map 5 (van Deventer *et al*., 2018), except the Makuleke wetland complex which was updated using survey points, contours, and ecological notes (Figure 3-3) and the Malahlapanga delineation (Figure 3-25). It is recommended that these new more accurate delineations be incorporated into the next national wetland map update.
- Frequently the two main drivers of deterioration in the ecostatus of wetlands are agriculture, of different forms, and invasive alien plants. The existence and operation of Working for Water SA recognizes the risks associated with alien plant species but better regulatory policies at the national scale need to take more direct cognizance of agricultural activities within delineated wetlands if wetland condition is to be conserved.

5 REFERENCES

Convention on Wetlands. 2021. Global Wetland Outlook: Special Edition 2021. Gland, Switzerland: Secretariat of the Convention on Wetlands.

Department of Water Affairs (DWA). 2012. Guideline for identifying appropriate levels of Resource Protection Measures for inland Wetlands: Version 1.0. Joint Department of Water Affairs and Water Research Commission report, prepared by M. W. Rountree, B. Weston and J. Jay. Department of Water Affairs, Pretoria.

Department of Water and Sanitation (DWS), South Africa. 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQIS-RDM: http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx

Department of Water and Sanitation, South Africa, October 2016. Development of Procedures to Operationalise Resource Directed Measures. Wetland tool analysis and standardisation Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Report no RDM/WE/00/CON/ORDM/0616.

Grootjans, A. P., Grundling, P-L., Grundling, A., Linstorm, A., Engelbrecht, J. & Price, and J.S., 2010: Spring mounds fed by hot water artesian water in the Kruger National Park, South Africa, Mounds and Peat, 6: 1-10.

Grundling, P-L., Grundling A.T., Pretorius, L., Mulders, J. and Mitchell, S. 2017. South African Peatlands: Ecohydrological Characteristics and Socio-Economic Value. Report to the Water Research Commission. WRC Report No. 2346/1/17.

Joosten, H and Clarke, D., 2002: Wise Use of Mounds and Peatlands. International Mound Conservation and International Peat Society.

MacFarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. and Goge, C. 2007. WET-Health: a technique for rapidly assessing wetland health. Version 1.0. Water Research Commission, Pretoria.

McCarthy T.S., Ellery W.N., Backwell L., Marren P., de Klerk B., Tooth S., Brandt D. and Woodborne, S. 2010. The character, origin and palaeoenvironmental significance of the Wonderkrater spring mound, South Africa. Journal of African Earth Sciences 58 (2010) 115–126. Elsevier Ltd.

Mitsch, W.J and Gosselink J.G. 2000. The value of wetlands: importance of scale and landscape setting. Ecological Economics. Volume 35, Issue 1, October 2000, Pages 25-33.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L., and Nienaber, S. 2011.

Technical Report for the National Freshwater Ecosystem Priority Areas Project. WRC Report No. 1801/2/11.

Ollis, DJ., JA Day, HL Malan, JL Ewart-Smith and NM Job. 2014. Development of Decision-Support Tools for Assessment of Wetland Present Ecological Status (PES) Vol 2: Development of a Decision-Support Framework for Wetland Assessment in South Africa and a Decision-Support Protocol for the Rapid Assessment of Wetland Ecological Condition. Report to the Water Research Commission. WRC Report No. TT 609/14.

Olwoch, J. M., 2011: Analysis of Temperature Trends over Limpopo Province, South Africa, Journal of Geography and Geology, 1(3): 13-21.

Rountree, M.W., H. Malan and B. Weston (editors). 2013. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission Study. Report No. 1788/1/13. Water Research Commission, Pretoria.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.