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Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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)

DELINEATION AND STATUS QUO REPORT

No. WEM/WMA01&02/00/CON/RDM/0322

DRAFT

APRIL 2022

PREPARED BY:

Myra Consulting (Pty) Ltd with Southern Waters, Anchor Research & Monitoring and Delta-H as Sub-Consultants
P. O. Box 1309, PRETORIA, 0001

PREPARED FOR:

Department of Water and Sanitation
Chief Directorate: Water Ecosystems Management
Private Bag X313, PRETORIA, 0001

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WP 11352

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Contract Title: 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)

Report Title: Delineation and Status Quo Report

Authors: A Singh, T Tlou, K Reinecke, J Turpie, H Seyler, M Holland, J MacKenzie, G Howard, C Todd, J.N Rossouw

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Adhishri Singh Date

Project Manager

Department of Water and Sanitation: Chief Directorate: Water Ecosystems Management

Approved for the DWS by:

………………………………………….. ……………………………………………

Ndileka Mohapi Date

Chief Director: Water Ecosystems Management

DOCUMENT INDEX

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

Bold type indicates this report.

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02	WEM/WMA01&02/00/CON/RDM/0222	Water Resources Information Gap Analysis Report
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TERMINOLOGY AND ABBREVIATIONS

ACRONYMS	DESCRIPTION
BHN	Basic Human Needs
CMA	Catchment Management Agency
CoAL	Coal of Africa Limited
CVB	Channelled valley bottom
DEM	Digital Elevation Model
DSS	DRIFT Decision Support
DTM	Digital Terrain Model
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EI	Ecological Importance
ES	Ecological Sensitivity
EWR	Ecological Water Requirements
EcoSpecs	Ecological Specifications
ESBC	Ecologically Sustainable Base Configuration
FBIS	Freshwater Biodiversity Information System
FSC	Full Supply Capacity
GEP	Groundwater Exploitation Potential
GRAII	Groundwater Resource Assessment II
GLTP	Great Limpopo Transfrontier Park
GRIP	Groundwater Resource Information Project
GUA	Groundwater Units of Analysis
GVA	Gross Value Added
GW	Groundwater
GWS	Groundwater Schemes
GWBF	Groundwater Contribution to Baseflow
HFY	Historic Firm Yield
HGM	Hydro-geomorphic Unit

ACRONYMS	DESCRIPTION
HYDSTRA	Hydro-informatics database
INR	Institute of Natural Resources
IFR	Instream Flow Requirement
IUA	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
IWMI	International Water Management Institute
KNP	Kruger National Park
LEDET	Limpopo Economic Development, Environment and Tourism
LEIP	Limpopo Industrial Park
LIMCOM	Limpopo River Basin Commission
LLRS	Luvuvhu and Letaba Reconciliation Strategy
LM	Local Municipality
MAR	Mean Annual Runoff
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NEMP	National Eutrophication Monitoring Programme
NFEPA	National Freshwater Ecosystem Priority Areas
NGA	National Groundwater Archive
NMMP	National Microbiological Monitoring Data
NWM	National Wetland Map
ORWRDP – 2B	Olifants River Water Resources Development Project Phase 2
PES	Present Ecological Status
PSP	Professional Service Provider
QUATS	Quaternary Catchments
RDM	Resource Directed Measures
REMP	River Eco-Status Monitoring Programme
RHP	River Health Programme
RQIS	Resource Quality Information Services
RQO	Resource Quality Objectives
RSA	Republic of South Africa

ACRONYMS	DESCRIPTION
RU	Resource Unit
RWS	Regional Water Supply
RWSS	Rural Water Supply Schemes
RWQO	Resource Water Quality Objectives
SAB	South African Breweries
SAEON	South African Environment Observation Network
SANBI	South African National Biodiversity Institute
SC	Secondary Catchment
SCI	Socio-Cultural Importance
SEZ	Socio-Economic Zone
SQ	Sub-quaternary
SW	Surface Water
SWSA	Strategic Water Source Area
TWQR	Target Water Quality Range
UGEP	Utilisable Groundwater Exploitation Potential
UVB	Unchanneled valley bottom
VEGRAI	Riparian Vegetation Response Assessment Index
WARMS	Water Use Authorisation and Registration Management System
WRUI	Water Resource Use Importance
WMA	Water Management Area
WMS	Water Management System
WQI	Water Quality Index
WRCS	Water Resources Classification System
WRPM	Water Resources Planning Model
WRSM	Water Resources Simulation Model
WRYM	Water Resources Yield Model
WwTW	Wastewater Treatment Works

EXECUTIVE SUMMARY

INTRODUCTION

The Department of Water and Sanitation (DWS), Chief Directorate: Water Ecosystems initiated a three-year study 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 Measures 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 provide a mechanism against which the objectives set can be monitored for compliance.

The purpose of this report is to outline the process followed in delineating and determining the Integrated Units of Analysis (IUAs) and describes the status quo of the water resources in the study area. The delineation of the IUAs and status quo assessment is Step 1 of the DWS Classification procedure.

DEFINING THE SOCIO-ECONOMIC ZONES

Socio-economic zones (SEZ) were delineated after detailed inspection of a range of spatial and non-spatial information on population density, geography, climate, drainage, vegetation and land use. This was based mainly on Census data, Land Cover data, and Agricultural Census data. Once these areas had been broadly defined the initial boundaries were compared with river characteristics and catchment boundaries and were found to align well with these, not requiring any further realignment. Given that the ecological zones aligned well with the socio-economic zones at a broad catchment level, it was decided that any further division was not needed and that the SEZs would form the IUAs. Therefore, in this study, given the arrangement of economic activities with water, the SEZs have become the IUAs, which form the basis of assessment for changes in water use and socio-economic impacts.

RESOURCE UNITS

River Resource Units

The approach used to define the boundaries of significant water resources comprising River Resource Units (RUs) was to overlay six sets of ecologically relevant spatial datasets onto a basemap of catchment boundaries. These ecological datasets included the Level 1 Ecoregions, geomorphic zones, the hydrological index and perenniality, the present ecological status, the Ecological Importance and Ecological Sensitivity categories and the vegetation bioregions. Areas of similar ecological characteristics were combined and this provided a provisional delineation of eighteen (18) river resource units as indicated in Table 1 and Figure 1.

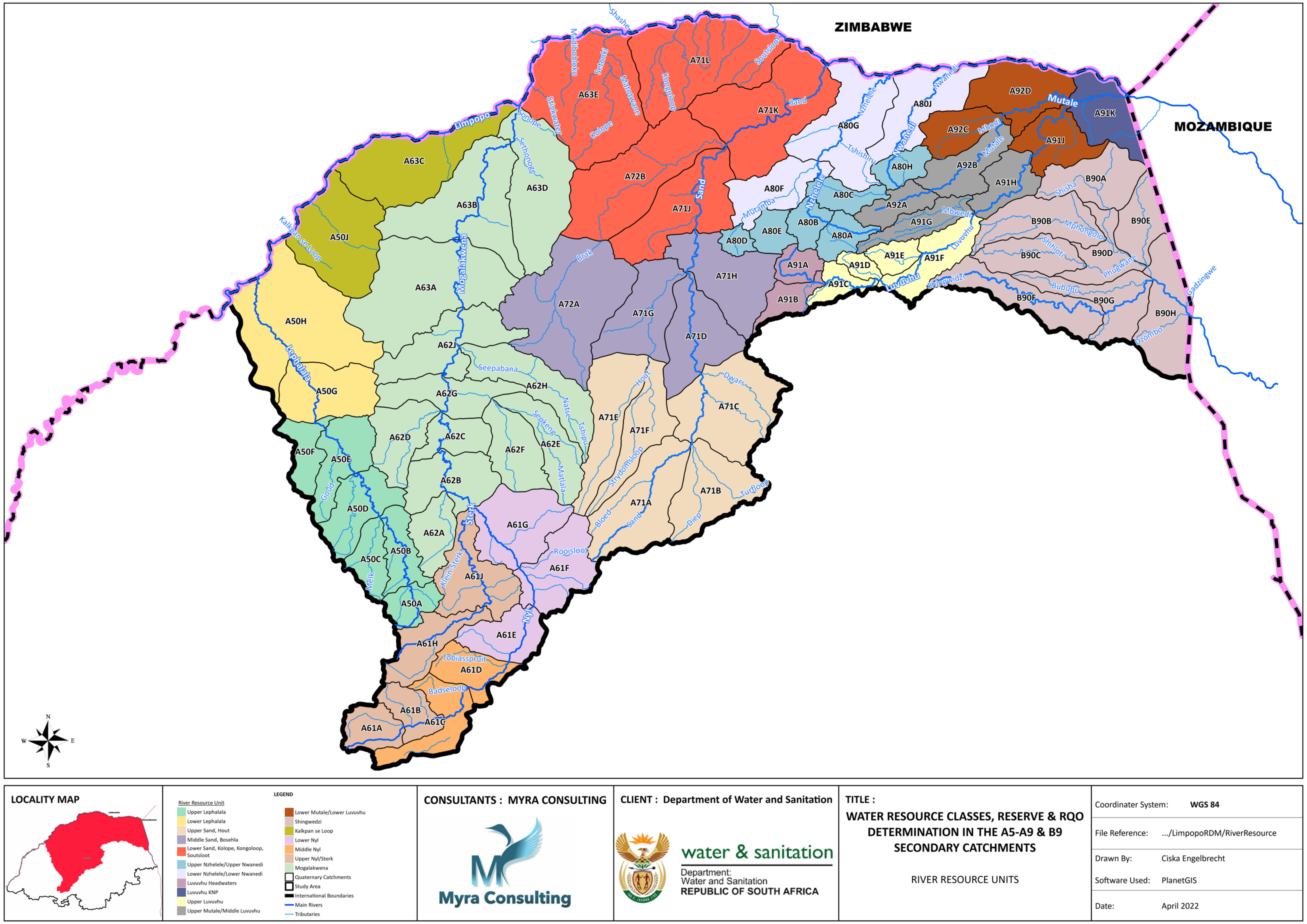

Figure 1. Preliminary delineation of River Resource Units

Table 1. Provisional Delineation of River Resource Units

River Resource Unit	Quaternary Catchments
Upper Lephalala	A50A, A50B, A50C, A50D, A50E, A50F
Lower Lephalala	A50G, A50H
Kalpan se Loop	A50J, A63C
Upper Nyl/Sterk	A61A, A61B, A61H, A61J
Middle Nyl	A61C, A61D
Lower Nyl	A61E, A61F, A61G
Mogalakwena	A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J, A63A, A63B, A63D
Upper Sand, Hout	A71A, A71B, A71C, A71E, A71F
Middle Sand, Bosehla	A71G, A71D, A71H, A72A
Lower Sand, Kolope, Kongoloop, Soutsloot	A63E, A71J, A71K, A71L, A72B
Upper Nzhelele/Upper Nwanedi	A80A, A80B, A80C, A80D, A80E, A80H
Lower Nzhelele/Lower Nwanedi	A80F, A80G, A80J
Luvuvhu Headwaters	A91A, A92B
Upper Luvuvhu	A91C, A91D, A91E, A91F
Upper Mutale/Middle Luvuvhu	A92A, A92B, A91G, A91H
Lower Mutale/Lower Luvuvhu	A92C, A92D, A91J
Luvuvhu KNP	A91K
Shingwedzi	B90A, B90B, B90C, B90D, B90E, B90F, B90G, B90H

Groundwater Units of Analysis

The quaternary catchments were used as the basis for delineation, with the groundwater resource units (termed groundwater units of analysis or GUAs) based on a single or a combination of quaternary catchments. The final delineation was driven by the following considerations:

- Although surface water and groundwater divides do not always correspond, groundwater must be considered in terms of an integrated water resource.
- The study area is drained by 8 major rivers flowing into the Limpopo River. As a result, the study area is easily divided into 8 sub-catchments. Considering that the groundwater component of the (ecological) Reserve is determined by calculating the groundwater contribution to baseflow it is necessary to integrate with the hydrological approach as far as possible.
- Using the data on groundwater levels obtained from the GRIP and NGA dataset the correlation between surface topography and elevation of the groundwater level was established. It can be assumed that the water table mimics the surface topography at the regional scale.
- Identification and recognition of aquifer type and groundwater regimes within each sub-catchment.

The delineated resource units generally combine a couple of quaternary catchments so that the integration of surface water and groundwater systems can be achieved (Figure 2). A summary of the delineated GUA within each sub-catchment is provided in Table 2. All GUAs coincide with the sub-catchments except for A63/A71-3, which straddles the Mogalakwena- and Sand River sub-catchments. The tributaries draining the associated quaternary catchments drain directly into the Limpopo River. These catchments also straddle the Limpopo Karoo Basin, so as a result they were delineated as a single GUA.

Table 2. Description of delineated groundwater units of analysis.

Drainage system	GUA	No. of Quats.	Catchments	Name	Dominant geology
Lephalala	A50-1	6	A50A,B,C,D,E,F	Upper Lephalala	Waterberg Group
	A50-2	1	A50G	Middle Lephalala	Bushveld Complex
	A50-3	1	A50H	Lower Lephalala	Basement Complex
Upper Mogalakwena	A61-1	5	A61A,B,C,D,E	Nyl River Valley	Bushveld Complex, Lebombo Group
	A61-2	2	A61H,J	Sterk	Bushveld Complex, Waterberg Group
	A61-3	3	A61F,G	Upper Mogalakwena	Bushveld- and Basement Complex, Dolomites
Middle- and Lower Mogalakwena	A62-1	3	A62A,B,C,D	Klein Mogalakwena	Bushveld Complex, Waterberg Group
	A62-2	2	A62E,F	Matlala	Bushveld- and Basement Complex,
	A62-3	3	A62G,H,J	Steilloop	Waterberg Group
	A63-1	3	A63A,B,D	Lower Mogalakwena	Basement Complex, Karoo Super Group, Lebombo Group
Upper Sand	A71-1	2	A71A,B	Upper Sand	Basement Complex, Alluvium
	A71-2	3	A71C,D,H	Middle Sand	Basement Complex
	A71-3	4	A71E,F,G	Hout	Basement Complex
Lower Sand	A71-4	2	A71J, A72B	Sandbrak	Basement Complex, Karoo Super Group, Lebombo Group
	A71-5	1	A71K	Lower Sand	Basement Complex, Karoo Super Group
Limpopo Tributary	A63-3/A71-6	2	A63E, A71L	Kolope	Basement Complex, Karoo super Group
Kalkpan	A50-4/A63-2	2	A63C, A50J	Kalkpan/Maasstroom	Basement Complex
Nzhelele	A81-1	6	A80A, B,C,D,E,F	Nzhelele	Soutpansberg Group, Karoo Super Group, Lebombo Group, Basement Complex
Lower Nzhelele	A81-2	1	A80G	Lower Nzhelele	Soutpansberg Group, Karoo Super Group, Basement Complex

Drainage system	GUA	No. of Quats.	Catchments	Name	Dominant geology
Nwanedi	A81-3	2	A80H,J	Nwanedi	Soutpansberg Group, Karoo Super Group, Basement Complex
Upper Luvuvhu	A91-1	7	A91A,B,C,D,E,F,G	Upper Luvuvhu	Soutpansberg Group, Basement Complex
Mutale /Luvuvhu	A91-2	7	A91H,J,K, A92A,B,C,D	Mutale /Luvuvhu	Soutpansberg Group, Basement Complex
Shingwedzi	B90-1	8	A90A,B,C,D,E,F,G,H	Shingwedzi	Basement Complex, Soutpansberg Group

Wetland Resource Units

The spatial distribution and extent of wetlands was explored in order to define and delineate meaningful groupings of wetlands, termed wetland RUs. Specific actions and data considerations included:

- Identifying the spatial distribution and extent of wetlands: The identification was based on the National Biodiversity Assessment (2018) and the National Freshwater Ecosystem Priority Area (NFEPA) spatial and metadata.
- Typing wetlands in terms of EcoRegions and Hydrogeomorphic (HGM) types: The typing of wetlands was based on EcoRegions and HGM types used from the National Wetland Classification System and embedded within the wetland coverage metadata.
- Determine wetland groups based on position, type and general condition: Wetland groups will likely include wetlands of different type, and general condition refers to "wetcon" data within the NWM[1] and NFEPA metadata. Groupings are not perfectly homogenous but focus on dominance of criteria.
- Consideration of IUAs and drainage catchment boundaries. It is preferable that wetland RUs do not span drainage or IUA boundaries. This facilitates a more practical approach to management and more logical assessments to, for example, responses to scenarios.

At the broadest scale, 3 wetlands zones were delineated based on predominance of wetland type (Level 4 classification of HGMs) and ecoregions (level 1) to include as much homogeneity as possible (Figure 4-14 3). Zone 1 is dominated by floodplain wetlands, Zone 2 has a wetland type diversity that is dominated by depressional wetlands and zone 3 is dominated by channelled and unchanneled valley bottom wetlands and has a high prevalence of riverine wetlands. These 3 zones formed the basis for finer-scaled units and 16 wetland RUs were delineated so that IUA and Wetland zone boundaries did not overlap (Figure 4).

[1] New Wetland Map (2018)

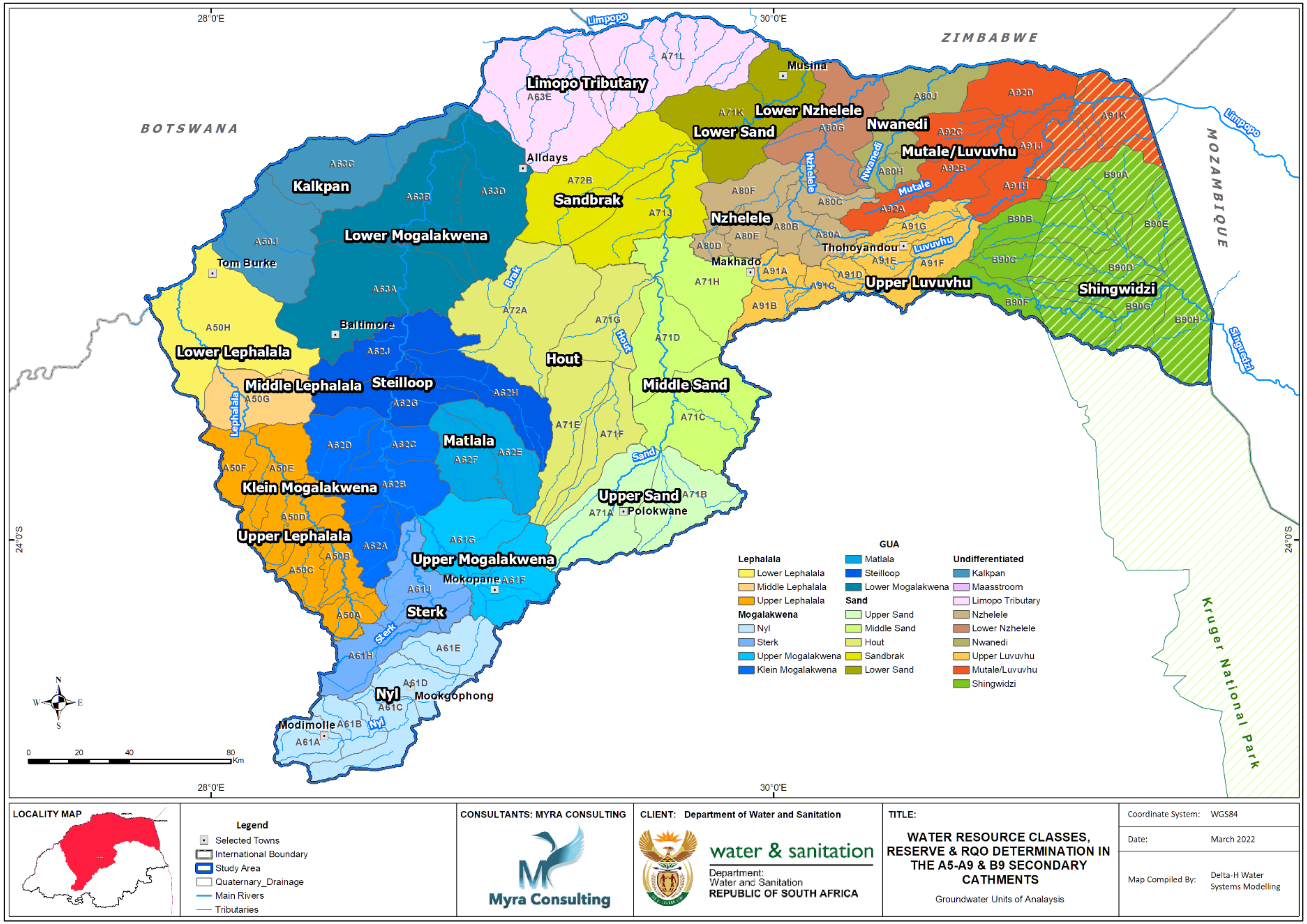

Figure 2. Delineated groundwater units of analysis.

The dominant extents of each wetland RU are summarised as follows:

- RU 1: Floodplains, D/E/F, CR, Not protected
- RU 2: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 3: Riverine, D/E/F, CR, Not protected
- RU 4: Channelled valley bottoms and Riverine, D/E/F, CR, Not protected
- RU 5: Depressions, A/B, LC, Poorly protected
- RU 6: Depressions and Riverine, A/B, LC, Poorly protected
- RU 7: Depressions and Unchannelled valley bottoms, A/B, CR Not protected
- RU 8: Riverine, D/E/F, CR, Poorly protected
- RU 9: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 10: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 11: Riverine, D/E/F, LC, Poorly protected
- RU 12: Riverine, D/E/F, CR, Poorly protected
- RU 13: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 14: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 15: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 16: Channelled valley bottoms, C, CR, Poorly protected

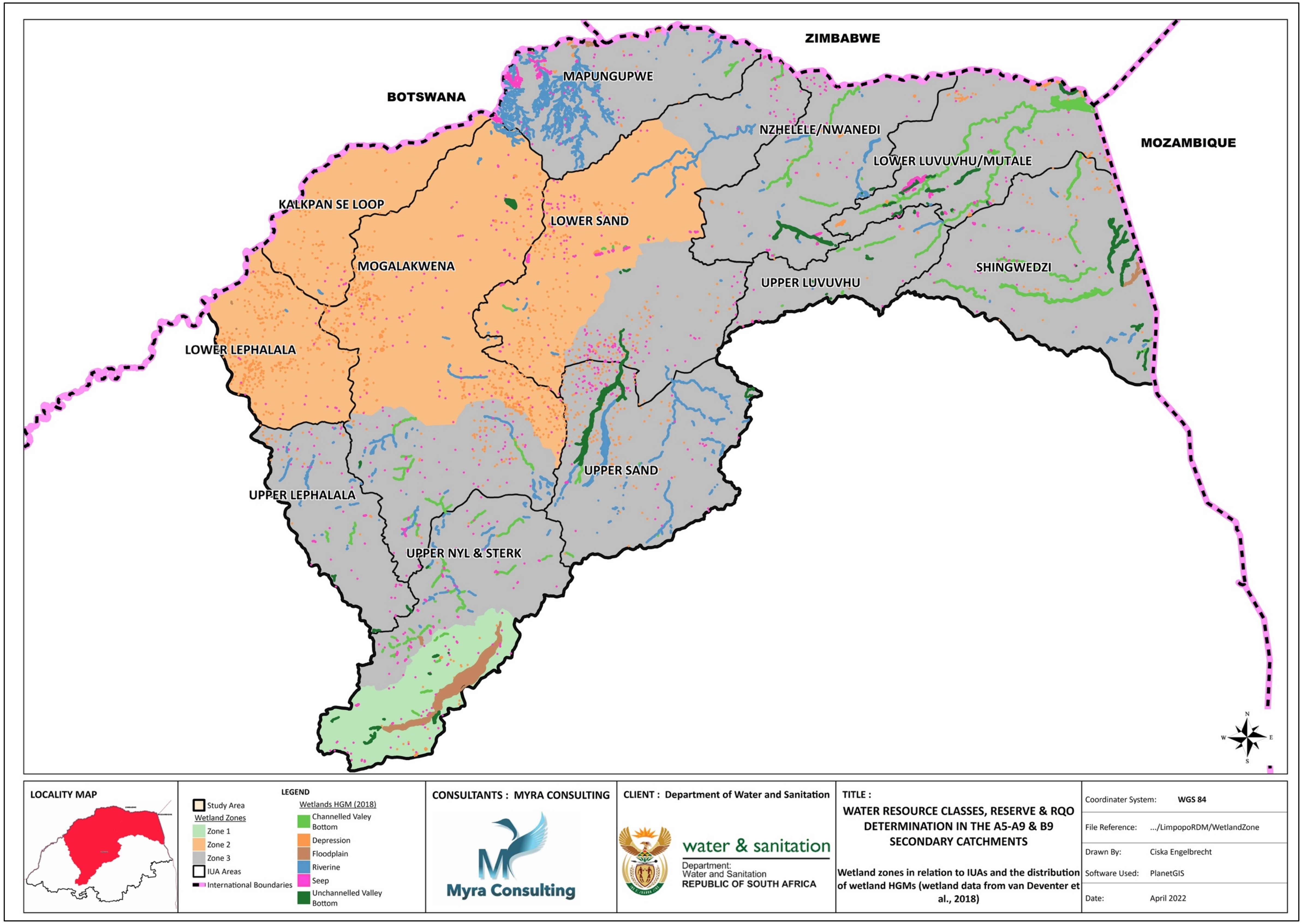

Figure 3. Wetland zones in relation to IUAs and the distribution of wetland HGMs (wetland data from van Deventer et al., 2018)

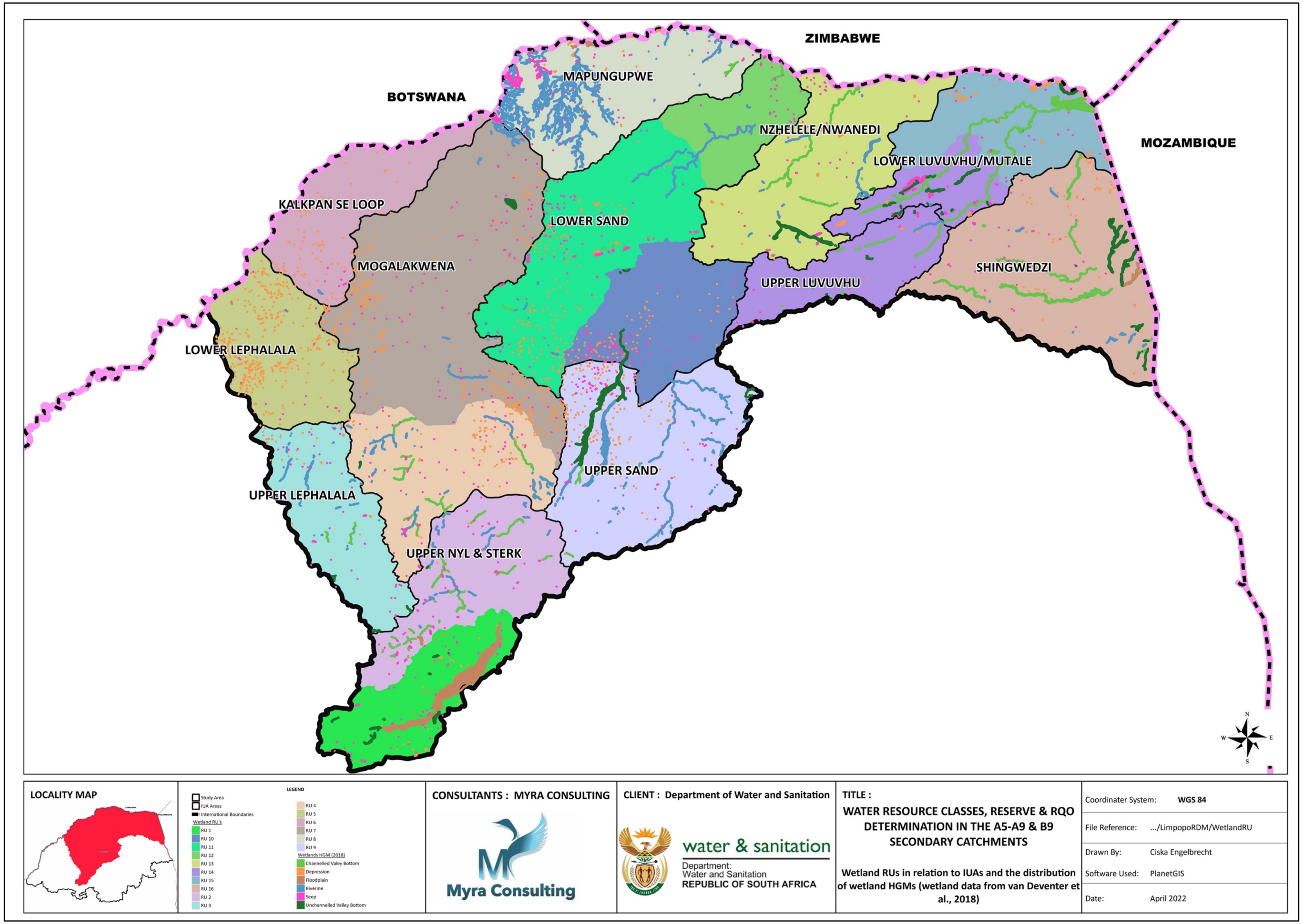

Figure 4. Wetland RUs in relation to IUAs and the distribution of wetland HGMs (wetland data from van Deventer et al., 2018).

DEFINING THE IUAs

The river resource units aligned well with Socio-Economic Zones at a broad catchment level. In some cases the SEZs did cover two (2) or more river resource units. However, it was decided that no further sub-division was needed as the river RUs could be combined based on further similarity in ecological character and state. The SEZs were then taken forward to become the IUAs, which form the basis of assessment for changes in water use and socio-economic impacts. A description of the IUAs are provided in Table 3 and the IUA boundaries are illustrated in Figure 5.

Table 3. Composition of provisional IUAs delineated for the study area

Socio-Economic Zone	River Resource Units	Iua Name	Quaternary Catchments
Upper Lephalala	Upper Lephalala	Upper Lephalala	A50A, A50B, A50C, A50D, A50E, A50F
Lower Lephalala	Lower Lephalala	Lower Lephalala	A50G, A50H
Kalkpan se Loop	Kalkpan se Loop	Kalkpan se Loop	A50J,A63C
Upper Nyl & Sterk	Upper Nyl/Sterk	Upper Nyl & Sterk	A61A, A61B, A61C, A61D, A61E, A61F, A61G, A61H, A61J
	Middle Nyl		
	Lower Nyl		
Mogalakwena	Mogalakwena	Mogalakwena	A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J, A63A, A63B, A63D
Mapungubwe	Mapungubwe/Lower Sand	Mapungubwe	A63E, A71L
Upper Sand	Upper Sand	Upper Sand	A71A, A71B, A71C, A71E, A71F
Lower Sand	Middle Sand	Lower Sand	A71D, A71G, A71H, A71J, A71K, A72A, A72B
Nzhelele/Nwanedi	Upper Nzhelele/Upper Nwanedi	Nzhelele/Nwanedi	A80A, A80B, A80C, A80D, A80E, A80F, A80G, A80H, A80J
	Lower Nzhelele/Upper Nwanedi		
Upper Luvuvhu	Luvuvhu Headwaters	Upper Luvuvhu	A91A, A91B, A91C, A91D, A91E, A91F, A91G
	Upper Luvuvhu		
Lower Luvuvhu/Mutale	Upper Mutale/Middle Luvuvhu	Lower Luvuvhu/Mutale	A91H, A91J, A91K, A92A, A92B, A92C, A92D
	Lower Mutale/Lower Luvuvhu		
	Luvuvhu KNP		
Shingwedzi	Shingwedzi	Shingwedzi	B90A, B90B, B90C, B90D, B90E, B90F, B90G, B90J

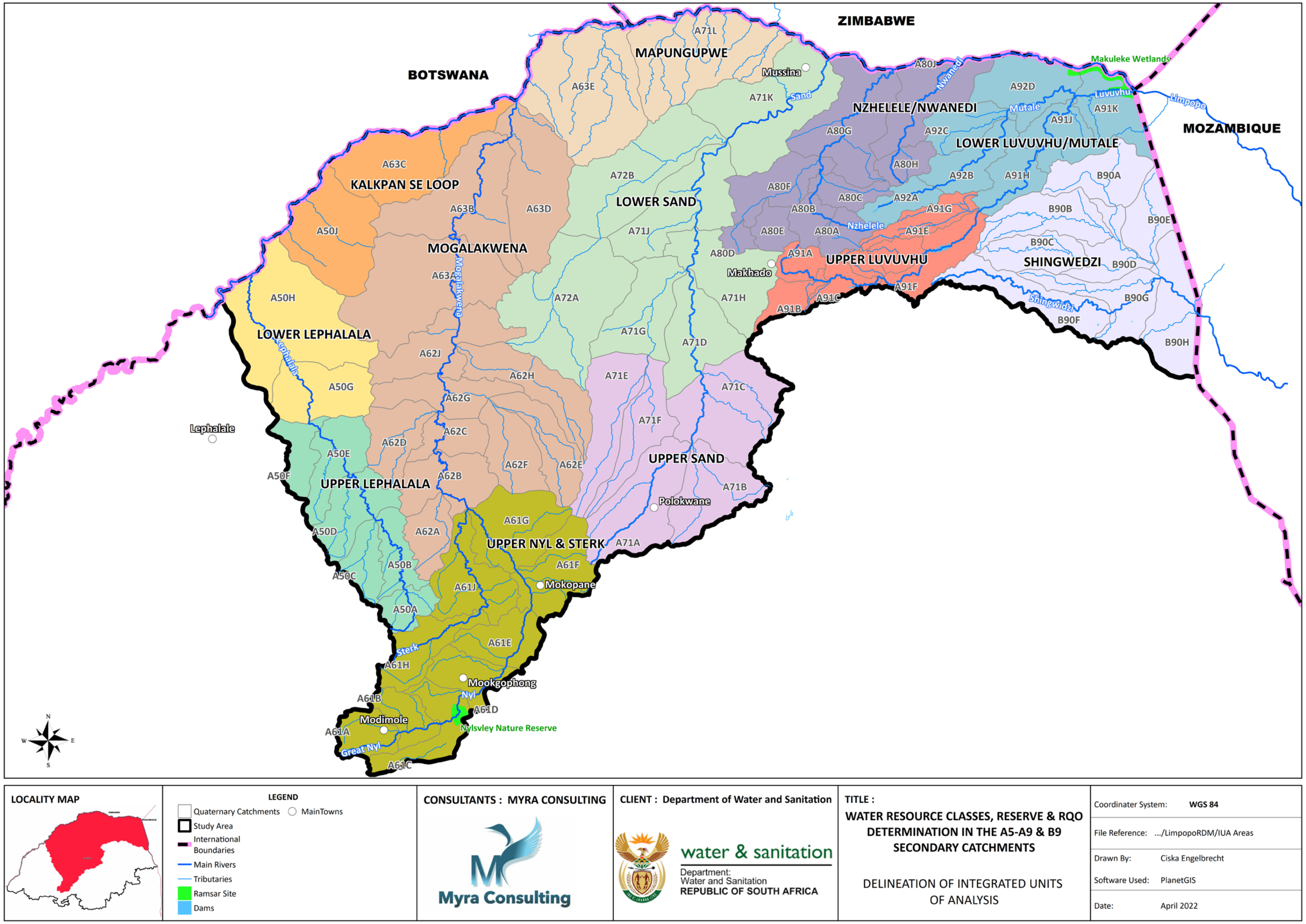

Figure 5. Provisional delineation of Integrated Units of Analysis

STATUS QUO OF SIGNIFICANT WATER RESOURCES

The current status of the water resources in the study area were defined in terms of the water resources, the ecological characteristics, the socio-economic conditions and the community well-being.

The **surface water resources** status quo were assessed according to rainfall; dams and bulk water transfers; water requirements and allocations. Two hydrological studies that cover the area (AECOM, 2015 and WRP, 2014) consisted of historical configurations that were adapted to create a natural and current day configuration. Several improvements to the configurations were undertaken to provide the status quo of the hydrological models.

The **river ecological status quo** was assessed in terms of the ecological condition per sub-quaternary reach, as described in the national Present Ecological State (PES) dataset (2014), the Ecological Importance (EI) and Ecological Sensitivity (ES). Additionally the Freshwater Ecosystem Protection Areas (FEPA), the Strategic Water Source Areas (SWSA) and historic and recent biotic data were used in the assessment.

The **groundwater status quo** assessment includes a description of key groundwater characteristics (recharge, discharge, groundwater use and groundwater quality) across the groundwater resources units/groundwater unit of analysis. A detailed status quo and trend analysis of groundwater level and groundwater quality per groundwater unit of analysis is documented separately.

Assessment of the present **surface water quality status quo** was based on assessing the fitness for use of the water for key water user sectors, namely irrigation water use, domestic water use, and aquatic ecosystems. The fitness for use is described using four water quality categories, namely Ideal (blue), Acceptable (green), Tolerable (yellow), and Unacceptable (red) for concentrations greater than the upper boundary of the Tolerable range.

The **wetland status quo assessment** was conducted by considering the distribution and extent of different wetland types (HGMs, level 4 classification) within the study area. Named wetlands from the National Spatial Biodiversity Assessment was assessed in terms of their protection and threat status.

BIOPHYSICAL AND ALLOCATION NODES

The biophysical and allocation river nodes for the study area were defined according to the procedures described in DWAF (2007). Eleven (11) tiers of information were sequentially analysed and rules applied in order to establish nodes for each tier. Nodes were sequentially added for Tiers I to Tier VIII where after rationalisation rules were applied to eliminate nodes which were too close (less than 10km apart) or where the cumulative contribution to nMAR was less than 1%.

Further nodes were then added where additional information was likely to be needed for planning or allocation purposes. Nodes were also added to cater for Strategic Water Source Areas, FEPA status 1 and Fish Support Areas. if they were not already captured in the initial node delineation process.

A total of seventy four (74) biophysical and allocation nodes were identified in the study area, which are illustrated in Figure 6.

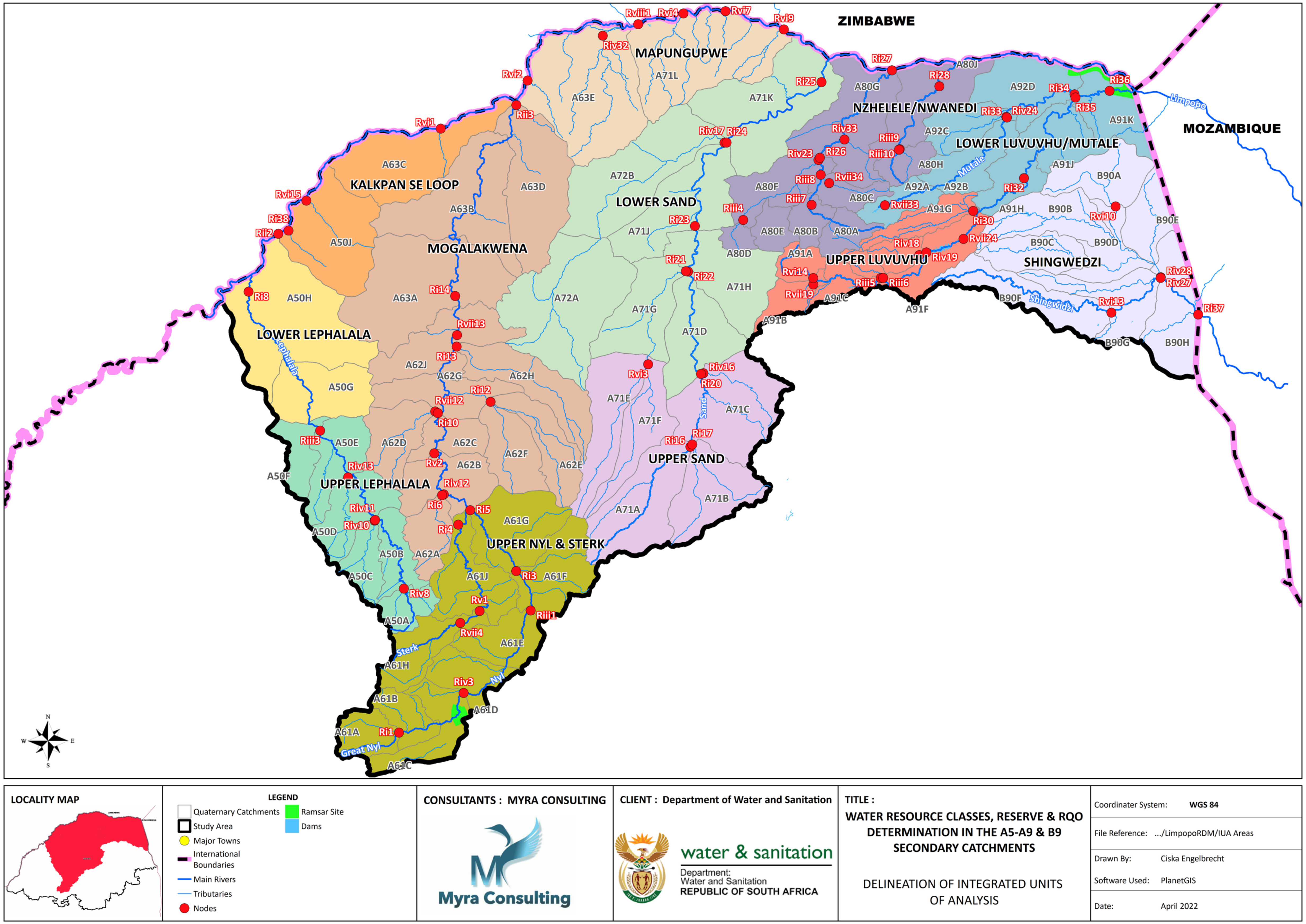

Figure 6. Biophysical and allocation nodes within the IUAs

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1 INTRODUCTION

1.1 Background

The Department of Water and Sanitation (DWS), Chief Directorate: Water Ecosystems Management initiated a three-year study 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 Measures 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.

1.2 Objectives of the Study

The overall objective of this project is 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 DWS Procedures to Determine and Implement RQOs.

1.3 Purpose of this Delineation and Status Quo Report

The purpose of this report is to outline the process followed in delineating and determining the Integrated Units of Analysis (IUAs) and describes the status quo of the water resources in the study area. The delineation of the IUAs and status quo assessment is Step 1 of the Classification procedure as documented in (Department of Water Affairs and Forestry (DWAF), 2007a).

The IUAs represent the spatial units that will be defined as significant water resources. Each IUA represents a homogenous area which requires its own specification of the Water Resource Class (WRC).

2 OUTLINE OF PROCEDURE TO DETERMINE IUAS

2.1 Generic WRCS outline

The WRCS provides for a structured process to identify the agreed trade-off point between resource protection and development of river basins, through an assessment of the economic, social and ecological implications for alternative future scenarios for a given water resource (DWAF, 2007b). The outcome of the Classification Process will be the setting of a Water Resource Class, Reserve and RQOs by the Minister or delegated authority for every significant water resource (river, wetland, estuary and aquifer) in each WMA.

The Class can range from Minimally to Heavily Used as defined in Table 2-1 and sets the boundaries for the volume, distribution and quality of the Ecological Reserve and RQOs and therefore informs the determination of the allocatable portion of a water resource for use. This has considerable economic, social and ecological implications (DWAF, 2007b).

Table 2-1. Definition of Water Resource Classes (DWAF, 2007b)

Class I: Minimally Used The configurate of ecological categories of the water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
Class II: Moderately used The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
Class III: Heavily used The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

The 7-Step Classification procedure prescribed in the WRCS Overview Report (DWAF, 2007a), leading to the recommendation of the Class of the water resource is summarised in Figure 2-1.

Step 1: Delineate the units of analysis and describe the status quo of the water resource
↓
Step 2: Link the socio-economic and ecological value and condition of the water resources
↓
Step 3: Quantify the ecological water requirements and changes in non-water quality ecosystem goods, services and attributes
↓
Step 4: Determine an ecologically sustainable base configuration scenario
↓
Step 5: Evaluate scenarios within the integrated water resource management process
↓

Step 6: Evaluate the scenarios with stakeholders
↓
Step 7: Gazette and implement class configuration

Figure 2-1. Water Resource Classification 7-step procedure (DWAF, 2007b)

2.2 Generic outline of IUA determination sub-steps

In order to arrive at the final IUA delineations the sub-steps listed below and further described in DWAF (2007) needed to be undertaken. It is important to note that, although the sub-steps are portrayed sequentially, in reality, various sub-steps are undertaken sequentially.

The sub-steps to delineate the IUAs and describe the status quo of the study area were as follows:

a) Describe the present-day socio-economic status of the catchment.
b) Divide the catchment into socio-economic zones.
c) Identify a network of significant resources, describe the water resource infrastructure and identify the water user allocations.
d) Define a network of significant resources and establish the biophysical nodes and allocation nodes.
e) Describe communities and their wellbeing.
f) Describe the value and the use of water.
g) Describe and value the use of aquatic ecosystems.
h) Define the Integrated IUAs.
i) Develop and/or adjust the socio-economic framework and the decision-analysis framework.
j) Describe present-day community wellbeing within each IUA.

3 DEFINE SOCIO-ECONOMIC ZONES

3.1 General approach

The purpose of delineating socio-economic zones (SEZs) is to make it easier to provide descriptions of the socio-economic implications of different classification scenarios that can be readily understood by stakeholders who can relate to the various areas that they depend upon. The rationale for the zonation process was that zones should be relatively homogenous in terms of the relationships of the economic activities in the zones with water. For example, some zones are heavily dependent on irrigation, with associated pressures on water resources, others may be dominated by dryland crops, others by use of natural areas for which ecosystem health is of greatest importance, and others by urban and industrial activities which have a high impact on water resources. In reality, the study area contains a diversity of activities and zones cannot be quite so neatly defined.

While the division of the study area into zones makes the socio-economic descriptions somewhat easier to digest, the study area should not be overly subdivided. In reality, economic activity is not confined to regions, but rather the activities in an area are linked to the economy of local towns, which in turn link to larger towns and cities, etc. Furthermore, when the balance of economic activity is changed by changing circumstances, be it the development of new mining or new tourism activities, people tend to shift towards those opportunities. It is therefore not desirable to analyse changes at too fine a spatial scale, but rather to examine the economic implications for the region as a whole.

Socio-economic zones were delineated after detailed inspection of a range of spatial and non-spatial information on population density, geography, climate, drainage, vegetation and land use. This was based mainly on Census data, Land Cover data, and Agricultural Census data. Once these areas had been broadly defined the initial boundaries were compared with river characteristics and catchment boundaries and were found to align well with these, not requiring any further realignment. Given that the ecological zones aligned well with the socio-economic zones at a broad catchment level, it was decided that any further division was not needed and that the SEZs would form the IUAs. Therefore, in this study, given the arrangement of economic activities with water, the SEZs have become the IUAs, which form the basis of assessment for changes in water use and socio-economic impacts.

3.2 Delineation of Socio-Economic Zones

The delineation of SEZs is described and shown in section 5.2 as the delineation of IUAs.

4 DEFINE RESOURCE UNITS

4.1 River Resource Units

4.1.1 General approach

The general approach followed to define the boundaries of significant surface water resources comprising the River Resource Units (Rivers RUs), was to overlay six different sets of spatial data that are ecological relevant on a base map of major catchment boundaries and quaternary catchment boundaries. These six sets of overlaying spatial data were as follows:

- Ecoregions
- Geomorphic zones
- Hydrological index
- Present ecological status (PES)
- Ecological Importance and Sensitivity Category
- Vegetation bioregions.

4.1.2 Delineation of river resource units

4.1.2.1 Ecoregions

The study area comprised eight (8) main ecoregion 1 types. The Limpopo Plain dominates the northern part of the study area, encompassing the lower reaches of the Lephalala, Nzhelele, Nwanedi and Luvuvhu Rivers, as well as the Mogalakwena River. The Soutpansberg ecoregion level 1 is found toward the centre-east of the study area. The upper reaches of the Nzhelele and Nwanedi Rivers, the Mutale River and the lower reaches of the Luvuvhu a small portion of the middle reaches of the Sand are found in this ecoregion. The majority of the Luvuvhu River and the Shingwedzi River, lie in the Lowveld Ecoregion. The upper reaches of the Sand and some of the tributaries to the Mogalakwena lie in the Northern Plateau Ecoregion. The Waterberg ecoregion is located to the west of the study area, incorporating the upper Lephalala River. The upper reaches of the Sterk River falls into the Western Bakenveld while the upper reaches of the Nyl lie in the Bushveld and Eastern Bakenveld. Figure 4-1 illustrates the distribution of the ecoregions within the study area.

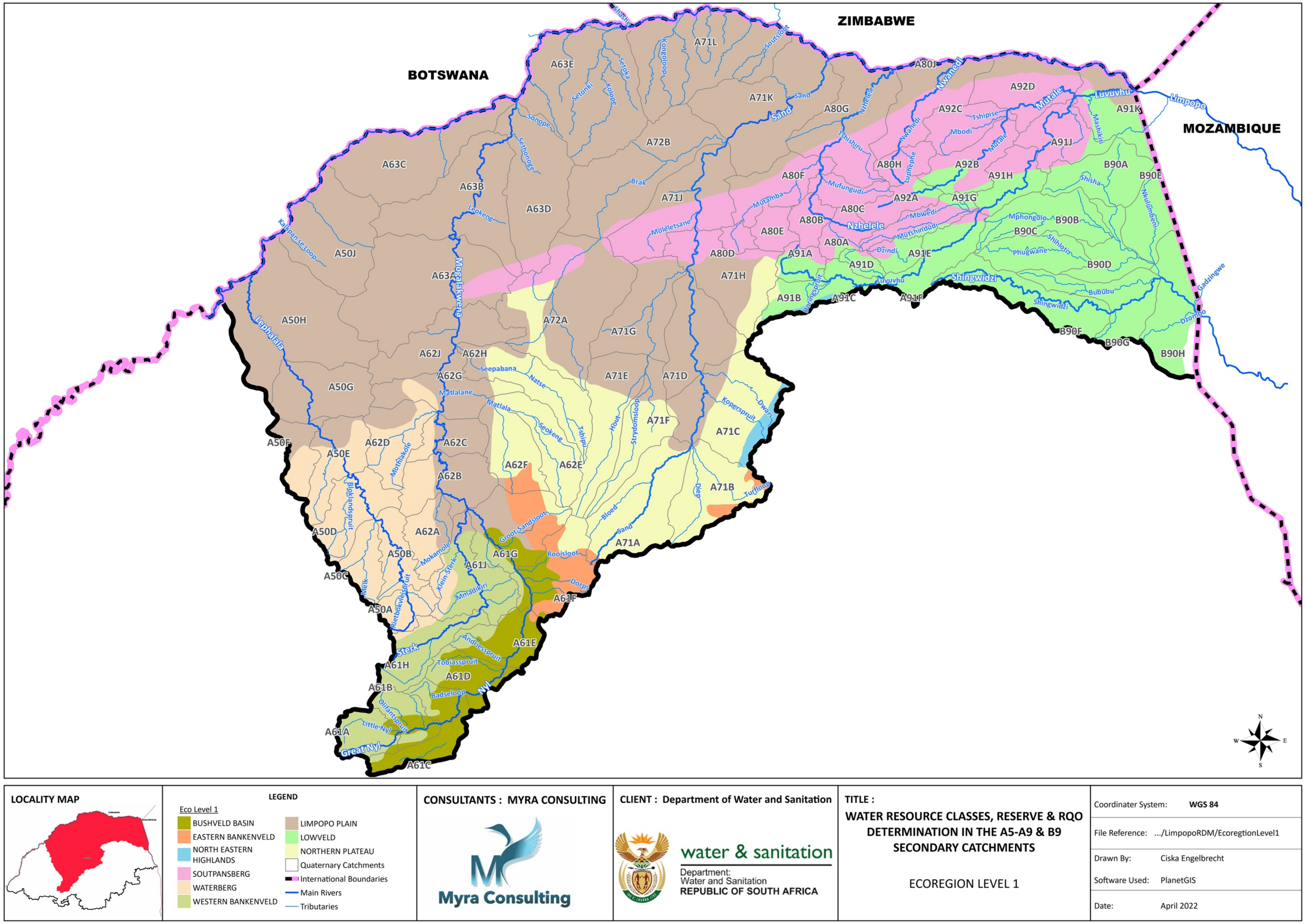

Figure 4-1. Ecoregion Level 1 distribution within the study area

4.1.2.2 Geomorphic zones

The rivers in the study area falls predominantly into two (2) geomorphic zones, the Upper Foothills and Lower Foothills, which Lowland Rivers in certain areas. The geomorphic zones are depicted in Figure 4-2.

4.1.2.3 Hydrological index

The study area comprises a nearly 50% split between perennial and ephemeral rivers as seen in Figure 4-3. The rivers to the west of the study area, the Lephalala and Mogalakwena rivers are perennial systems. East of these rivers is the ephemeral Sand River system, bordered by the perennial Nzhelele, Nwanedi and Luvuvhu Rivers. The Shingwedzi River to the east of the study area which flows into the KNP is an ephemeral system.

4.1.2.4 Present Ecological Status

The DWS (2014) data set was used to describe the ecological condition of the rivers in the study area. This is illustrated in Figure 4-4. The majority of rivers in the study area in a C (moderately modified) or D (largely modified) present ecological category. There are a few B (largely natural) rivers interspersed in the study area with rivers in a very good ecological condition in the Shingwedzi catchment within the Kruger National Park. The smaller individual rivers in the A63D, A63E and A71L that flow directly into the Limpopo River are also in a very good present ecological condition.

4.1.2.5 Ecological Importance and Ecological Sensitivity

The DWS (2014) data set was used to describe the Ecological Importance (EI) and Ecological Sensitivity (ES) of the rivers in the study area. Those rivers with a High or Very High EI are depicted in Figure 4-5 below while rivers with a High or Very High ES are depicted in Figure 4-6.

4.1.2.6 Vegetation bioregions

The Central Bushveld Bioregion is the dominant bioregion found in the west and central part of the study area. The northern and eastern parts of the study area fall into the Mopani Bioregion with a small area of Lowveld Bioregion toward the eastern part of the area as seen in Figure 4-7.

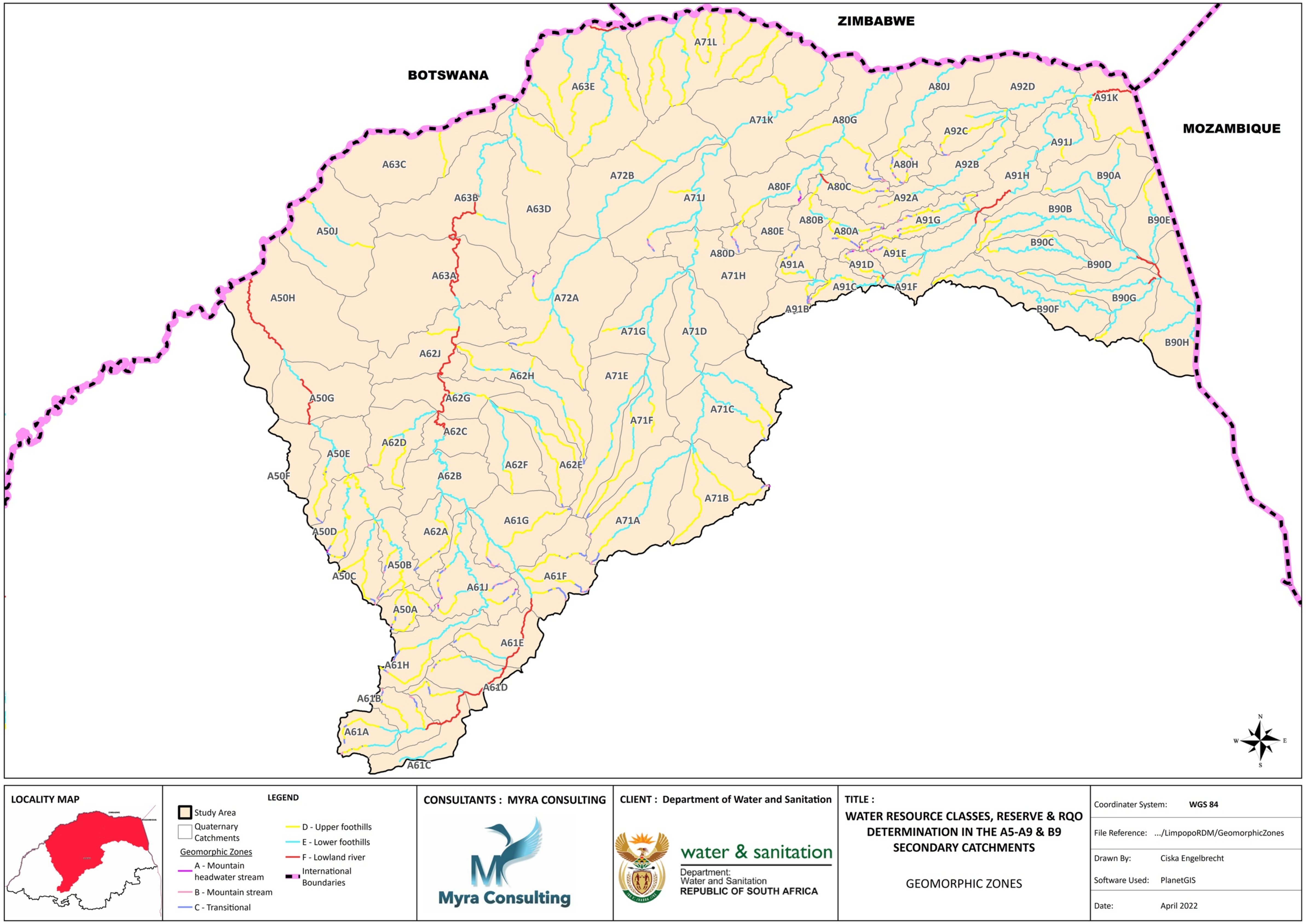

Figure 4-2. Geomorphic zones in the study area

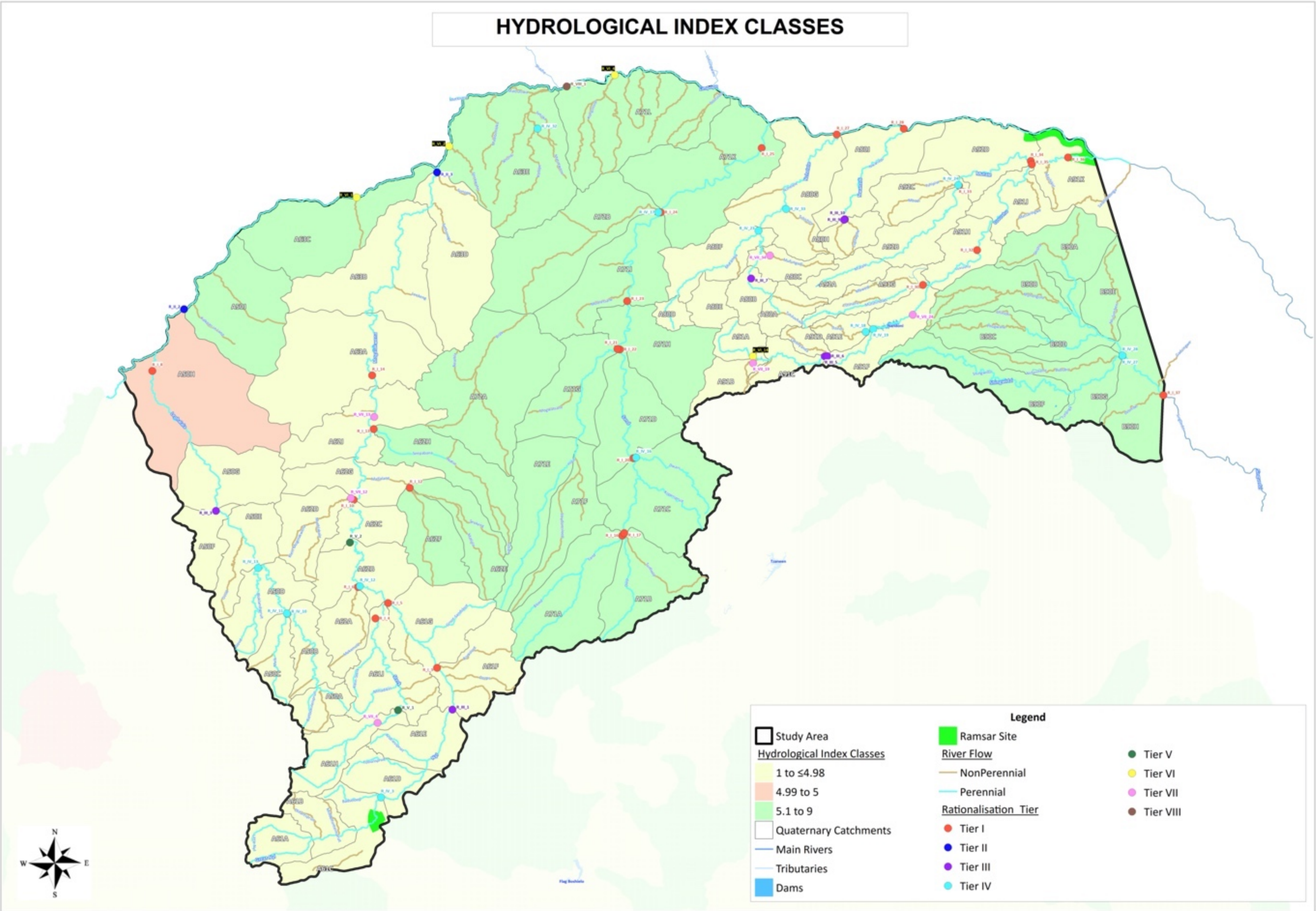

Figure 4-3. Hydrological index and river perenniality

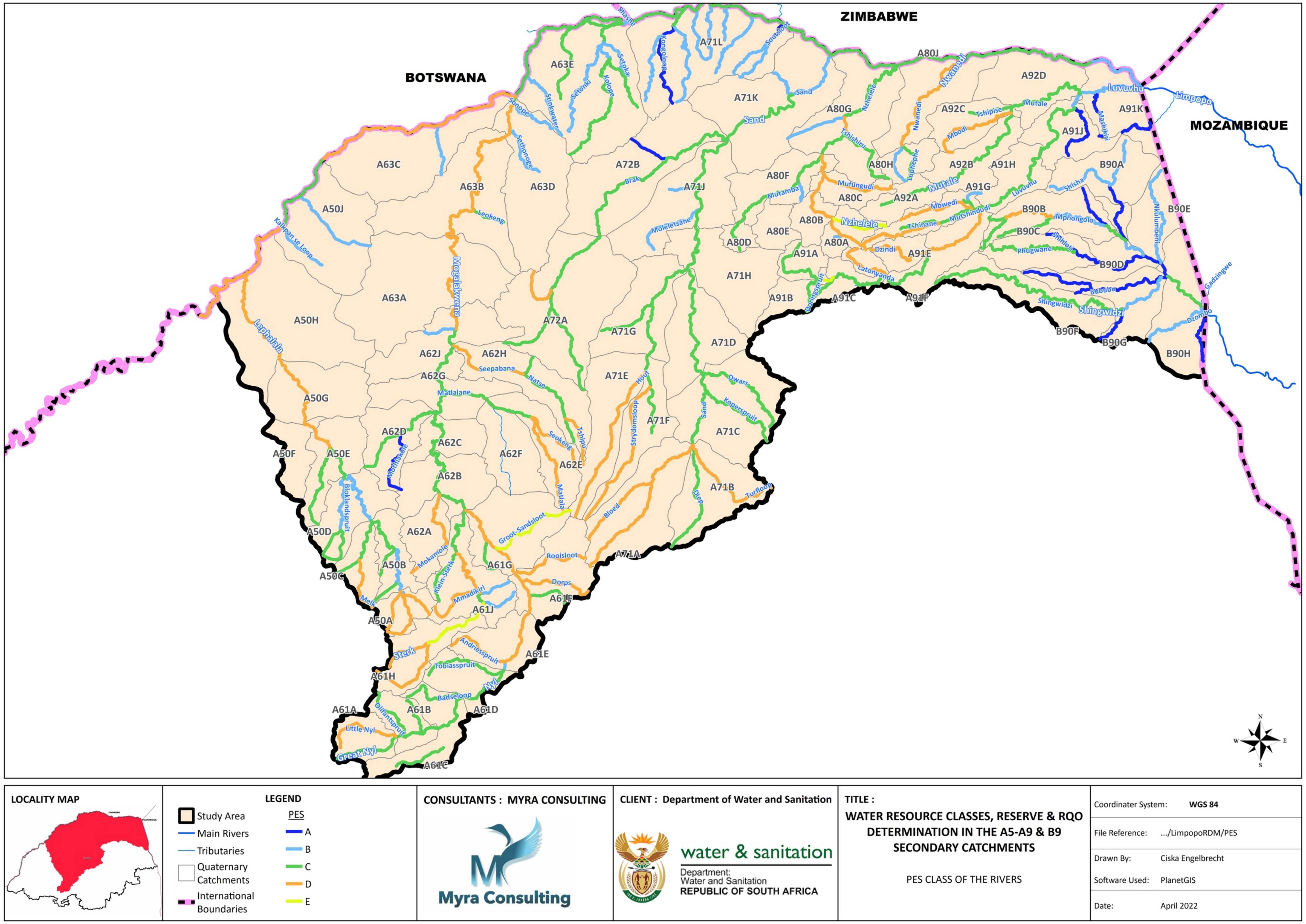

Figure 4-4. PES class of the rivers in the study area

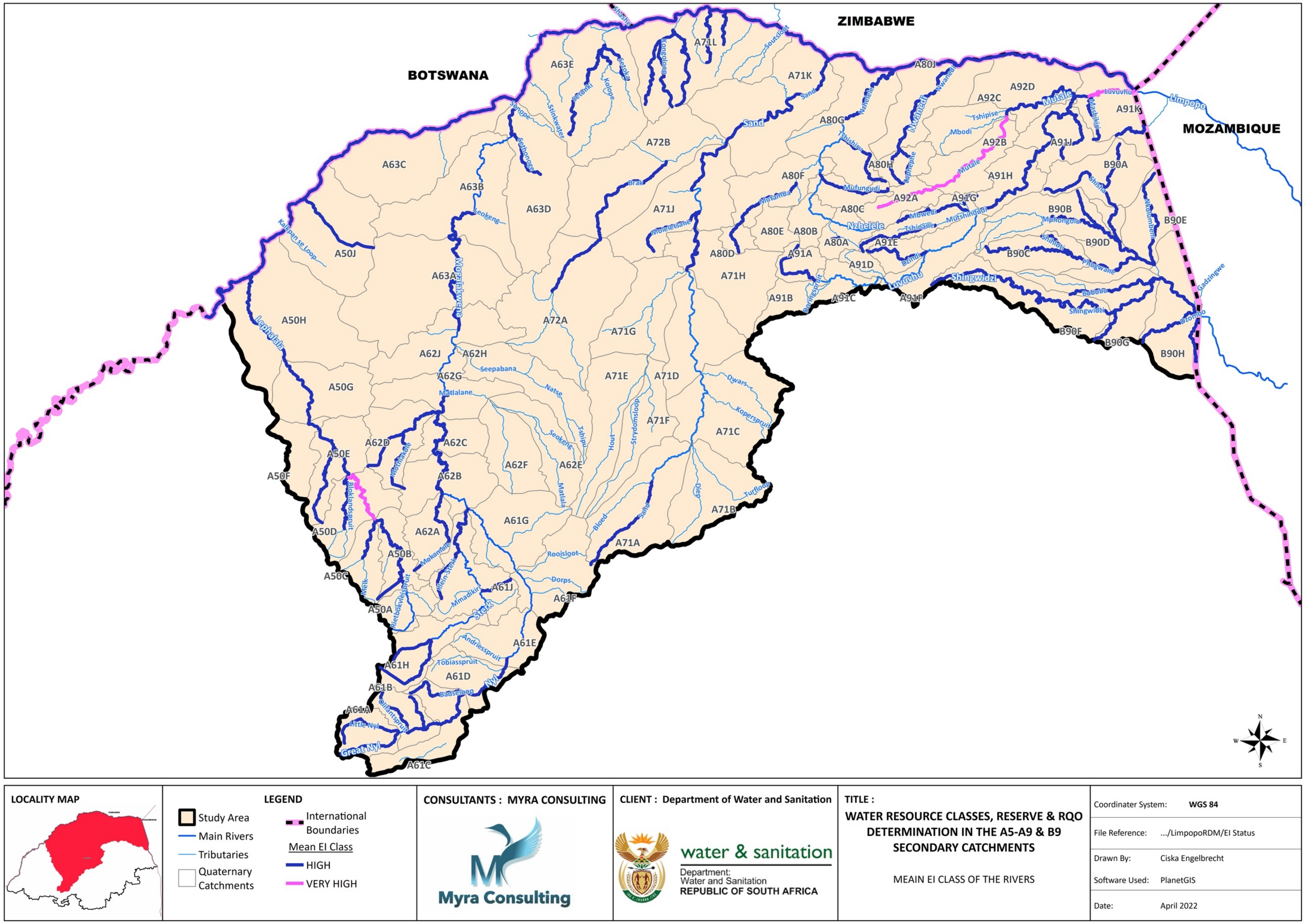

Figure 4-5. Mean Ecological Importance of the rivers in the study area

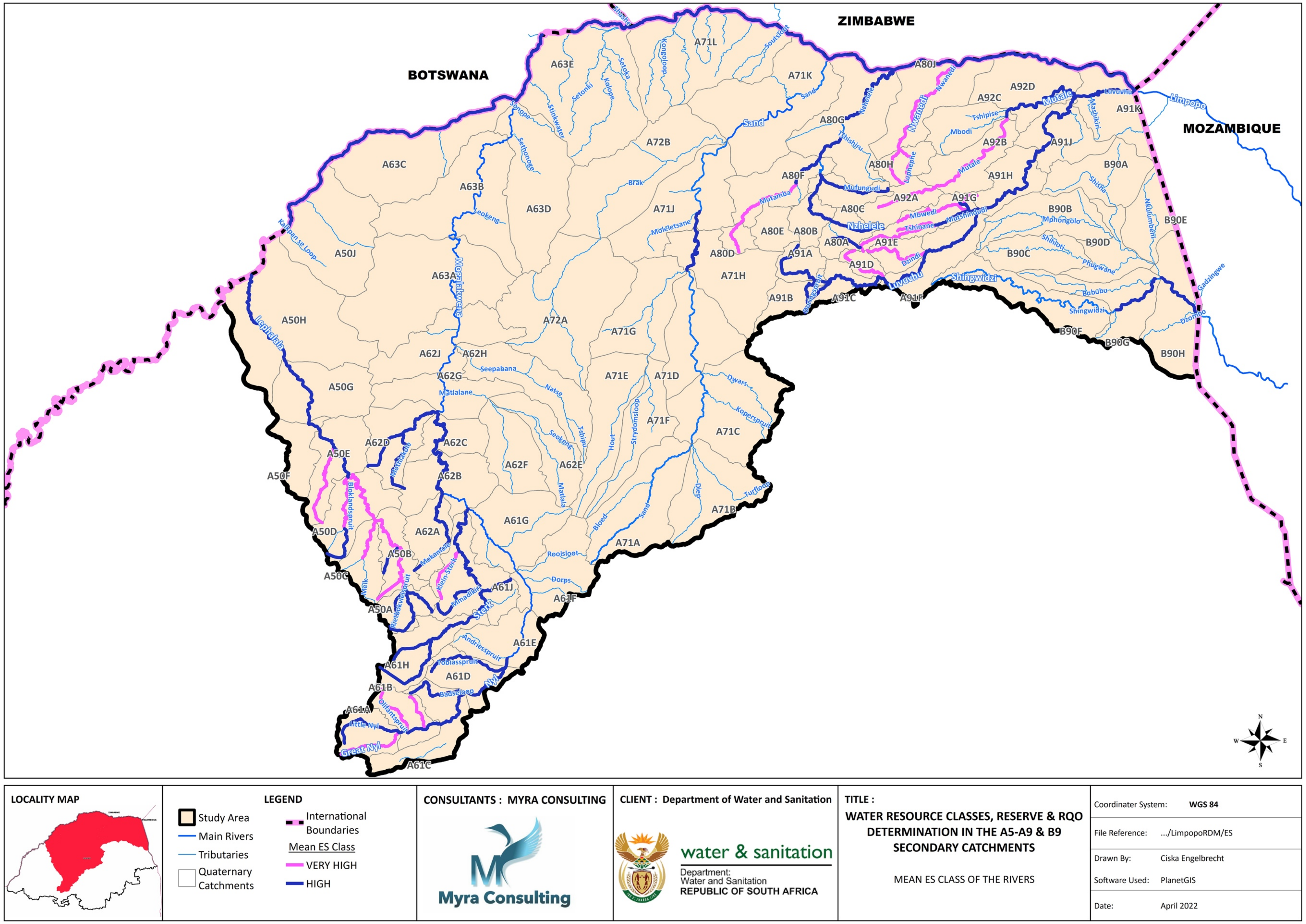

Figure 4-6. Mean Ecological Sensitivity of the rivers in the study area

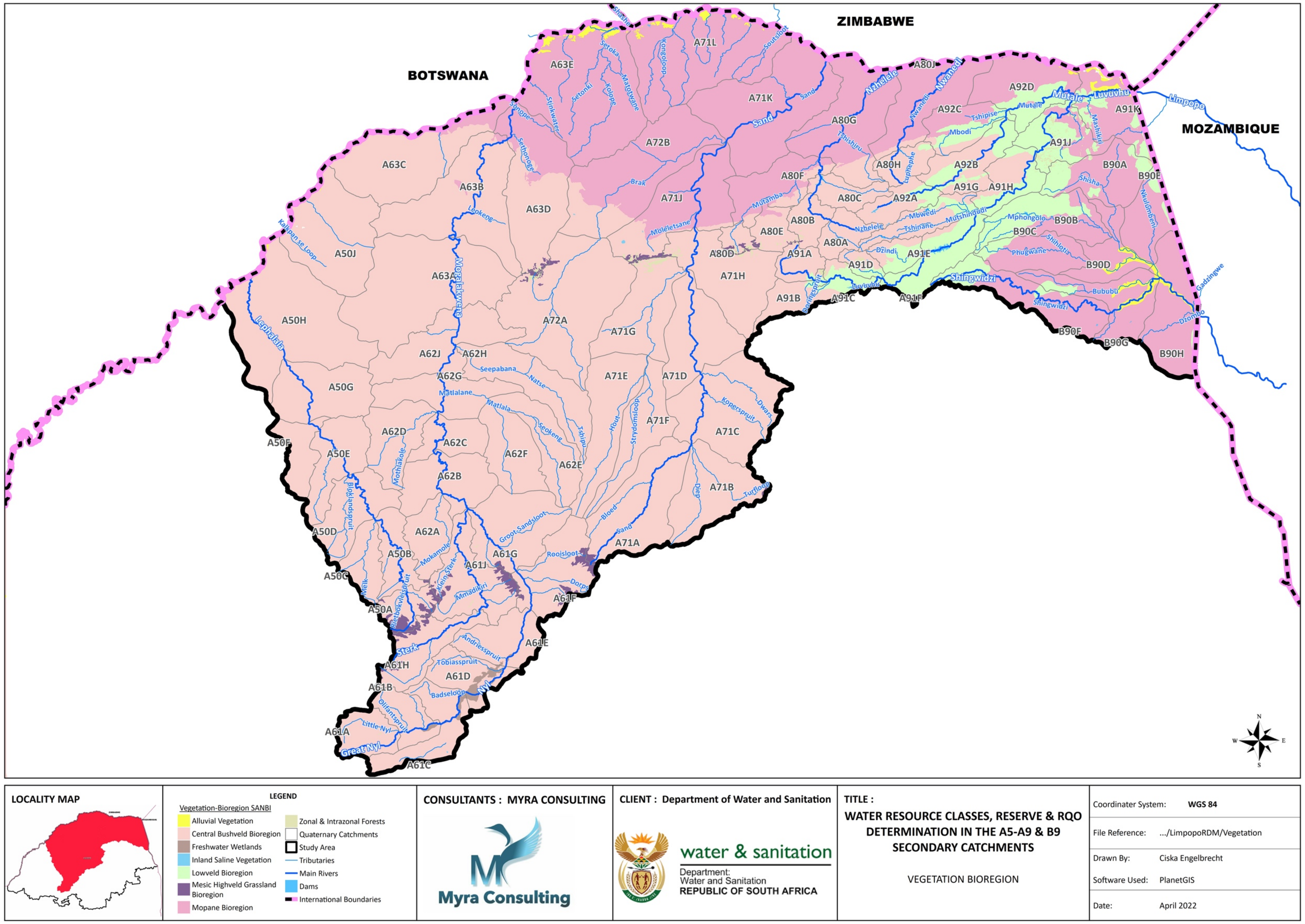

Figure 4-7. Vegetation Bioregions in the study area

4.1.3 Provisional river resource unit delineation

Overlaying the six sets of spatial data and combining areas of similarity provided the provisional delineation of the River Resource Unit (Ru) as described in Table 4-1 and shown in Figure 4-8.

Table 4-1. Provisional Delineation of River Resource Units

River Resource Unit	Quaternary Catchments
Upper Lephalala	A50A, A50B, A50C, A50D, A50E, A50F
Lower Lephalala	A50G, A50H
Kalpan se Loop	A50J, A63C
Upper Nyl/Sterk	A61A, A61B, A61H, A61J
Middle Nyl	A61C, A61D
Lower Nyl	A61E, A61F, A61G
Mogalakwena	A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J, A63A, A63B, A63D
Upper Sand, Hout	A71A, A71B, A71C, A71E, A71F
Middle Sand, Bosehla	A71G, A71D, A71H, A72A
Lower Sand, Kolope, Kongoloop, Soutsloot	A63E, A71J, A71K, A71L, A72B
Upper Nzhelele/Upper Nwanedi	A80A, A80B, A80C, A80D, A80E, A80H
Lower Nzhelele/Lower Nwanedi	A80F, A80G, A80J
Luvuvhu Headwaters	A91A, A92B
Upper Luvuvhu	A91C, A91D, A91E, A91F
Upper Mutale/Middle Luvuvhu	A92A, A92B, A91G, A91H
Lower Mutale/Lower Luvuvhu	A92C, A92D, A91J
Luvuvhu KNP	A91K
Shingwedzi	B90A, B90B, B90C, B90D, B90E, B90F, B90G, B90H

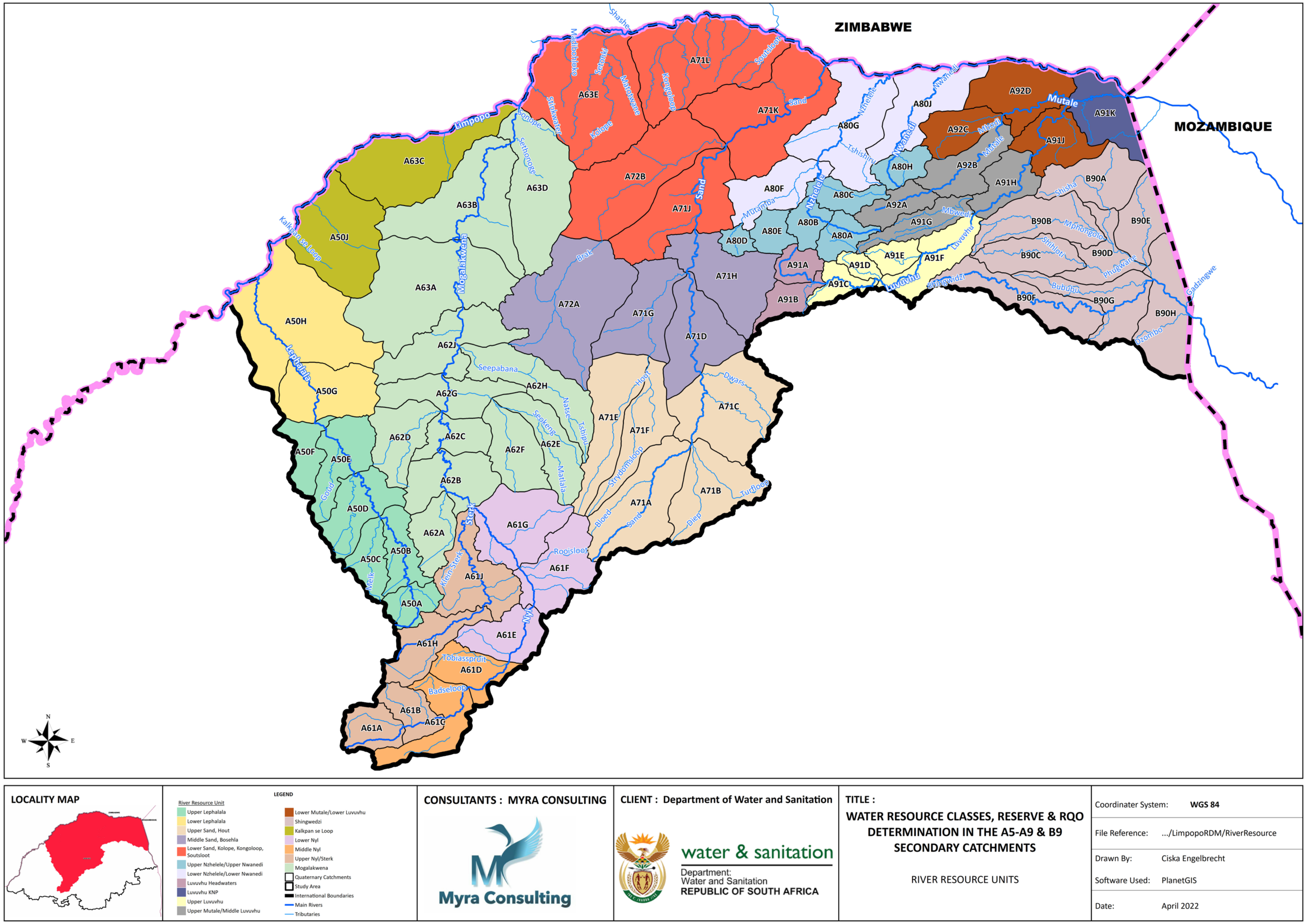

Figure 4-8. Preliminary delineation of River Resource Units

4.2 Groundwater Unit of Analysis

4.2.1 Overview

It is practical to consider the status quo for groundwater resources in respect of groundwater resource units (termed groundwater units of analysis (GUAs)). As such, the hydrogeological characteristics of the area, the delineation of groundwater units of analysis, and status quo of GUAs are presented together in this report.

Quaternary catchments are used as the primary delineation of water resource units in RDM assessments. The delineation of groundwater resource units depends on the hydrogeological characteristics of the area (e.g. aquifer types and flow regimes), and due to the nature of groundwater flows, hydraulic boundaries for groundwater flow are often different to that of surface water systems. Although the hydraulic boundaries may differ, the delineation should consider that a Class, Reserve and RQOs must be set for each unit, and therefore linkages with other components have to be considered, and each unit will have to be managed. The delineation of GUAs presented in this section therefore considers the following physical, management and functional criteria together:

- Surface water divides on a quaternary and secondary level
- Geological structures (i.e. fault, hydrostratigraphy or lithological contact zones)
- River systems
- Recharge and discharge zones and groundwater flow regimes
- Zones of groundwater use
- Groundwater management (size and extent of units)

4.2.2 Delineation

4.2.2.1 Aquifer types

The study area is dominated by Intergranular and fractured aquifer systems with borehole yields between 0.1 and > 5 L/s (Figure 4-9). The dominant rock types in the study area are the Goudplaats, Hout River, Alldays and Sand River Gneiss as well as the Beit Bridge complex including the number of granitic intrusions. These rocks form the major subgroups of the Basement Crystalline Complex as they form part of the Achaean eon 3.1 to 2.5 Ga. Aquifers are developed within the weathered overburden and fractured bedrock of these hard crystalline or re-crystallised rocks of igneous or metamorphic origin. Crystalline rocks are characterised by very low primary porosity (fresh or unweathered crystalline rocks contain virtually no water), and almost all groundwater movement and storage in these rocks takes place via fractures, faults, weathered zones and other secondary features that enhance the aquifer potential only locally. Intrusive batholiths and fractured contact zones can displace the host rocks during intrusion to create space for the ascending magma. These 10 to 100 metres wide zones are highly productive and can yield in boreholes in excess of 30 L/s (Du Toit, 2001). Several exceptionally high yielding areas within the crystalline basement aquifer system occur in the Dendron (Mogwadi), Vivo, Baltimore and Tolwe regions (Figure 4-9). These aquifers have provided for large scale irrigation for the last few decades.

The southwest of the study area is dominated by the Waterberg Group sandstones and the Karoo Super Group rocks which are classified as a fractured aquifer with expected borehole yields between 0.1 and > 2 L/s (Figure 4-9). Primary aquifers (or intergranular aquifers) occur throughout the study area and exist in the vicinity of drainage channels where alluvial material overlies or replaces the weathered overburden creating a distinct intergranular aquifer type. The elongated alluvial aquifers follow rivers (so called valley trains), sand rivers or drainage lines with limited width and depth, which typically vary according to the topography and climate.

The mountainous area east of Mokopane are also of special interest as far groundwater is concerned as this area consists primarily of dolomite and has considerable groundwater resources. The karst aquifer with excepted yields of more than > 5L/s is however heavily exploited, within quaternary catchment A61F (DWAF, 2004)

Three main types of aquifers occur within the study area, namely

- Intergranular (alluvial aquifer).
- Intergranular (“primary” or weathered sandy aquifers) and fractured (“secondary” aquifers).
- Karst aquifer system.

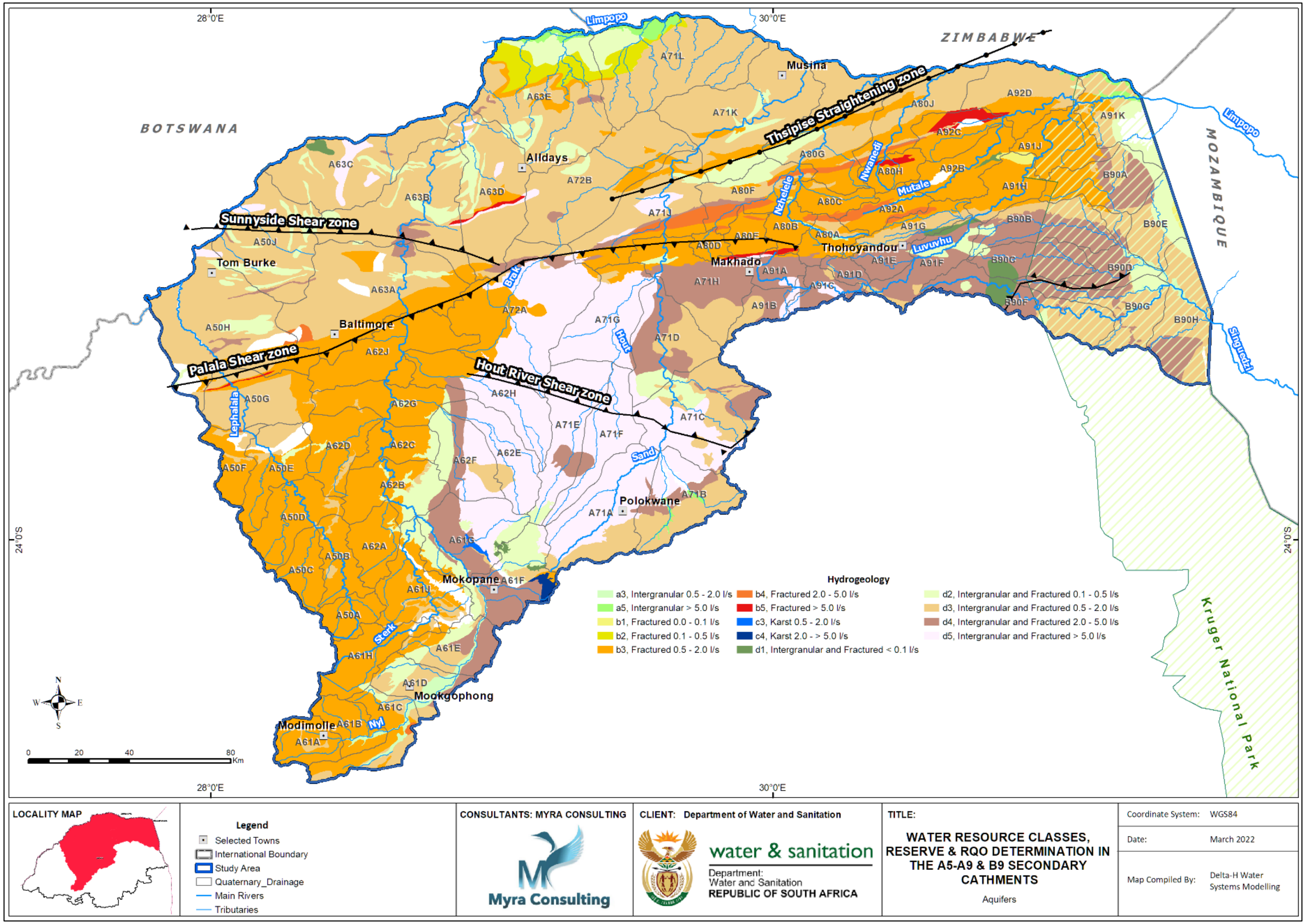

Figure 4-9. Aquifer type and yield

4.2.2.2 Groundwater regions

Groundwater divisions were proposed by Vegter (2000), and are primarily based on geology and not hydraulic units as such. As a result, the delineated regions group similar geological rocks that has uniform water bearing properties. A comparison of the borehole information of the groundwater regions within the study area after Vegter (2000) is provided in Table 4-2 for information. The regions were adapted in this study to isolate the Nyl River Flats more distinctly from the larger Waterberg regions, shown in Figure 4-10. In addition, the dolomites found at Mokopane (in the old Eastern Bankenveld) was renamed as Mokopane dolomites. From the results, the variability between delineated groundwater regions is clear. As expected, the Mokopane dolomite region have above average transmissivity and yields, while lower transmissivities and yields are associated with the Karoo- and Soutpansberg Strata. The variability in groundwater potential is also evident between the crystalline basement complexes, where the Houdenbrak Granulite-Gneiss has higher average yields compared to the Limpopo Granulite-Gneiss Belt.

Table 4-2. Comparison of hydrogeological parameters for the delineated groundwater regions.

Groundwater Region	Info	BH Depth	Water Level	Water Strike	Transmissivity	Rec. Yield	Blow Yield
		(mbgl)			(m^2/day)	(L/s for 24hrs)	(L/s)
Granulite-Gneiss Plateau	N	1050	1136	278	149	76	208
	Min	-	<1	<1	0.1	0.02	<0.01
	Max	250	78.5	160	960	12	40
	Mean	59.5	15.2	37.3	39.7	1.3	3.2
Houdenbrak Granulite-Gneiss	N	1363	1567	430	255	97	299
	Min	-	<1	<1	0.3	0.01	<0.01
	Max	300	93.6	204	640	11	99
	Mean	61.8	24.8	43.1	33.4	1.2	2.5
Koedoesrand Bushveld Cpx	N	274	204	183	40	65	88
	Min	-		2	0.2	0.05	<0.01
	Max	290.5	115	289	527	7	27
	Mean	54.4	18.0	50.2	51.7	1.0	2.1
Limpopo Granulite-Gneiss Belt	N	1443	1297	654	93	79	355
	Min	<1	<1	<1	0.1	0.04	<0.01
	Max	335	200	306	387	15	30
	Mean	50.5	24.0	49.4	37.5	1.1	1.7
Limpopo Karoo Basin	N	338	201	165	1	1	100
	Min	<1	<1	6	12.4	0.8	<0.01
	Max	259	66	259	12.4	0.8	0.7
	Mean	34.6	17.4	43.2	12.4	0.8	1.1
Mokopane Dolomites	N	195	172	130	20	21	94
	Min	<1	2	5	4	0.05	0.1

Groundwater Region	Info	BH Depth	Water Level	Water Strike	Transmissivity	Rec. Yield	Blow Yield
		(mbgl)			(m^2/day)	(L/s for 24hrs)	(L/s)
	Max	238	122	149	500	6.6	36
	Mean	59.6	20.1	41.7	112.3	1.6	8.2
Northern Lebombo	N	118	99	121	none	none	102
	Min	<1	<1	4	none	none	<0.01
	Max	137.5	54	114	none	none	15
	Mean	45.9	13.7	29.9	none	none	1.9
Northern Limb Bushveld Cpx	N	610	580	244	124	57	133
	Min	<1	<1	2	0.1	0.01	<0.01
	Max	204	92	150	380	11.0	15
	Mean	54.4	15.5	42.8	52.8	1.0	1.7
Nyl River Flats	N	526	405	299	14	13	194
	Min	<1	<1	<1	0.4	0.06	<0.01
	Max	281	90	192	68	3.6	28
	Mean	57.8	15.8	44.2	24.1	1.4	2.1
Soutpansberg Hinterland	N	777	664	399	80	58	264
	Min	<1	<1	<1	0.2	0.02	<0.01
	Max	340	137	266	925	15	60
	Mean	64.1	22.5	47.8	68.2	1.2	3.0
Soutpansberg Trough	N	792	746	263	154	64	214
	Min	<1	<1	2	0.2	0.02	<0.01
	Max	340	140	340	428	11	49
	Mean	63.4	15.1	44.6	16.6	0.8	2.7
Waterberg Karoo Coal Basin	N	58	32	61	none	none	21
	Min	<1	6	3	none	none	<0.01
	Max	300	160	258	none	none	9
	Mean	69.9	34.4	88.9	none	none	0.7
Waterberg Plateau	N	1005	778	560	122	69	288
	Min	<1	<1	2	0.1	0.02	<0.01
	Max	291	220	257	800	0.3	38
	Mean	64.3	19.6	51.0	43.1	0.5	1.6

4.2.2.3 Transboundary aquifers (TBAs)

Two international transboundary aquifers occur in the study area namely the AF9 – Tuli Karoo Sub-Basin and the AF8 – Limpopo Basin and the (Figure 4-11). A summary of the characteristics of the aquifers is provided below:

- AF9 – Tuli Karoo Sub-Basin

The predominant lithology is crystalline rocks – volcanic and basement rocks with sedimentary rocks -sandstones and extensive sands - alluvial deposits along the major drainage channels.

- AF8 – Limpopo Basin
  The predominant lithology is crystalline rocks – granitic basement.

A comprehensive description of the Limpopo TBAs is generally lacking due to the lack of data from adjacent countries. These two specific TBAs have generally low transmissivities with a slow rate of groundwater movement. In addition, groundwater occurs within disconnected “pockets” determined by geology and weathering processes (e.g. basement aquifers) (Cobbing et al., 2008). The impression of a large interconnected and high yielding shared aquifer resources are, therefore not the case for these two TBAs. However, the Limpopo River alluvial aquifer might be of more importance to the four countries sharing the resource. The seasonal flow regime of the Limpopo River is characterised by wet season runoff that recharges the alluvial aquifer; surface flows decline during the dry winter months, reducing to dislocated pools of standing water connected by sub-surface flows. At this stage the AF8 and AF9 TBAs is not believed to be at risk of competition for water between South African and neighbouring countries. In addition, these TBAs north of the Limpopo River will be excluded from the study area purely based on the basis and methodology applied to delineate of the groundwater resource units.

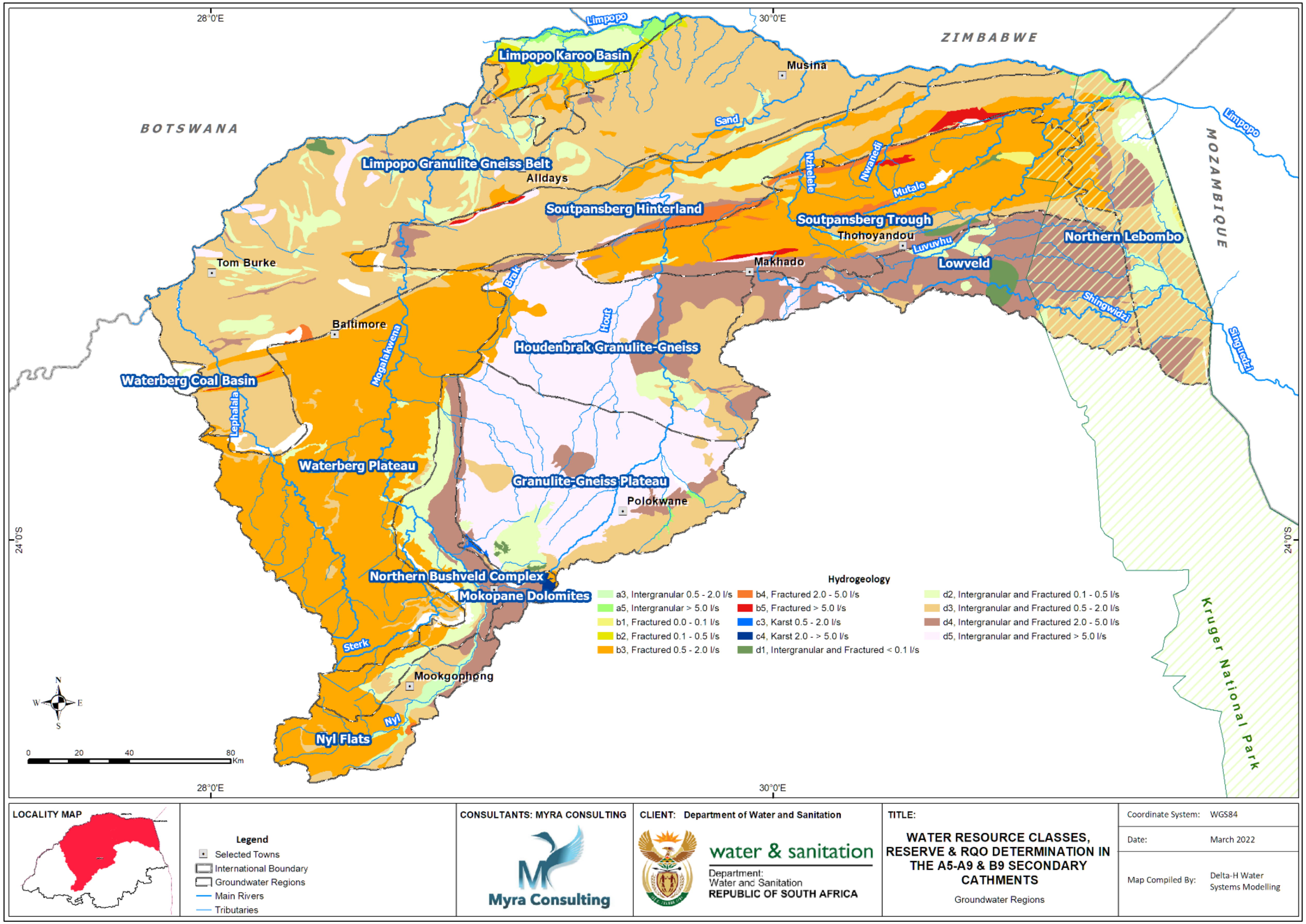

Figure 4-10. Groundwater regions (adapted from Vegter, 2000).

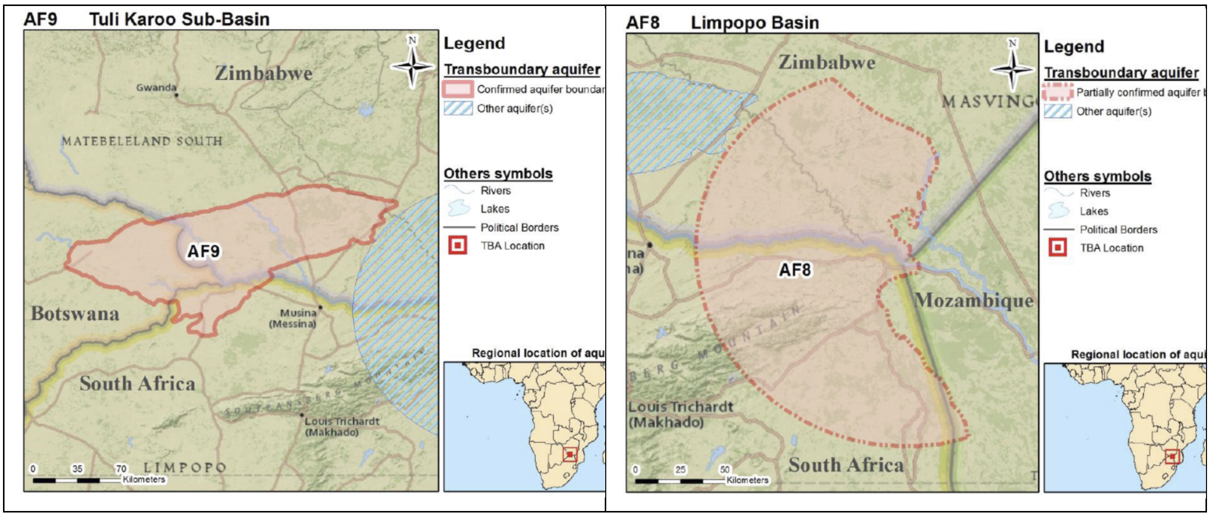

Figure 4-11. Transboundary aquifers of the study area (TWAP, 2022).

4.2.2.4 Resulting Delineation

In this study the quaternary catchments were used as the basis for delineation, with the GUAs based on a single or a combination of quaternary catchments. The final delineation was driven by the following considerations:

- Although surface water and groundwater divides do not always correspond, groundwater must be considered in terms of an integrated water resource.
  - The study area is drained by 8 major rivers flowing into the Limpopo River. As a result, the study area is easily divided into 8 sub-catchments. Considering that the groundwater component of the (ecological) Reserve is determined by calculating the groundwater contribution to baseflow it is necessary to integrate with the hydrological approach as far as possible.
- Using the data on groundwater levels obtained from the Groundwater Resource Information Project (GRIP) and National Groundwater Archive (NGA) dataset the correlation between surface topography and elevation of the groundwater level was established (Figure 4-12). Based on the regional results a good correlation between the measured water levels and surface topography is obvious (R^2 = 1.00, i.e., approximately 100% of observed water level variations can be explained by variations in surface elevation) and it can be assumed that the water table mimics the surface topography at the regional scale.
- Identification and recognition of aquifer type and groundwater regimes within each sub-catchment.

The delineated resource units generally combine a couple of quaternary catchments so that the integration of surface water and groundwater systems can be achieved (Figure 4-13). A summary of the delineated GUA within each sub-catchment is provided in Table 4-3. All GUAs coincide with the sub-catchments except for A63/A71-3, which straddles the Mogalakwena- and Sand River sub-catchments. The tributaries draining the associated quaternary catchments drain directly into the

Limpopo River. These catchments also straddle the Limpopo Karoo Basin, so as a result they were delineated as a single GUA.

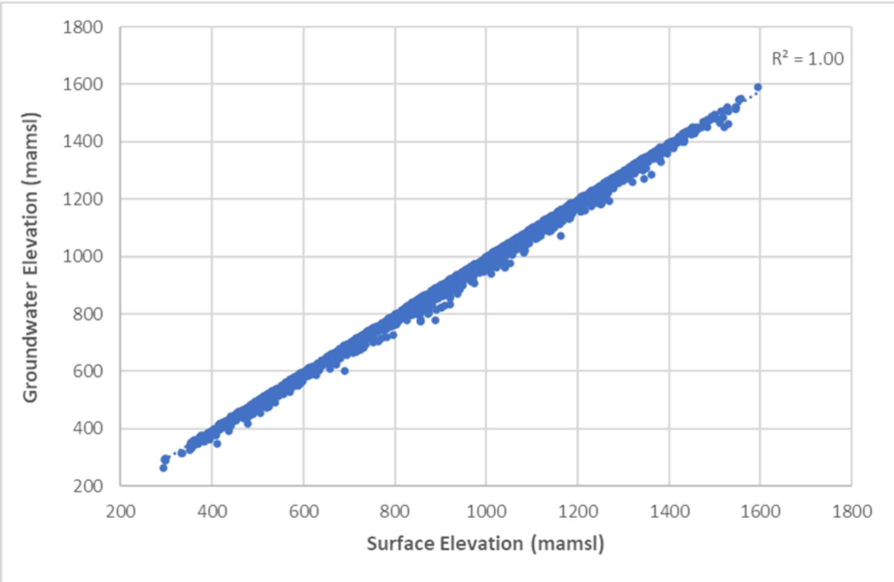

Figure 4-12. Correlation between surface topography and groundwater elevations for the study area

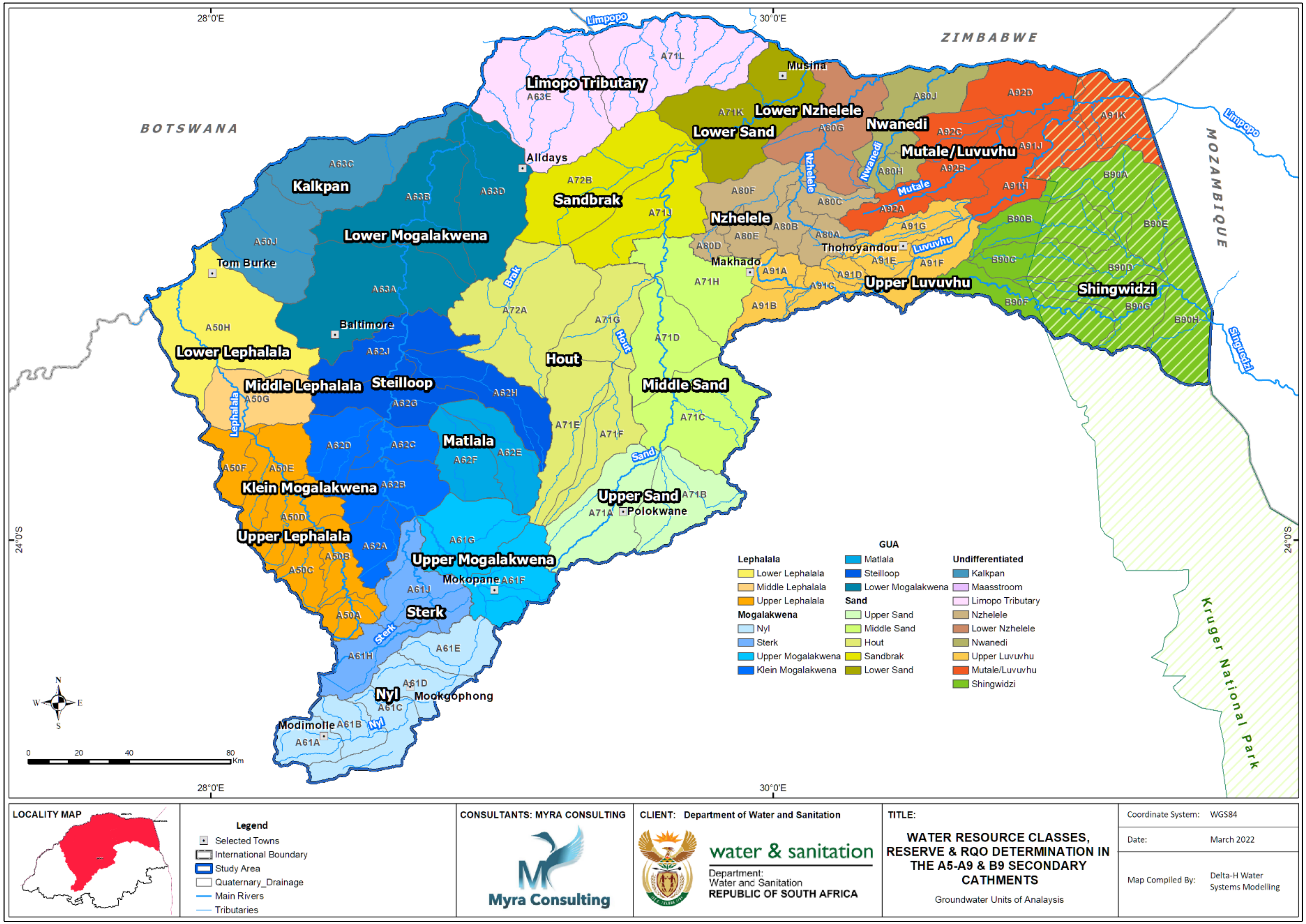

Figure 4-13. Delineated groundwater units of analysis

Table 4-3. Description of delineated groundwater units of analysis

Drainage system	GUA	Nr of Quats.	Catchments	Name	Dominant geology
Lephalala	A50-1	6	A50A,B,C,D,E,F	Upper Lephalala	Waterberg Group
	A50-2	1	A50G	Middle Lephalala	Bushveld Complex
	A50-3	1	A50H	Lower Lephalala	Basement Complex
Upper Mogalakwena	A61-1	5	A61A,B,C,D,E	Nyl River Valley	Bushveld Complex, Lebombo Group
	A61-2	2	A61H,J	Sterk	Bushveld Complex, Waterberg Group
	A61-3	3	A61F,G	Upper Mogalakwena	Bushveld- and Basement Complex, Dolomites
Middle and Lower Mogalakwena	A62-1	3	A62A,B,C,D	Klein Mogalakwena	Bushveld Complex, Waterberg Group
	A62-2	2	A62E,F	Matlala	Bushveld- and Basement Complex,
	A62-3	3	A62G,H,J	Steilloop	Waterberg Group
	A63-1	3	A63A,B,D	Lower Mogalakwena	Basement Complex, Karoo Super Group, Lebombo Group
Upper Sand	A71-1	2	A71A,B	Upper Sand	Basement Complex, Alluvium
	A71-2	3	A71C,D,H	Middle Sand	Basement Complex
	A71-3	4	A71E,F,G	Hout	Basement Complex
Lower Sand	A71-4	2	A71J, A72B	Sandbrak	Basement Complex, Karoo Super Group, Lebombo Group
	A71-5	1	A71K	Lower Sand	Basement Complex, Karoo Super Group
Limpopo Tributary	A63-3/A71-6	2	A63E, A71L	Kolope	Basement Complex, Karoo super Group
Kalkpan	A50-4/A63-2	2	A63C, A50J	Kalkpan/Maasstroom	Basement Complex
Nzhelele	A81-1	6	A80A, B,C,D,E,F	Nzhelele	Soutpansberg Group, Karoo Super Group, Lebombo Group, Basement Complex
Lower Nzhelele	A81-2	1	A80G	Lower Nzhelele	Soutpansberg Group, Karoo Super Group, Basement Complex
Nwanedi	A81-3	2	A80H,J	Nwanedi	Soutpansberg Group, Karoo Super Group, Basement Complex
Upper Luvuvhu	A91-1	7	A91A,B,C,D,E,F,G	Upper Luvuvhu	Soutpansberg Group, Basement Complex
Mutale / Luvuvhu	A91-2	7	A91H,J,K, A92A,B,C,D	Mutale /Luvuvhu	Soutpansberg Group, Basement Complex
Shingwedzi	B90-1	8	A90A,B,C,D,E,F,G,H	Shingwedzi	Basement Complex, Soutpansberg Group

4.3 Wetland Resource Units

The spatial distribution and extent of wetlands was explored in order to define and delineate meaningful groupings of wetlands. The objective of this step is to define wetland groups, termed wetland RUs, and provide a status quo description of each group, including general condition of wetlands. A group should represent a homogenous catchment or region based on the similarity of ecological state, system operation and land use. The status quo description provides information at a broad scale to inform the delineation of the wetland groups. Specific actions and data considerations included:

- Identifying the spatial distribution and extent of wetlands: The identification was based on the National Biodiversity Assessment (2018) and the National Freshwater Ecosystem Priority Area (NFEPA) spatial and metadata (Van Deventer et al., 2018; Nel et al., 2011).
- Typing wetlands in terms of EcoRegions and Hydrogeomorphic (HGM) types: The typing of wetlands was based on EcoRegions and HGM types used from the National Wetland Classification System and embedded within the wetland coverage metadata.
- Determine wetland groups based on position, type and general condition: Wetland groups will likely include wetlands of different type, and general condition refers to “wetcon” data within the NWM2 and NFEPA metadata. Groupings are not perfectly homogenous but focus on dominance of criteria.
- Consideration of IUAs and drainage catchment boundaries. It is preferable that wetland RUs do not span drainage or IUA boundaries. This facilitates a more practical approach to management and more logical assessments to, for example, responses to scenarios.

At the broadest scale, 3 wetlands zones were delineated based on predominance of wetland type (Level 4 classification of HGMs) and ecoregions (level 1) to include as much homogeneity as possible (Figure 4-14). Zone 1 is dominated by floodplain wetlands, 73 849 Ha, distinctly more than the other zones despite it being the smallest and includes the Nylsvley RAMSAR site (Table 4-4). Zone 2 has a wetland type diversity that is dominated by depressional wetlands and zone 3 is dominated by channelled and unchanneled valley bottom wetlands and has a high prevalence of riverine wetlands (Table 4-4). These 3 zones formed the basis for finer-scaled units and 16 wetland resource units (RUs) were delineated so that IUA and Wetland zone boundaries were not overlapped (Figure 4-15).

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[2] New Wetland Map (2018)

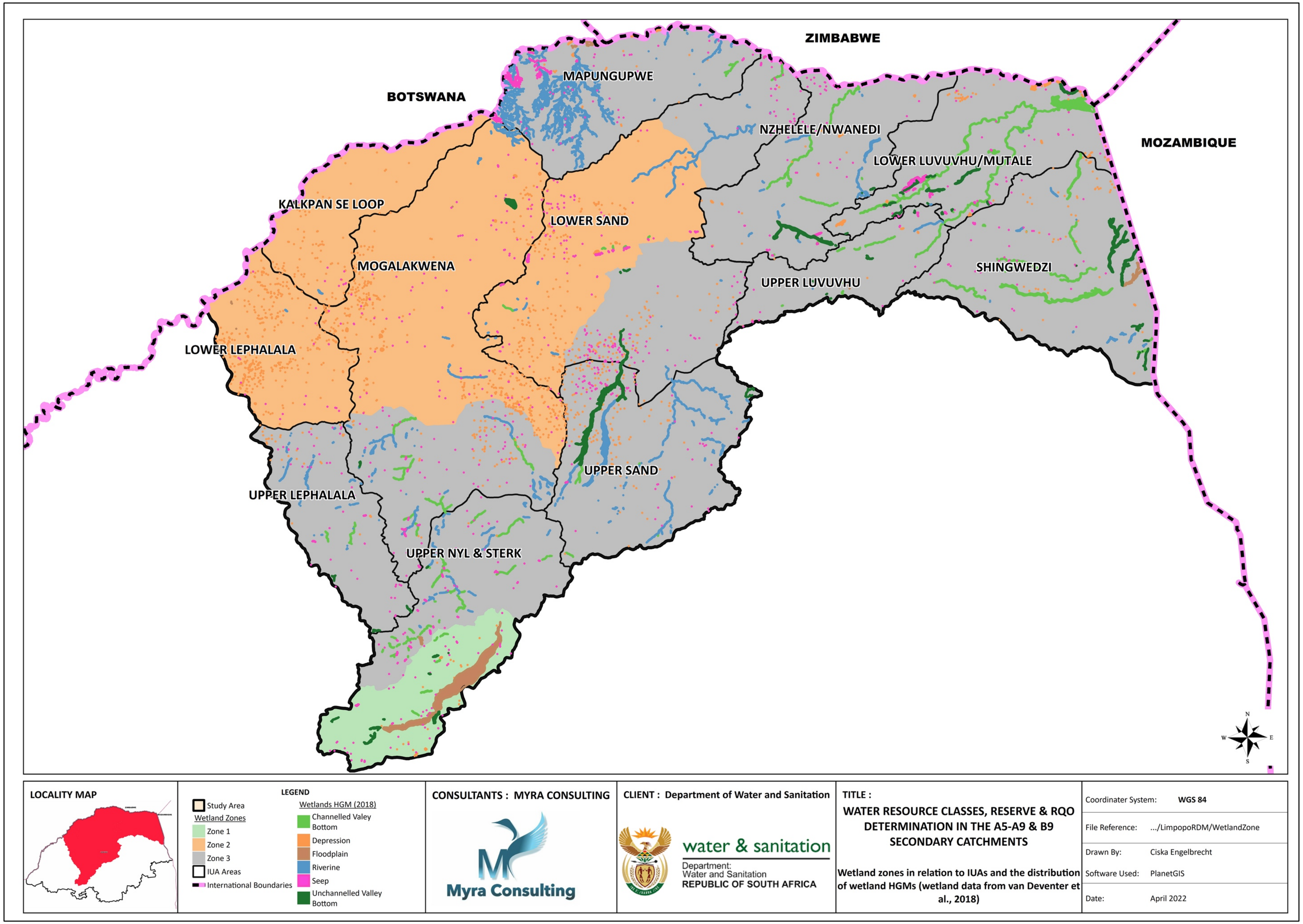


Figure 4-14. Wetland zones in relation to IUAs and the distribution of wetland HGMs (wetland data from van Deventer et al., 2018)

Table 4-4. Extent of wetlands HGMs (Ha) within wetlands zones

	Wetland HGM						
Wetland Zone	Depressions	Floodplains	Riverine	Seeps	Channelled valley bottoms	Unchannelled valley bottoms	Total
Zone 1	100	73849		71	172	1105	75298
Zone 2	1881	9	1860	426	240	982	5399
Zone 3	1585	1192	21308	2862	38142	30772	95860
Total	3565	75050	23168	3360	38554	32859	176556

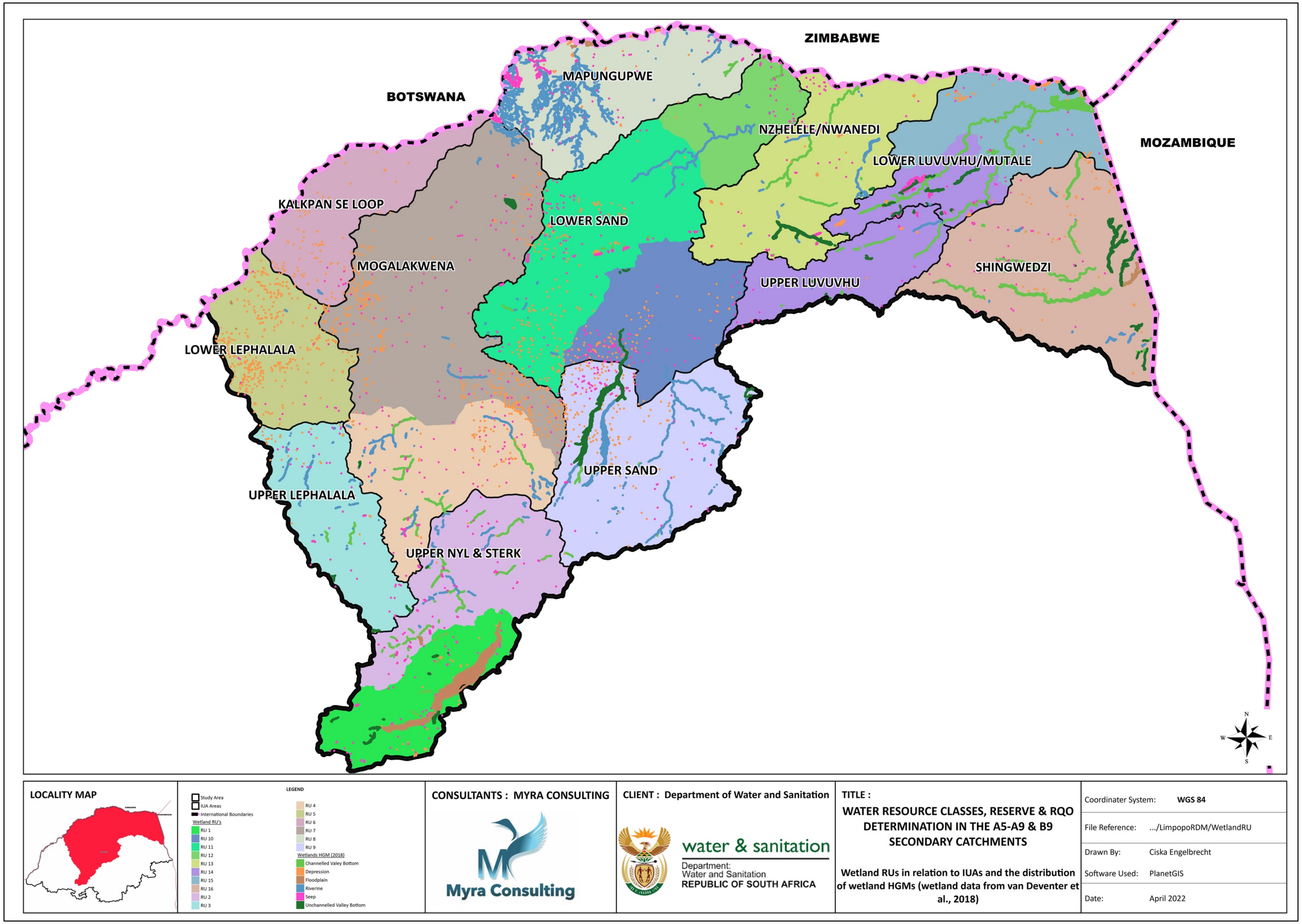


Figure 4-15. Wetland RUs in relation to IUAs and the distribution of wetland HGMs (wetland data from van Deventer et al., 2018).

The extent (Ha) of various variables was assessed for each of the wetland RUs using the latest wetland map metadata (NWM5, 2018). Variables included wetland type (HGM), general wetland condition, wetland threat status and level of wetland protection. Details are shown respectively in Table 4-5 for HGMs, Table 4-6 for wetland condition, Table 4-7 for wetland threat status,

Table 4-8 for level of wetland protection and dominant extents of each are summarised as follows:

- RU 1: Floodplains, D/E/F, CR, Not protected
- RU 2: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 3: Riverine, D/E/F, CR, Not protected
- RU 4: Channelled valley bottoms and Riverine, D/E/F, CR, Not protected
- RU 5: Depressions, A/B, LC, Poorly protected
- RU 6: Depressions and Riverine, A/B, LC, Poorly protected
- RU 7: Depressions and Unchannelled valley bottoms, A/B, CR Not protected
- RU 8: Riverine, D/E/F, CR, Poorly protected
- RU 9: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 10: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 11: Riverine, D/E/F, LC, Poorly protected
- RU 12: Riverine, D/E/F, CR, Poorly protected
- RU 13: Unchannelled valley bottoms, D/E/F, CR, Not protected
- RU 14: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 15: Channelled valley bottoms, D/E/F, CR, Not protected
- RU 16: Channelled valley bottoms, C, CR, Poorly protected

Table 4-5. Extent of wetlands HGMs (Ha) within wetlands RUs.

	Wetland HGM						
Wetland RU	Channelled valley bottoms	Depressions	Floodplains	Riverine	Seeps	Unchannelled valley bottoms	Total
RU 1	172	100	73849		71	1105	75298
RU 2	1359	4	195	458	225	87	2330
RU 3	115	56		326	36	196	729
RU 4	804	75		1182	99	47	2208
RU 5		522	9	23	0		554
RU 6		51		54	0		105
RU 7	139	879	0	617	57	982	2675
RU 8	65	171	345	10356	364	0	11300
RU 9	202	149		6013	16	13642	20022
RU 10		98		297	12	6792	7198

	Wetland HGM						
Wetland RU	Channelled valley bottoms	Depressions	Floodplains	Riverine	Seeps	Unchannelled valley bottoms	Total
RU 11	101	429		1166	369		2065
RU 12	52	1		620	15		688
RU 13	1755	203		1476	142	4585	8160
RU 14	11545	304	65	197	1927	1443	15480
RU 15	16797	434		0	6	391	17628
RU 16	5448	90	586	383	20	3589	10117
Total	38554	3565	75050	23168	3360	32859	176556

Table 4-6. Extent of wetland RUs (Ha) assessed for wetland condition ("WETCON" metadata from NWM5[3]; N/A – not assessed)

	Wetland Condition				
Wetland RU	A/B	C	D/E/F	N/A	Dominant Condition
RU 1	121	95	75082		D/E/F
RU 2	100	96	1675	458	D/E/F
RU 3	41	26	336	326	D/E/F
RU 4	86	87	853	1182	D/E/F
RU 5	440	46	44	23	A/B
RU 6	43	4	4	54	A/B
RU 7	1556	55	447	617	A/B
RU 8	198	325	422	10356	D/E/F
RU 9	90	25	13894	6013	D/E/F
RU 10	86	31	6784	297	D/E/F
RU 11	234	131	535	1166	D/E/F
RU 12	16		52	620	D/E/F
RU 13	13	35	6636	1476	D/E/F
RU 14	82	339	14862	197	D/E/F
RU 15	129	5529	11969	0	D/E/F
RU 16	201	4849	4684	383	C
Total	3434	11673	138281	23168	D/E/F

[3] NWM = New wetland map; (van Deventer et al., 2018)

Table 4-7. Extent of wetland RUs (Ha) assessed for wetland threat status (metadata from NWM5[4]; N/A – not assessed).

	Wetland Threat Status					
Wetland RU	**CR**	**EN**	**LC**	**VU**	**N/A**	**Dominant Threat Status**
RU 1	75198		100			CR
RU 2	1867		4		458	CR
RU 3	347		56		326	CR
RU 4	950		75		1182	CR
RU 5	9		522		23	LC
RU 6	0		51		54	LC
RU 7	1133	46	807	71	617	CR
RU 8	410	364		171	10356	CR
RU 9	13860		149		6013	CR
RU 10	6804		98		297	CR
RU 11	385	85	403	26	1166	LC
RU 12	52	15		1	620	CR
RU 13	6481	0	8	195	1476	CR
RU 14	14856	319	22	86	197	CR
RU 15	17188	6		434	0	CR
RU 16	9624	20		90	383	CR
Total	**149163**	**856**	**2294**	**1075**	**23168**	**CR**

Table 4-8. Extent of wetland RUs (Ha) assessed for wetland protection level (metadata from NWM5[5]; N/A – not assessed).

	Level of Wetland Protection				
Wetland RU	**Not protected**	**Poorly protected**	**Well protected**	**N/A**	**Dominant Protection**
RU 1	75198	100			Not protected
RU 2	1867	4		458	Not protected
RU 3	347	56		326	Not protected
RU 4	950	75		1182	Not protected
RU 5	9	522		23	Poorly protected
RU 6	0	51		54	Poorly protected
RU 7	1133	853	71	617	Not protected
RU 8	345	429	171	10356	Poorly protected

[4] NWM = New wetland map; (van Deventer et al., 2018)

[5] NWM = New wetland map; (van Deventer et al., 2018)

	Level of Wetland Protection				
Wetland RU	**Not protected**	**Poorly protected**	**Well protected**	**N/A**	**Dominant Protection**
RU 9	13860	149		6013	Not protected
RU 10	6804	98		297	Not protected
RU 11	345	528	26	1166	Poorly protected
RU 12		67	1	620	Poorly protected
RU 13	6481	8	195	1476	Not protected
RU 14	14081	1117	86	197	Not protected
RU 15	11275	5919	434	0	Not protected
RU 16	586	9057	90	383	Poorly protected
Grand Total	**133282**	**19031**	**1075**	**23168**	**Not protected**

5 DEFINE IUAs

5.1 General approach

The delineation of the provisional IUAs followed the approach below:

- Tentative socio-economic areas were sketched based on land cover data, homogenous farm areas, vegetation types, topography, etc.
- These were then consolidated into relatively homogenous Socio-Economic Zones.
- The Socio-Economic Zones were overlaid on the River Resource Units that had been delineated.
- The river resource units aligned well with Socio-Economic Zones at a broad catchment level. In some cases the SEZs did cover two (2) or more river resource units. However, it was decided that no further sub-division was needed as the river RU could be combined based on similarity in ecological character and state. The SEZs were then taken forward to become the IUAs, which form the basis of assessment for changes in water use and socio-economic impacts.

5.2 Provisional delineation of IUAs

The composition of the individual provisional IUAs is provided in Table 5-1. The map illustrating the IUAs are provided in Figure 5-1.

Table 5-1. Composition of provisional IUAs delineated for the study area

SOCIO-ECONOMIC ZONE	RIVER RESOURCE UNITS	IUA NAME	QUATERNARY CATCHMENTS
Upper Lephalala	Upper Lephalala	Upper Lephalala	A50A, A50B, A50C, A50D, A50E, A50F
Lower Lephalala	Lower Lephalala	Lower Lephalala	A50G, A50H
Kalkpan se Loop	Kalkpan se Loop	Kalkpan se Loop	A50J,A63C
Upper Nyl & Sterk	Upper Nyl/Sterk	Upper Nyl & Sterk	A61A, A61B, A61C, A61D, A61E, A61F, A61G, A61H, A61J
	Middle Nyl		
	Lower Nyl		
Mogalakwena	Mogalakwena	Mogalakwena	A62A, A62B, A62C, A62D, A62E, A62F, A62G, A62H, A62J, A63A, A63B, A63D
Mapungubwe	Mapungubwe/Lower Sand	Mapungubwe	A63E, A71L
Upper Sand	Upper Sand	Upper Sand	A71A, A71B, A71C, A71E, A71F
Lower Sand	Middle Sand	Lower Sand	A71D, A71G, A71H, A71J, A71K, A72A, A72B
Nzhelele/Nwanedi	Upper Nzhelele/Upper Nwanedi	Nzhelele/Nwanedi	

SOCIO-ECONOMIC ZONE	RIVER RESOURCE UNITS	IUA NAME	QUATERNARY CATCHMENTS
	Lower Nzhelele/Upper Nwanedi		A80A, A80B, A80C, A80D, A80E, A80F, A80G, A80H, A80J
Upper Luvuvhu	Luvuvhu Headwaters	Upper Luvuvhu	A91A, A91B, A91C, A91D, A91E, A91F, A91G
	Upper Luvuvhu		
Lower Luvuvhu/Mutale	Upper Mutale/Middle Luvuvhu	Lower Luvuvhu/Mutale	A91H, A91J, A91K, A92A, A92B, A92C, A92D
	Lower Mutale/Lower Luvuvhu		
	Luvuvhu KNP		
Shingwedzi	Shingwedzi	Shingwedzi	B90A, B90B, B90C, B90D, B90E, B90F, B90G, B90J

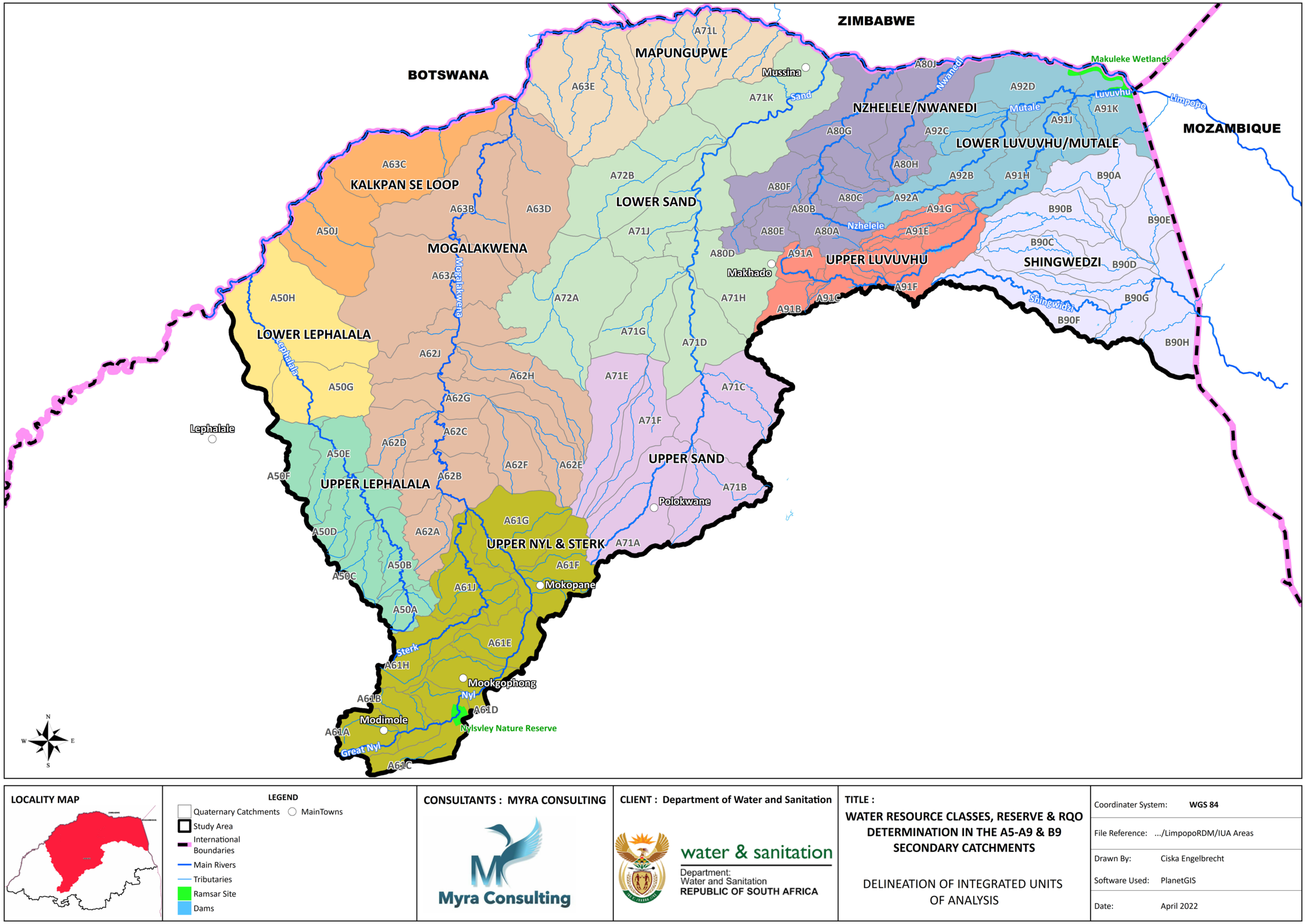


Figure 5-1. Provisional delineation of Integrated Units of Analysis

6 STATUS QUO OF SIGNIFICANT WATER RESOURCES

6.1 Surface Water Resources and Infrastructure

6.1.1 Approach

This chapter addresses the surface water resources in the study area, in terms of their water availability, water allocations and water use as well as bulk surface water infrastructure, such as dams, diversion weirs, inter-basin transfer schemes and pipelines. The source of information for these aspects was the DWS 2017 Limpopo Water Management Area North Reconciliation Strategy and the DWA 2014 Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System. Potential development options identified in the catchments have been highlighted in this chapter.

The available existing hydrological studies and water resource system models that cover the study area were examined for suitability for the study and have been described below.

6.1.2 Description

6.1.2.1 Climate in the study area

The climate of the study area is temperate and semi-arid in the south to arid in the north. Rainfall usually occurs in summer with thunderstorms and is strongly influenced by the topography.

Mean annual rainfall ranges from 800 mm in the mountainous regions of the Waterberg to 300mm near the Limpopo River. The eastern parts of the study area (catchments A9 and B9) have their headwaters located in the mountainous regions of the Soutpansberg where mean annual rainfall is about 1000mm, dropping to 400mm in the lower reaches of the catchment.

Potential evaporation is well in excess of rainfall and runoff is low due to the prevalence of sandy soils that predominate in most of the study area. The water resources, especially surface water resources, are heavily stressed due to the present levels of development.

6.1.2.2 Surface water resources

The study area spans six main river catchments: Lephalala, Mogalakwena, Sand, Nzhelele and Luvuvhu in the Limpopo WMA and the Shingwedzi in the Olifants WMA. The rivers in the Limpopo WMA form part of the internationally shared Limpopo River Basin between South Africa, Botswana, Zimbabwe and Mozambique.

Lephalala River in SC A5. The middle reaches of the Lephalala catchment have a high conservation value, with irrigation activities dominant in the remainder of the catchment. Irrigation is supplied by surface water in the upper and middle reaches and alluvial aquifer abstraction in the lower reaches. The catchment has no major towns, and smaller settlements, such as Witpoort, are concentrated in the lower reaches close to the Lephalala River. There are several nature reserves and tourist attractions in the catchment. The Wilderness area in the middle reaches of the catchment has high conservation importance. The primary domestic and stock watering needs of 38 villages are supplied by five local Groundwater Schemes (GWSs). There is no significant development expected in the catchment due to the limited water available and the high conservation value of the middle reaches of the catchment.

Mogalakwena River in SC A6. The Mogalakwena catchment is the study area's largest and most densely populated, and industrialised catchment. The central part of the catchment is densely populated, with more than 80% of the population classified as rural. Major towns include Modimolle, Mookgopong and Mokopane, all situated in the upper regions of the catchment, where rainfall is relatively high. The Nylsvley wetland, a designated RAMSAR site is in the upper reaches of the Mokgalakwena catchment and provides a source of water to downstream users.

Considerable groundwater resources exist but have been extensively exploited by the dominant irrigation sector, especially in the upper reaches of the catchment. Surface water resources in the catchment are limited and have been fully developed. More than 700 farm dams and weirs have been constructed to improve the level of assurance for irrigation. The major dams are the Doorndraai, Glen Alpine and Donkerpoort dams.

Groundwater resources augment supply during peak demand periods. Modimolle is mainly supplied by the Magalies Water pipeline from Roodeplaat Dam (Crocodile West River catchment). Yield is available at Donkerpoort Dam; however, users prefer the Magalies Water transfer due to the lower cost. Water supply to Mookgopong is obtained from groundwater (mainly from the Nyl wellfield) and the Welgevonden dam. Mokopane, Mahwelereng and several denser settlements in the Mogalakwena Local Municipality (LM) are supplied from the Doorndraai Dam and groundwater resources (Planknek, Rooisloot and Weenen wellfields). Smaller settlements located in the Blouberg LM are mainly supplied by groundwater.

Anglo Platinum has been purchasing treated sewerage effluent from the Polokwane LM and Mokopane Wastewater Treatment Works (WwTW) to supply the Mogalakwena Platinum Mine (previously the Potgietersrus Platinum or PPL Mine). However, due to the inadequate quality of the treated effluent from Polokwane, Anglo Platinum has stopped using the transferred effluent.

The Lonmin Mining Company has purchased a portion of the irrigation entitlements from Doorndraai Dam but is not using the water yet. Since Lonmin Mine plans to start using their allocation in 2022, Lephelle Northern Water has made an application to be allocated some of the Lonmin Mine allocations to alleviate water shortages until the ORWRDP-2B is commissioned. It is uncertain, however, if the licence has been issued.

Several possible new platinum mines were identified in the Mokopane area, considered the platinum growth point of the Limpopo Province. Possible new nickel, vanadium and iron ore mines north of Mokopane are also planned. Increased domestic water requirements in the Mokopane area (including the Mogalakwena and Aganang LMs) will increase significantly due to the possible future mining activities. Most of the new mines and additional water requirements in the Mogalakwena and Aganang LMs will be supplied by the ORWRDP-2B and 2G.

Sand River in SC A7. The Sand catchment is the driest in the study area and has the most extensive water requirement. The main urban centres include Polokwane, Louis Trichardt and Musina, as well as small urban areas such as Mogwadi and Soekmekaar. Major industrial water users include the South Africa Breweries (SAB) and the Anglo Platinum smelter in Polokwane. Mining industries include the Vele Coal mine (currently in maintenance phase), Messina Copper Mine (closed) and the Artonvilla Copper Mine (closed).

Surface water resources in the catchment are limited to the small Seshego and Houtrivier dams and run-of-river abstractions. There are no major dams in the catchment. Groundwater is the only dependable water source for many rural settlements and villages. Large quantities of groundwater are abstracted for irrigation, the primary water user in the catchment. Although exceptional groundwater reserves exist, they have been entirely and possibly over-exploited in some areas.

Urban requirements are augmented from transfers from neighbouring WMAs. The Polokwane LM is supplied via the Olifants-Sand Regional Water Supply Scheme (RWS) by transfers from Ebenezer Dam and the Dap Naude Dam in the Luvuvhu and Letaba WMA, as well as the Olifantspoort Weir in the Olifants River catchment. Polokwane also recycled effluent water through an innovative artificial recharge scheme to Anglo Platinum Mogalakwena Mine near Mokopane. However, the mine has stopped using the treated effluent due to water quality non-compliances. Louis Trichardt currently receives transferred water from the Albasini Dam, situated in the Luvuvhu and Letaba WMA. Musina, located in the northern part of the catchment, receives most of its water from alluvial aquifers next to the Limpopo River. The alluvial aquifers are considered a surface water resource due to the shallow depth of the aquifer. Water to smaller settlements is supplied by one of the 28 regional/rural supply schemes of which the primary resource is groundwater.

The catchment has a high coal mining potential. Coal of Africa Limited (CoAL) has identified several possible coal mining projects between Musina and Louis Trichardt, such as the Mopane and Chapudi operations. Significant industrial development in the Musina area includes the Musina SEZ and the Limpopo Industrial Park (LEIP). It is considered that the Musina SEZ refers to the area that will be occupied by industrial operations, whereas the LEIP refers to some of the actual industries.

Nzhelele River and Nwanedi River in SC A8. The Nzhelele catchment is a small rural catchment in the north-eastern corner of the Limpopo WMA. The small Nwanedi River catchment is included in the Nzhelele River catchment for this study. There are no large urban centres in the catchment except for several settlements in the high rainfall regions, including Makhado town, Dzanani and Siloam. Small industries include a vegetable processing factory, bakery and furniture factory. A small area of afforestation is found in the Soutpansberg area.

Surface water resources in the catchment are developed. Major dams in the catchment include the Nzhelele Dam, Mutshedzi Dam and the connected Ṅwaneḓi and Luphephe Dams. Cross Dam downstream of the Nwanedi and Luphephe dams serves as a balancing dam. Domestic water requirements are supplied from Mutshedzi Dam, the Tshifiri and Muruṅwa weirs and groundwater resources. The Nzhelele, Ṅwaneḓi and Luphephe dams supply irrigation. A licence to supply domestic water requirements from the twin dams to the Luphephe Nwanedi RWS has recently been granted, although the dam is significantly over-allocated. Due to illegal water use in the catchment, some industries had to reduce production due to interrupted water supply and are considering closing.

Due to the high coal mining potential in the catchment, several coal mining projects along the Mutamba River have been identified by CoAL. The Makhado Coal mine is expected to be operational from 2019 to 2034 and the General Project from 2030 until after 2040. Should water resources become available, citrus and tomato irrigation in the Nzhelele Valley is expected to expand significantly.

Luvuvhu River in Tertiary Catchment (TC) A91. The Luvuvhu River catchment is in the north-eastern corner of South Africa. The Mutale River catchment is included in the Luvuvhu River catchment for this study. Intensive irrigation farming is practised in the Luvuvhu River catchment, supplied by surface water and groundwater. The Albasini, Vonḓo, Ḓamani, Mukumbani and Tshakhuma dams are located in the upper tributaries of the Luvuvhu River, with the Ṋanḓoni Dam on the Luvuvhu River.

The Luvuvhu River GWS comprises the Ṋanḓoni Dam and Xikundu Weir with the Albasini, Vonḓo, Phiphidi and Tshakhuma dams and the associated bulk purified water supply infrastructure. This scheme is managed as an integrated system to supply water for domestic/industrial, irrigation and the ecological component of the Reserve. The intention is for the Ṋanḓoni dam to partly or wholly support many rural water supply schemes and towns. Significant irrigation development from surface and groundwater upstream of Albasini Dam resulted in a decrease in the available yield from the dam such that irrigation schemes downstream of the dam could not be supplied with water from the dam. Land claims in the catchment have resulted in large irrigated areas no longer being utilised. These areas, however, still have allocations from the dams. The main dam in the Luvuvhu catchment is the Albasini Dam. This is a multipurpose dam supplying the town of Makhdo as well as irrigated agriculture downstream of the dam.

Mutale River in TC A92. Water resources in the Mutale catchment are undeveloped, with supply being met from both surface and groundwater resources. The Rambuda/Dzimauli and Tshiombo irrigation Schemes are formal irrigation schemes which supplies water through canals and are important in contributing to the rural economy.

Lake Fundudzi has no obvious outlet and is formed from water off the Mutale River. The Lake is sacred to the Venda people. Deforestation, agriculture and development are causing the lake to silt up. A local project is busy rehabilitating the area.

The Tshikondeni mine, some 100km east of Tshipise and 17km south-east of Masisi started operating in 1984 as an underground high-quality, hard-coking coal mine and closed in 2014. The mine is situated adjacent to the Luvuvhu River and Kruger National Park. Attempts to revive the economy in the Tshikondeni area is underway.

The Makuleke contractual park in the northern Kruger National Park is bordered by the Limpopo River on the northern side and the Luvuvhu River to the south. It is considered to be the most biodiverse area in Kruger. The Makuleke area was designated a Ramsar Wetland in 2007 and the wetlands are considered important bird habitats and are of international importance.

Shingwedzi in SC B9 of the Olifants River system. This catchment falls predominately in the Kruger National Park. There are no major dams in the Shingwedzi catchment due to the limited water resources and unsuitable dam sites. Rural water schemes that operate in this catchment includes North and South Malamulele East RWS, which has its source as the Malamulele weir, Xikundo Weir and Minga Weir in the Luvuvhu River. Parts of the Middle Letaba RWS, Malamulele West, Giyani sub-systems F1 & F2 are located partly within the Shingwedzi catchment, currently receiving water from the Middle Letaba – Nsami sub-system. Water for a small irrigation area in the Maphophe Community is sourced from the Makuleke Dam on the Mphongolo River, a tributary of the Shingwedzi River.

6.1.2.3 Dams and bulk water infrastructure

Major dams are mainly located within the higher rainfall regions of the study area (Figure 6-1). These dams were constructed to supply irrigation and larger towns. The characteristics of the major dams, including the historic firm yield (HFY) are provided in Table 6-1.

Table 6-1. Characteristics of the major dams in the study area

Dam	Catchment	Quaternary	MAR(1) (Million M^3/A)	FSC (Million M^3)	HFY(2,3) (Million M^3/A)
Donkerpoort	Mogalakwena	A61A	5.3	2.4	1.44
Doorndraai		A61H	38.1	44.2	9.64
Glen Alpine		A62J	204.0	18.9	7.09
Turfloop	Sand	A71B	0.6	3.3	0.01
Houtrivier		A71E	0.4	7.5	0.06
Nzhelele	Nzhelele	A80C	73.4	51.2	16.81
Mutshedzi		A80A	15.5	2.2	1.98
Luphephe		A80H	21.4	14.8	6.87
Ṅwaneḓi		A80H	9.5	5.3	1.54
Albasini	Luvuvhu	A91B	14.56	28.2	5.0
Vonḓo	Mutshinduḓi	A91G	132.75	30.45	16.8
Ṋanḓoni	Luvuvhu	A91F	30.82	116.2	62.0 (5)
Lake Fundudzi	Mutale	A92A	114.92	21.5	
Makuleke	Shingwedzi	B90B	10.08	13.0	0.1
Ḓamani/Mvuwe	Mbwedi	A91G	132.75	12.9	4.8
Mambedi	Luvuvhu	A91C	57.72	4.5	
Mukumbani	Mutale	A92A	114.92	3.9	
Tshakuma	Latonyanda	A91D	48.12	2.47	1.4
Phiphidi	Mutshinduḓi	A91G	132.75	0.19	0.2

Notes:
(1) MAR simulated in the WRSM2000 model with active groundwater abstractions.
(2) HFY based on analysis of 91 years from the 1920 to the 2010 hydrological years.
(3) Yields are before meeting EWR water requirements.
(4) MAR based on WRSM2012 model for the 1920 to the 2009 hydrological years
(5) System yield of Ṋanḓoni without EWR

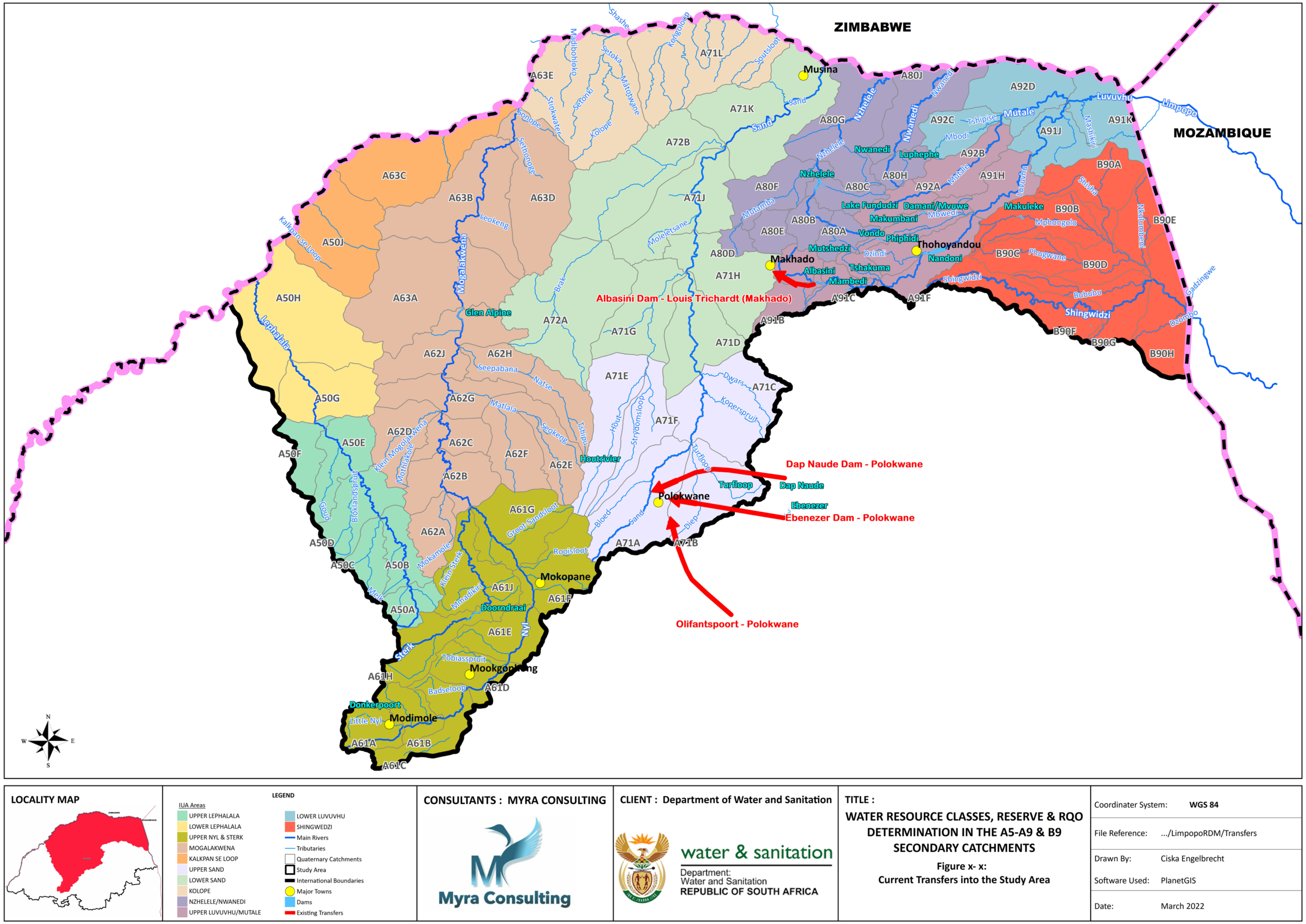


Figure 6-1. Dams and transfers into the study are

The Donkerpoort Dam is a small dam in the upper Mogalakwena catchment. It was initially constructed to supply Modimolle, however due to the high water tariff for use from the dam compared to the Roodeplaat Dam Transfer Scheme, water use has reduced, resulting in the dam being under-utilised.

The Doorndraai Dam supplies the Mokopane LM and downstream irrigation; however, the Lepelle Northern Water has bought some of the irrigation allocation from the Dam in 1990. Mining companies such as Lonmin Mine has bought the remainder of the irrigation allocation as no growth in irrigation water requirements from the Dam has taken place and several irrigation farmers have switched to game farming in the recent years.

The Glen Alpine Dam was constructed to supply irrigation water requirements via releases from the dam into the river. No canal nor formal conveyance system exists downstream of the dam and it is estimated that 78% of the water released from the dam is lost. Additional to the irrigation allocation, there is an allocation for distribution losses of 5.67 million m^3/a. Downstream irrigators were allowed to construct storage weirs up to a set capacity.

The Turfloop and Houtrivier dams are small dams located in the Sand catchment that supply mainly rural requirements. The Houtrivier Dam supplies the Houtrivier Regional Water Supply Scheme, located just north of Polokwane. The yield and subsequent use from the Turfloop Dam is almost neglible.

The Mutshedzi Dam was built for the purpose of supplying domestic water o the surrounding communities in the vicinity of Makhado Town. There is a release from the dam for run-off -river irrigation abstractions, however according to the Government Gazette, 16 September 2016 (DWS, 2016) the total irrigation from Mutshedzi Dam is 5.65 million m3/a for domestic purposes only. This is less than the available yield from the dam.

The Nzhelele Dam as well as the Ṅwaneḓi and Luphephe twin dams in the Nzhelele catchment was constructed to mainly supply irrigation. The Nzhelele Dam is over-allocated. Weirs constructed downstream of Nzhelele Dam are used to abstract water released from the dam for irrigation purposes. There is significant water losses due to illegal connections, aged infrastructure and reticulations leaks. Approximately 60% of the water released from the Dam is lost along the Nzhelele Canal.

The Ṅwaneḓi and Luphephe twin dams are situated inside the Nwanedi Nature Reserve, at the confluence of the Nwanedi and Luphephe rivers. These dams mainly provide water for wildlife and irrigation. Water is released from the dam into a canal system which distributes the water to the irrigators. The Cross Dam situated downstream of these dams is primarily used as a balancing dam to regulate the water releases for irrigators downstream. There is a pipeline from the dams which supplies the limited domestic water requirements of a camp in the Nwanedi Nature Reserve. The allocations from these dams are significantly more than the available combined yield of the dams. Nevertheless, a licence to supply 1.135 million m3/a to the domestic water requirements of the Luphephe Nwanedi Regional Water Scheme have recently been granted.

The Ṋanḓoni Dam and Xikundu Weir together with the existing Albasini, Vonḓo, Phiphidi and Tshakhuma Dams and the associated bulk purified water supply are known as the Luvuvhu River

Government Water Scheme. The scheme is managed as an integrated system to supply water for domestic/industrial, irrigation and for the ecological component of the Reserve. Current planning is that the Ṋanḓoni system will in future supply partly or fully a large number of Rural Water Supply Schemes (RWSS). Ḓamani. Mambedi and Frank Ravelle dams are also part of the Luvuvhu River system, but are used to supply local water requirements and are therefore managed independently. The Mambedi Dam was severe damaged during a flood event and is no longer in use.

The Xikundu/Malamulele sub-system consists of three weirs and respective water works, which are the Mhinga Weir and Treatment Works, Malamulele Weir and Treatment Works and Xikundu Weir and Treatment Works. The sub-system covers the Tshifundi RWS, Lambani RWS, North Malamulele East RWS and South Malamulele East RWS.

Significant irrigation developments from surface and groundwater upstream of Albasini Dam resulted in a decrease in the yield available from the Albasini Dam. The irrigation scheme downstream of the Dam is seldomly supplied with water from the dam and the dam struggles for meet the urban/industrial demand of Makhado.

There are no major dams in the Shingwedzi, due to the limited water resources and the non-availability of suitable dam sites. Some small dams have, however been constructed in the Kruger National Park for game watering. The most notable of these is the Kanniedood Dam on the Shingwedzi River. Water for a small area of irrigation is sourced from the Makuleke Dam on the Mphongolo River a tributary of the Shingwedzi River.

The water resources in the Mutale catchment are underdeveloped with limited storage structures in the catchment. The Mukumbani Dam is located in the upper reaches of the Tshirovha River and supplies water to the Mukumbani Tea Estate is the only dam in the catchment. The Vondo North Rural RWS and the Ḓamani RWS are both partly located in the Mutale catchment are supplied with water from Vonḓo and Ḓamani Dams respectively, which are both located in the Luvuvhu River catchment. The remainder of the Rural Water Supply Schemes are supplied from Mutale surface (50%) and groundwater resources (50%). Some irrigation did exist in the past, however it is not certain how much irrigation is still practiced.

A summary of the major users and allocations from the dams are provided in Table 6-2.

Table 6-2. Major water users and allocations from the dams in the study area

DAM	MAJOR USERS	CURRENT ALLOCATIONS (million m^3/a)
Donkerpoort	Modimolle	0.9
Doorndraai	Mokopane	4.4

DAM	MAJOR USERS	CURRENT ALLOCATIONS (million m^3/a)
	Irrigation Mines	3.7 0.0
Glen Alpine	Irrigation	7.3 (+5.65 for losses)
Houtrivier	Rural villages	0.1
Seshego	Seshego	1.3
Nzhelele	Irrigation Tshipise Holiday Resort	29.0 0.5
Mutshedzi	Makhado Town Irrigation	3.6 (1) 1.4
Ṅwaneḓi	Irrigation	7.23
Luphephe	Irrigation	15.37
Albasini	Domestic and Irrigation	15.6
Vonḓo (2)	Domestic and Irrigation	14.2
Ṋanḓoni	Domestic	23.51
Lake Fundudzi	No use. Natural Lake	N/A
Makuleke	Domestic and Irrigation	
Ḓamani/Mvuwe	Domestic (historically irrigation)	3.4
Mambedi	Irrigation	No
Mukumbani	Irrigation?	
Tshakuma	Domestic	1.4
Phiphidi	Domestic	Incl in Vonḓo Dam

Note:

(1) Government Gazette of 16 September 2016: Only domestic allocation of 5.65 million m^3/a
(2) Includes releases from Phiphidi Dam

Diffuse water resources in the study area refer to other small storage dams and river abstractions that contribute to the yield of the system. A significant number of small dams are located with the study area, of which the majority are small storage dams used as a source of water for irrigation, stock watering and game farming, as well as for recreational purposes. Farmers and some rural communities' also abstract water directly from rivers. Table 6-3 summarises the diffuse water resources and availability in the study area.

Table 6-3. Summary of diffuse water resources

CATCHMENT	FSC (million m^3)	AVAILABLE SUPPLY FROM DAMS AND RUN-OFF RIVER (million m^3/a)
Lephalala	18.3	46.5
Mogalakwena	59.1	39.9
Sand(1)	44.2	56.3

Nzhelele	2.5	15.9
Luvuvhu	113.5	

Note: (1) This includes an allocation of 10.96 million m^3/a from the sand aquifers along the Limpopo River near Musina

6.1.3 Transfers into the study area

Due to the arid nature of the study area and the limited surface water available, a number of transfers from neighbouring catchments and WMAs into the study area exist. Figure 6-1 provides the transfers into the study area. No transfers are made from the study area to other catchments or WMAs. Table 6-4 provides a summary of the transfers into the study area.

Table 6-4. Summary of existing water transfer schemes

TRANSFER SCHEME	SOURCE CATCHMENT	RECIPIENT CATCHMENT	VOLUME ALLOCATED/AGREED @ 2010 (million m^3/a)
Ebenezer Dam - Polokwane	Luvuvhu and Letaba	Sand River	12.00(1)
Dap Naude Dam – Polokwane	Luvuvhu and Letaba	Sand River	6.53
Olifantspoort Weir – Polokwane	Olifants	Sand River	11.30(2)
Albasini Dam – Louis Trichardt	Luvuvhu and Letaba	Sand River	2.40
Roodeplaat Dam - Modimolle	Crocodile West	Mogalakwena	1.93
Total Current Transfers			34.16
Klipvoor-Modimolle and Mookgopong	Crocodile West	Mogalakwena	6.6
ORWRDP: Flag Boshielo-Mokopane	Olifants	Mogalakwena	50.0
Glen Alpine – Molemole West	Sand	Sand	0.6 - 22
Additional water via the Olifantspoort WMA	Olifants	Sand	17.3 – 26.2
Ṋanḓoni – Matoks pipeline	Luvuvhu and Letaba	Sand	4.66 – 5.5
Ṋanḓoni – Louis Trichardt	Luvuvhu and Letaba	Sand	5.5 – 8.5

Note: (1) The allocation has been increased to 16.2 million m^3/a from 2016.
(2) Refers only to the water transferred to the portion of the Polokwane LM located in the study area, the total allocation is 14.6 million m^3/a.

6.1.4 Water Users

A summary of the water users in each quaternary catchment (base water use taken at the 2012-development) is provided in Table 6-5.

Table 6-5. Summary of water users in each quaternary catchment

QUAT	IAP		FOREST		IRRIGATION		DOMESTIC & INDUSTRY	LARGE DAMS	FARM DAMS
	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Dem (Mm3/a)	Dem (Mm3/a)	FSC (Mm3)	FSC (Mm3)
A50A	3.9	0.37	-	-	12.31	8.43	-		4.66
A50B	0.77	0.07	-	-	1.82	1.33	-		1.5
A50C	7.9	0.75	-	-	2.12	1.31	-		1.56
A50D	-	-	-	-	-	-	-		0.84
A50E	-	-	-	-	12.9	10.83	-		2.6
A50F	-	-	-	-	0.32	0.29	-		0.32
A50G	-	-	-	-	1.9	1.62	-		0.18
A50H	-	-	-	-	15.41	14.68	-		3.39
A50J	-	-	-	-	-	-	-		3.29
A61A	5.6	0.17	-	-	2.97	2.06	2.05	2.4	1.07
A61B	5.65	0.17	-	-	0.37	0.25	0.87		0.42
A61C	7.93	0.25	-	-	2.07	1.3	-		1.03
A61D	2.65	0.08	-	-	0.26	0.17	0.49		0.4
A61E	-		-	-	0.06	0.05	0.41		0.94
A61F	39.34	1.23	-	-	0.57	0.22	3.25	5.14	2.36
A61G	8.82	0.27	-	-	0.78	0.49	0.14		4
A61H	3.37	0.11	-	-	22.36	14.92	-	46.22	12.17
A61J	5.98	0.19	-	-	11.55	5.22	0.58	6.81	6.22
A62A	2.53	0.08	-	-	2.42	2.12	-		1.75
A62B	-		-	-	-	-	-		0.02
A62C	-		-	-	-	-	-		-
A62D	-		-	-	-	-	-		0.66
A62E	1.03	0.03	-	-	-	-	0.13		-
A62F	-		-	-	0.24	0.15	-		0.39
A62G	-		-	-	-	-	-		-
A62H	-		-	-	-	-	-		-
A62J	-		-	-	-	-	-	18.89	15.95
A62K	-		-	-	-	-	-		-
									1.23
A63A	-		-	-	1.49	1.28	-		0.16
A63B	-		-	-	3.85	2.68	-		1.23
A63C	-		-	-	-	-	-		2.67
A63D	-		-	-	2.22	2.41	-		0.59
A63E	-		-	-	-	-			7.07

QUAT	IAP		FOREST		IRRIGATION		DOMESTIC & INDUSTRY	LARGE DAMS	FARM DAMS
	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Dem (Mm3/a)	Dem (Mm3/a)	FSC (Mm3)	FSC (Mm3)
A71A	20.13	0.15	-	-	2.66	2.04	-	2.6	4.71
A71B	14.46	0.11	-	-	-	-	-	3.3	-
A71C	56.71	0.42	0.96	0.01	2.88	2.01	-		9.82
A71D	5.21	0.04	-	-	0.33	0.22	-		0.21
A71E	15.77	0.12	-	-	0.41	0.14	0.29	15.74	1.98
A71F	2.3	0.02	-	-	0.98	0.37	-		4.55
A71G	3.57	0.03	-	-	0.68	0.34	-		1.69
A71H	16.16	0.12	8.15	0.77	0.47	0.25	-		3.8
A71J	-		-	-	4.51	3.3	-		0.32
A71K	-		-	-	0.55	0.51	-	1.32	9.5
A71L	-		-	-	-	-	-		-
A72A	-	-	-	-	1	0.55	-		1.68
A72B	-	-	-	-	0.4	0.22	-		-
A80A	-	-	17.61	1.8	-	-	1.34	2.16	0.09
A80B	3.73	0.13	1.42	0.15	0.78	0.38	0.96		0.11
A80C	3.89	0.14	-	-	-	-	0.19	51.23	-
A80D	-	-	0.18	0.02	0.27	0.09	-		0.05
A80E	9.74	0.35	0.09	0.01	0.13	0.08	0.34		0.02
A80F	-	-	-	-	5.58	4	0.11		-
A80G	15.85	0.56	-	-	19.94	14.9	0.18		2.17
A80H	25.79	0.92	-	-	-	-	1.55	20.11	-
A80J	-	-	-	-	-	-	-	2.6	0.03
A91A	6.2	0.6	39.4	3.7	5.3	4.9	1.9	-	0.17
A91B	2.9	0.1	1.6	0.1	2.9	2.9	-	3.5	1.66
A91C	-	-	26.7	4.5	19.3	17	-	-	1.79
A91D	-	-	39.6	7.6	9.3	6.7	1.4	0.4	0.5
A91E	-	-	8.6	1.7	-	-		1.7	0.17
A91F	-	-	-	-	3.4	3.2	3.5	166.1	0.16
A91G	6.3	1.1	22.9	2.4	-	-	17.7	31	0.43
A91H	-	-	0.8	0	-	-	3.9	-	0.13
A91J	-	-	-	-	-	-	-	-	0.02
A91K	-	-	-	-	-	-	-	-	-

QUAT	IAP		FOREST		IRRIGATION		DOMESTIC & INDUSTRY	LARGE DAMS	FARM DAMS
	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Red (Mm^3/a)	Area (Km2)	Dem (Mm3/a)	Dem (Mm3/a)	FSC (Mm3)	FSC (Mm3)
A92A	-	-	23.2	4.4	-	-	2.2	2.2	0.02
A92B	-	-	-	-	-	-	-	-	-
A92C	-	-	-	-	-	-	-	-	0.78
A92D	-	-	-	-	-	-	-	-	0.3
B90A	-	-	-	-	-	-	-		-
B90B	-	-	-	-	-	-	-	2.2	2.38
B90C	-	-	-	-	-	-	-	0.9	0.9
B90D	-	-	-	-	-	-	-	-	-
B90E	-	-	-	-	-	-	-	-	-
B90F	-	-	-	-	-	-	-	-	2.18
B90G	-	-	-	-	-	-	-	-	0.67
B90H	-	-	-	-	-	-	-	-	1.31

6.1.5 Potential developments

No significant growth is expected in the irrigation water requirements due to the stressed water resources and subsequent low assurance of supply in the irrigation sector. Many farmers are converting to game farming. The mining and industrial sectors are shown to be the largest growing sectors in terms of water requirements. Associated with the growth in the industrial and mining water requirements, it is expected that the domestic water requirements will also increase.

A summary of the potential developments and proposed intervention measures that will impact on the current water resource situation are outlined below.

Lephalala catchment

There are no significant developments expected in the Lephalala catchment due to the limited water available and the high conservation importance of the Wilderness area in the middle reaches of the catchment.

Mogalakwena catchment

Developments in the catchment expected to increase water requirements include:

- Platinum mining activities – Several possible new platinum mines were identified in the Mokopane area which is considered to be the platinum growth point of the Limpopo Province.
- Other mining activities – Possible new nickel, vanadium, and iron ore mines north of Mokopane have been identified.

- Increased domestic water requirements – Domestic water requirements in the Mokopane area (including the Mogalakwena and Aganang LMs) will increase significantly due to possible future mining activities.

Most of the new mines and additional water requirements in the Mogalakwena and Aganang LMs will be supplied by the ORWRDP-2B and 2G.

The main interventions considered for the Mogalakwena catchment besides Water Conservation and Demand Management (WC/WDM) include:

- Reinstatement of the Polokwane effluent transfer to Mogalakwena Platinum Mine.
- Bought over irrigation allocation from Doorndraai Dam.
- The Magalies Water (Klipvoor Dam) transfer.
- Additional effluent is transferred from Polokwane to the Mogalakwena catchment.
- The ORWRDP - 2B and 2G.

Sand catchment

The catchment has a high coal mining potential, which will significantly increase the water requirements of the catchment if developed. The overall water requirements of the catchment can be met, however water resource intervention measures may be required in the economic focus areas of Polokwane LM, Makhado LM and Musina LM.

Polokwane LM: Intervention options, besides WC/WDM, include:

- Augmenting supply to Polokwane LM from the Olifants WMA - investigated as part of the Olifants River Water Resources Development Project (ORWRDP).
- Re-use of effluent to be generated by the new Polokwane Regional WwTW.
- Rehabilitation of groundwater resources.

Makhado LM: Interventions identified include the following:

- Re-use of effluent from Louis Trichardt.
- The Ṋanḓoni Dam transfer to Louis Trichardt.
- Bought over irrigation allocation from Nzhelele Dam.
- The Nzhelele Valley Bulk Water Supply Scheme, which includes:
  - Groundwater development.
  - Augmenting supply from Nzhelele Dam by raising the dam and providing the additional infrastructure.
  - Augmenting supply from Mutshedzi Dam by raising the dam, upgrading the WwTW and providing the additional infrastructure.
  - Augmenting supply from the Vonḓo Dam scheme.

In terms of the Nzhelele Valley Bulk Water Supply Scheme, water supplied to the Thohoyandou area from the Vonḓo Dam will be replaced by water from the Ṋanḓoni Dam in future. It was suggested that the available water from Vonḓo Dam be transferred to the Nzhelele Valley area by 2019. The time, however, for which the surplus water from Vonḓo Dam is available is only five years before the water will be utilised by other users in the Luvuvhu and Letaba catchment. Further investigation is also required to determine if the Mutshedzi Dam can be raised and if so, what the additional available water will be. Considering the current storage capacity and yield available from the Mutshedzi Dam, it is highly unlikely that 10 million m3/a will be additionally available. Based on the water balance the Nzhelele Valley Bulk Water Supply Scheme should only be implemented by 2029 and not by 2019 as initially planned.

Musina and environs: The water requirements in the Musina area are expected to increase significantly due to the development of the LEIP and SEZ. Due to the close proximity of the LEIP, SEZ and Musina town it is proposed that a holistic approach is followed when identifying possible water sources. It is anticipated that the LEIP will require 23 million m3/a by 2022 when in full operation and will be operated on a zero-liquid discharge basis. The developers of LEIP are negotiating the upgrade of the Musina WwTW to enable re-use of treated effluent. To top up the system, approximately 18 million m3/a is required and options to supply this top up water include a 20 to 23 million m3/a abstraction from the Limpopo River via an infiltration gallery system over three months per year, which is then pumped to off-channel dams with a combined capacity of 17 million m3. The water requirements for the SEZ is not currently available.

<u>Nzhelele catchment</u>

It seems that the available water will be able to meet the water requirements up to 2040. However, the following should be noted as it affects the availability of the water resource:

- Nzhelele catchment is plagued by a significant number of opportunistic users that have built weirs and canals from local streams to supply subsistence irrigation or domestic water requirements, which has reduced the available streamflow to other users and supply sources.
- Losses from the Nzhelele Dam are significant and the assurance of supply is very low.
- The allocation from the Ṅwaneḓi and Luphephe twin dams, exceeds the available yield, and
- Water availability from the Nzhelele Bulk Water Supply Scheme is uncertain.

<u>Luvuvhu catchment</u>

The Luvuvhu system comprises several sub-systems of which some are currently linked. Ṋanḓoni Dam is the largest storage dam in the system and will support almost all the sub-systems within, as well as some located outside the Luvuvhu catchment.

The main water resources forming part of this integrated system are Ṋanḓoni Dam and the weirs downstream of Ṋanḓoni Dam, Vonḓo, Phiphidi and Tshakuma dams, with support from two run off river abstractions and related package plants at Dzindi and Dzingae, as well as groundwater abstractions. The Greater Thohoyandou yield refers to the combined system yield from Vonḓo, Phiphidi and Tshakuma dams as well as the two package plants. Deficits are expected to occur in this system from 2031 onwards. By then a dam in the Mutale River is an option that was identified for possible future support. Another possibility is to better utilise the incremental flow downstream of Ṋanḓoni Dam by increasing the abstractions from the existing downstream weirs as well as increase the weir capacities and the implementation of real-time monitoring. Possibilities for new dams in the catchment include the Paswane Dam (90.0 million m3 FSC) on the Mutshinduḓi River and the Xikundu Dam (139.0 million m3 FSC) on the Luvuvhu River.

Mutale catchment

A significant portion of the rural domestic water requirement (at 2010 development level) is supplied from sources with a non-firm yield and an unacceptable low level of assurance. Medium to long term intervention measures include the possible Rambuda Dam (13.5 million m^3 FSC) and the Tswere Dam (131 million m^3 FSC), the combined yield which will be provided more than the 2040 urban rural domestic requirement, including the current irrigation. A possible new dam on the Lower Mutale, Thengwe Dam (116 million m^3 FSC) is proposed to specifically satisfy mining demands.

Shingwedzi catchment

Transfer of water from the Luvuvhu to Shingwedzi is anticipated to cater for future developments.

6.1.6 Hydrology

The two recent hydrological studies that cover the study area (the AECOM, 2015 and WRP, 2014 studies) consisted of historical configurations that were used for calibration. A separate configuration is available for each of the river basins. The historical configurations were then adapted to create a natural and current-day configuration. Each configuration was checked by stepping through each operation and performing a mass balance.

Several improvements were undertaken and are summarized under the following points.

- Introduced demands on large dams where they were missing (such as Ṋanḓoni Dam). This information was obtained from the WR2012 Model.
- Replaced observed releases with modelled flows (for instance, the model was configured to use measured releases below Doorndraai Dam).
- Added in major tributaries in correct sequence (e.g. A92D did not flow into A91K)
- Fragmented the configurations to generate flows at each quaternary outlet (e.g. Moved A72B flow to below A72A).

The configurations reflect the status quo of the hydrological models. Figure 6-2 shows the main river basins and quaternary catchment locations that is the basic architecture of the hydrological model. The hydrological models were then used to summarise the natural and current day mean annual runoff (MAR) at each quaternary outlet (Table 6-6).

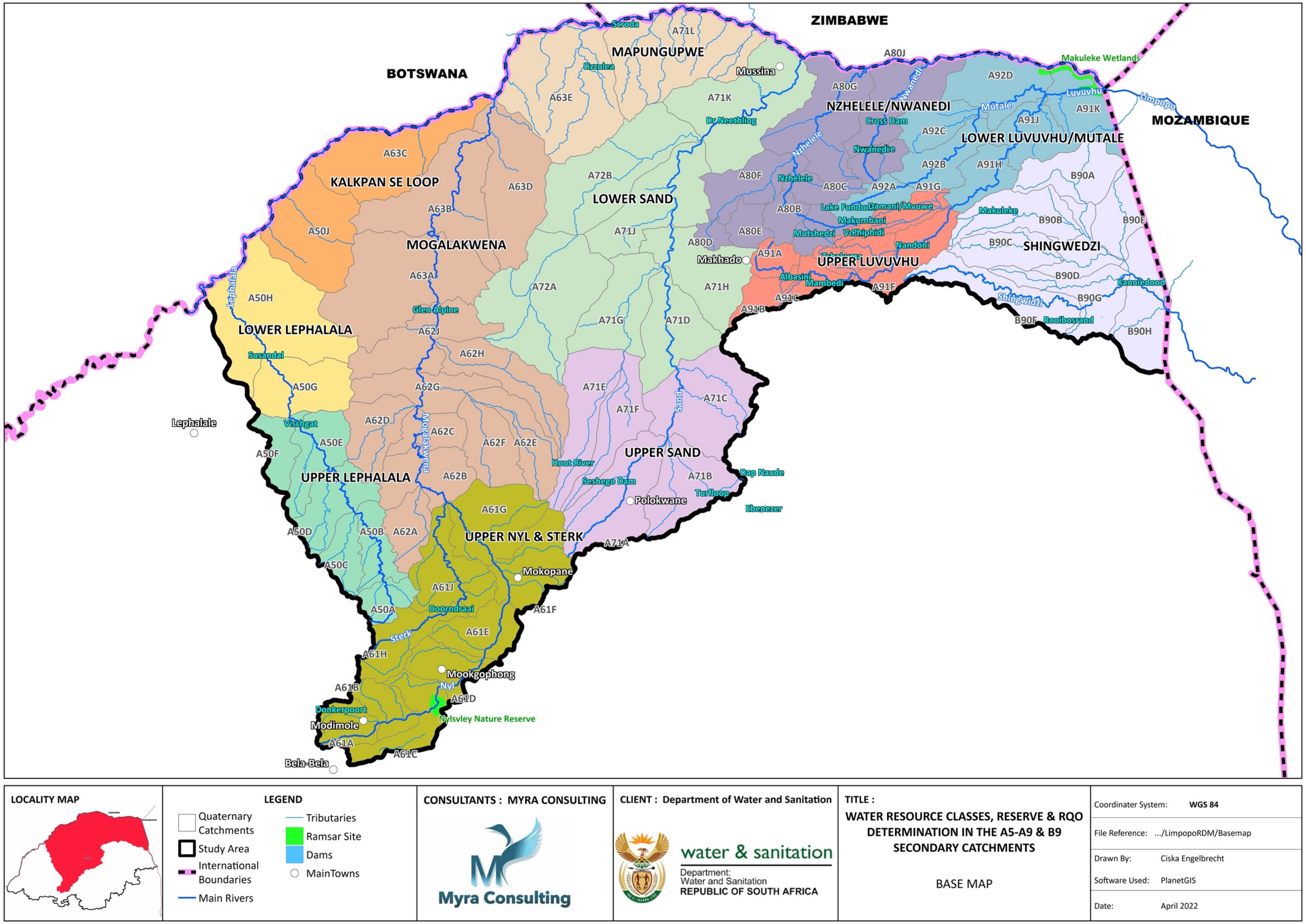


Figure 6-2. Basic architecture of the hydrological model

Table 6-6. Hydrological model output summarising natural and current day mean annual flows (Mm3) at quaternary catchment outlets in the study area

QUAT No.	NATURAL (Mm^3)	CURRENT DAY (Mm^3)	QUAT No.	NATURA L (Mm^3)	CURRENT DAY (Mm^3)	QUAT No.	NATURAL (Mm^3)	CURRENT DAY (Mm^3)
A50A	32.3	22.7	A61A	0.4	0.2	A62A	14.2	11.6
A50B	67.1	55.3	A61B	21.9	20.5	A62B	157.3	95.0
A50C	81.8	67.4	A61C	17.1	13.7	A62C	161.4	97.5
A50D	102.1	87.1	A61D	25.6	19.3	A62D	4.5	3.4
A50E	121.1	94.9	A61E	32.5	23.8	A62E	3.7	3.3
A50F	130.6	103.8	A61F	52.0	36.0	A62F	4.7	3.7
A50G	134.7	107.4	A61G	71.9	52.3	A62G	176.9	109.9
A50H	136.6	94.0	A61H	39.9	10.4	A62H	4.1	3.6
A50J	4.8	3.6	A61J	59.5	21.1	A62J	185.6	104.3
A63A	191.9	109.5	A71A	10.3	28.0			
A63B	196.0	110.0	A71B	7.3	8.2	A91A	21.6	7.2
A63C	3.0	2.4	A71C	25.7	42.4	A91B	32.4	12.5
A63D	198.3	111.2	A71D	25.7	42.9	A91C	73.4	20.8
A63E	3.5	1.9	A71E	3.7	1.9	A91D	64.4	47.5
			A71F	6.0	2.8	A91E	69.4	66.1
A80A	49.4	43.0	A71G	10.1	4.6	A91F	254.0	159.6
A80B	66.0	58.3	A71H	47.1	56.8	A91G	128.8	106.4
A80C	75.7	42.1	A71J	63.3	70.1	A91H	409.7	289.2
A80D	7.0	6.8	A71K	90.4	92.2	A91J	415.9	295.5
A80E	14.1	13.1	A71L	7.5	5.9	A91K	574.6	442.8
A80F	99.7	65.9						
A80G	105.4	77.6	A72A	11.3	11.3	A92A	105.5	94.5
A80H	32.2	26.9	A72B	17.3	17.0	A92B	150.3	138.8
A80J	34.6	28.4				A92C	4.6	4.5
						A92D	155.5	144.1
B90A	7.2	7.2	B90D	34.0	31.2			
B90B	11.9	9.3	B90E	5.9	5.9	B90G	34.6	33.9
B90C	9.0	9.0	B90F	19.1	18.6	B90H	91.3	87.5

The detailed checking and correction of the existing hydrological configurations have identified several issues, summarised below, that must be rectified.

1) Replace catchment areas with the appropriate area. In most configurations the most downstream quaternary catchment area is the full quaternary catchment. This should be the catchment relevant to the main river and not include small tributaries flowing directly into the Limpopo River.
2) Include the catchment that crosses the South African border (in B90 the configurations only include the catchment on the South African side). This affects B90E and B90H.

3) Investigate and potentially rectify the many farm dams with no demands. These would either be livestock or domestic demands (for example, in quaternary catchment B90F there is an on-channel dam of 2.18 Mm^3 with no demand, but it is located near townships and is likely a domestic supply).
4) Improve on the simulation of the wetlands in A61A to A61E (Nysvlei). Currently simulated using a reservoir with a large surface area and practically zero outflow. Should be using the comprehensive wetland module.
5) Recalibrate the models paying more attention to low flows. Of particular concern is the Sand River (A71) where the model output has elevated low flows because of modelled return flows and has no periods of zero flow. Also, in order to correctly simulate the Nysvlei wetland the outflow from wetlands should be measured.

If the model is to achieve a high level of accuracy than immediate flow measurement (using a flow meter) at selected locations should take place. It is still possible to obtain an indication of the nature of wet season flow recession into the dry season which can be used to improve model output.

In addition to the issues mentioned above, there are two additional tasks that must be undertaken.

1) Extend the hydrology from 2010 to the 2021 hydro year using the CHIRPS database. This would also include extending all the current-day water-use demands assuming that current day demands have not increased during this extension period.
2) Further work is also required to fragment the model to sites of interest (where EWR nodes that are not located at quaternary catchment outlets).

6.2 Rivers

6.2.1 Approach

Several tiers (Classification process, DWAF, 2007) were utilised, as described in Section 4.1 when identifying river resource units. In addition to this, additional layers were added, including Freshwater Ecosystem Protection Areas (FEPAs) as they relate to areas of conservation importance, as well as Strategic Water Source Areas (Le Maitre et al., 2019). Ecological condition per sub-quaternary reach, allocated an Ecological Category (DWS, 2014), as indicated in Table 6-7 below, are used to give an indication of the status quo of the rivers within the study area. The national PES dataset (DWS, 2014) describes the ecological condition of the river per sub-quaternary reach, describing a range of bio-physical data including fish, macroinvertebrates, instream habitat and riparian vegetation. In addition, the EI and ES are also used to give an indication of the status quo per resource unit (DWS, 2014). Various historic and recent biotic data was sourced, including the REMP (River Ecostatus Monitoring Programme) data (C. Thirion, *Pers. Comm.*, March 2022) and used where relevant, when assessing the status quo of the rivers in the study area.

Resource Units were derived by utilizing information including flow (perennial versus non-perennial), geomorphological zonation and adjacent vegetation type. Refer to Section 4.1.2.

Table 6-7. Generic table for Ecological Integrity Categories (modified from Kleynhans 1996 & Kleynhans 1999)

ECOLOGICAL CATEGORY	GENERIC DESCRIPTION OF ECOLOGICAL CONDITIONS	GUIDELINE SCORE (% OF MAXIMUM THEORETICAL TOTAL)
A	**Unmodified/natural.** Close to natural or close to predevelopment conditions within the natural variability of the system drivers: hydrology, physico-chemical and geomorphology. The habitat template and biological components can be considered close to natural or to pre-development conditions. The resilience of the system has not been compromised.	>92 - 100
A/B	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.	>88 - ≤92
B	**Largely natural with few modifications**. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged.	>82 - ≤88
B/C	Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category.	>78 - ≤82
C	**Moderately modified.** Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The resilience of the system to recover from human impacts has not been lost and it is ability to recover to a moderately modified condition following disturbance has been maintained.	>62 - ≤78

C/D	**The system is in a close to moderately modified condition most of the time.** Conditions may rarely and temporarily decrease below the upper boundary of a D category.	>58 - ≤62
D	**Largely modified.** A large change or loss of natural habitat, biota and basic ecosystem functions have occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained.	>42 -≤58
D/E	**The system is in a close to largely modified condition most of the time.** Conditions may rarely and temporarily decrease below the upper boundary of an E category. The resilience of the system is often under severe stress and may be lost permanently if adverse impacts continue.	>38 - ≤42
E	**Seriously modified.** The change in the natural habitat template, biota and basic ecosystem functions are extensive. Only resilient biota may survive and it is highly likely that invasive and problem (pest) species may dominate. The resilience of the system is severely compromised as is the capacity to provide Ecosystem Services. However, geomorphological conditions are largely intact but extensive restoration may be required to improve the system's hydrology and physico-chemical conditions.	20 - ≤38
F	**Critically / Extremely modified.** Modifications have reached a critical level and the system has been modified completely with an almost complete change of the natural habitat template, biota and basic ecosystem functions. Ecosystem Services have largely been lost This is likely to include severe catchment changes as well as hydrological, physico-chemical and geomorphological changes. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible. Restoration of the system to a synthetic but sustainable condition acceptable for human purposes and to limit downstream impacts is the only option.	<20

6.2.2 Description

6.2.2.1 Upper Lephalala IUA

The Upper Lephalala River traverses the Waterberg Level I Ecoregion at its source and in its mid-sections. At its source, the mainstem Lephalala River occurs within the Transitional geomorphological zone, moving into the Upper and Lower Foothills geomorphological zones in the mid-sections (Figure 6-4). Mountain Headwater Stream and Mountain Stream geomorphological zonation occur in the upper sections of some of the upper tributaries, including the Rietbokvleispruit, the Melk River and the Goud River. Some of the main tributaries include the Rietbokvleispruit, the Snyspruit, Melk River and the Goud River (DWS, 2014). The entire Lephalala catchment is situated mostly within the Central Bushveld Vegetation Bioregion and a very small portion of the upper catchment within the Mesic Highveld Grassland Vegetation Bioregion (Figure 6-5). The mainstem Lephalala River is perennial in nature, except for some of the tributaries in the upper reaches, including the Goud River as well as an unnamed tributary of the Melk River (Figure 6-3). Numerous conservation/protected areas occur in this IUA (Figure 6-12).

6.2.2.2 Lower Lephalala IUA

The Lower Lephalala IUA traverses the Limpopo Plain Level I Ecoregion, with Lowland River geomorphological zone in the downstream reaches before its confluence with the Limpopo River (Figure 6-4). The mainstem Lephalala River is perennial in nature in the Lower IUA. The lower Lephalala IUA occurs within the Central Bushveld Bioregion, with a very small section occurring within the Alluvial Vegetation Bioregion (Figure 6-5).

6.2.2.3 Kalkpan se Loop IUA

The rivers in this IUA are all non-perennial and occur within the Limpopo Plain Level I Ecoregion (DWS, 2014), with the Upper- and Lower Foothills geomorphological zonation present (Figure 6-4). The Central Bushveld Bioregion dominates this IUA, with very small portions of the IUA occurring within the Alluvial Vegetation Bioregion (Figure 6-5).

6.2.2.4 Upper Nyl & Sterk IUA

The source of the Mogalakwena River Catchment is situated in the Western Bankenveld Level I Ecoregion. The catchment traverses the Bushveld Basin Level I Ecoregion, with parts of the mid-catchment in the Eastern Bankenveld, Waterberg and Northern Plateau Ecoregions (Figure 6-3). The Nyl River system is situated in the upper reaches of the catchment. Some of the main tributaries in the IUA include the Little Nyl, Olifantspruit, Badseloop, Tobiasspruit and Sterk River. Mountain Headwater Stream and Mountain Stream geomorphological zonation occur in small sections in some of the upper tributaries, with the mainstem Mogalakwena River mostly comprising the Lower Foothills and Lowland River geomorphological zonation (Figure 6-4). Most of the IUA is situated within the Central Bushveld Vegetation Bioregion, with small sections of the catchment situated within the Mesic Highveld Grassland Vegetation Bioregion (Figure 6-5), as well as the Freshwater Wetlands Vegetation Bioregion. The Great Nyl, Little Nyl, Badseloop, Tobiasspruit and Sterkspruit, among others, are perennial in nature. Tributaries including the Dorps, Rooisloot and Olifantspruit are non-perennial (Figure 6-6).

6.2.2.5 Mogalakwena IUA

The Mogalakwena IUA traverses the Waterberg, Eastern Bankenveld, Northern Plateau and Limpopo Plain Level I Ecoregions, until the Mogalakwena River reaches its confluence with the Limpopo River (DWS, 2014). The mainstem Mogalakwena River comprises mostly Lower Foothills and Lowland River geomorphological zonation (Figure 6-4). Some of the larger tributaries include the Klein Mogalakwena River, Matlalane and Seepabana Rivers. The Mogalakwena and Seepabana rivers are perennial and the Matlala River non-perennial in nature. The Central Bushveld, Mopane and Alluvial Vegetation Bioregions dominate this IUA (Figure 6-5).

6.2.2.6 Mapungubwe IUA

This IUA consists of small tributaries that enter the Limpopo River directly, including the Soutsloot, Kongoloop, Kolope and Stinkwater Rivers, with some of the tributaries unnamed (DWS, 2014). These tributaries are all non-perennial. The Mapungubwe National Park is situated in this IUA (Figure 6-12). The geomorphological zonation of the rivers in this IUA consist only of Upper- and Lower Foothills (Figure 6-4).

6.2.2.7 Upper Sand IUA

The source of the Sand River is situated in the Eastern Bankenveld Level I Ecoregion. The mainstem and its tributaries traverse the Northern Plateau, North-eastern Highlands and the Limpopo Plain Level I Ecoregions. Main tributaries of the Sand River include Bloed River, Diep River, Turfloop River, Koperspruit and Dwars Rivers in this IUA. The mainstem Sand River and many of its tributaries are perennial in nature, with the Strydomsloop and Turfloop non-perennial. Mountain Headwater Stream and Mountain Stream geomorphological zonation occur in very small sections in the upper Sand, with the mainstem Sand River mostly comprising Upper- and Lower Foothills geomorphological zonation (Rowntree & Wadeson, 1999). Most of the Catchment is situated within the Central Bushveld Vegetation Bioregions, with small sections of the catchment situated within the Mesic Highveld Grassland (Figure 6-5).

6.2.2.8 Lower Sand IUA

Most of this IUA is situated within the Limpopo Plain Level I Ecoregion, with small sections in the Northern Plateau Ecoregion and sections of rivers passing through the Soutpansberg Level I Ecoregion. Some of the main tributaries include the Hout- and Brak Rivers, with the Hout and Moleletsane Rivers non-perennial in nature. The remainder of the catchment in this IUA is perennial. Very small sections of the Moleletsane River consists of Mountain Headwater and Mountain geomorphological zonation, as this river arises in the Soutpansberg Mountains. Most rivers in this IUA consist of Upper- and Lower Foothills geomorphological zonation (Figure 6-4). The Central Bushveld and Mopani Vegetation Bioregions are the dominant Bioregions in this IUA, with small sections of rivers occurring in the Alluvial, Mesic Highveld Grassland and Lowveld Vegetation Bioregions (Figure 6-5). Various conservation areas are found throughout this IUA (Figure 6-12).

6.2.2.9 Nzhelele/Nwanedi IUA

The source of the Nzhelele River occurs in the Soutpansberg Level I Ecoregion, with many of its tributaries also occurring in the Soutpansberg Ecoregion. The lower section of the Catchment is situated in the Limpopo Plain Level I Ecoregion. Tributaries include the Mutshedzi River, Mutamba River, Mufungudi and Tshishiru Rivers (DWS, 2014). In the upper sections of the Nzhelele and some of its tributaries, Mountain Headwater and Mountain Stream geomorphological zonation occur, with the mid- to lower sections of the catchment dominated by the Upper- and Lower Foothill geomorphological zonation (Figure 6-4). The Nzhelele mainstem is perennial, except for the upper section upstream of the confluence with the Mutshedzi River. The Mutamba River is also perennial, with the remainder of the tributaries non-perennial in nature. The Catchment is dominated by the Central Bushveld and Mopane Vegetation Bioregions, with very small sections occurring in the Mesic Highveld Grassland, Zonal and Intrazonal Forests Vegetation Bioregions (Figure 6-5). Conservation areas are situated mostly in the lower section of the IUA (Figure 6-12).

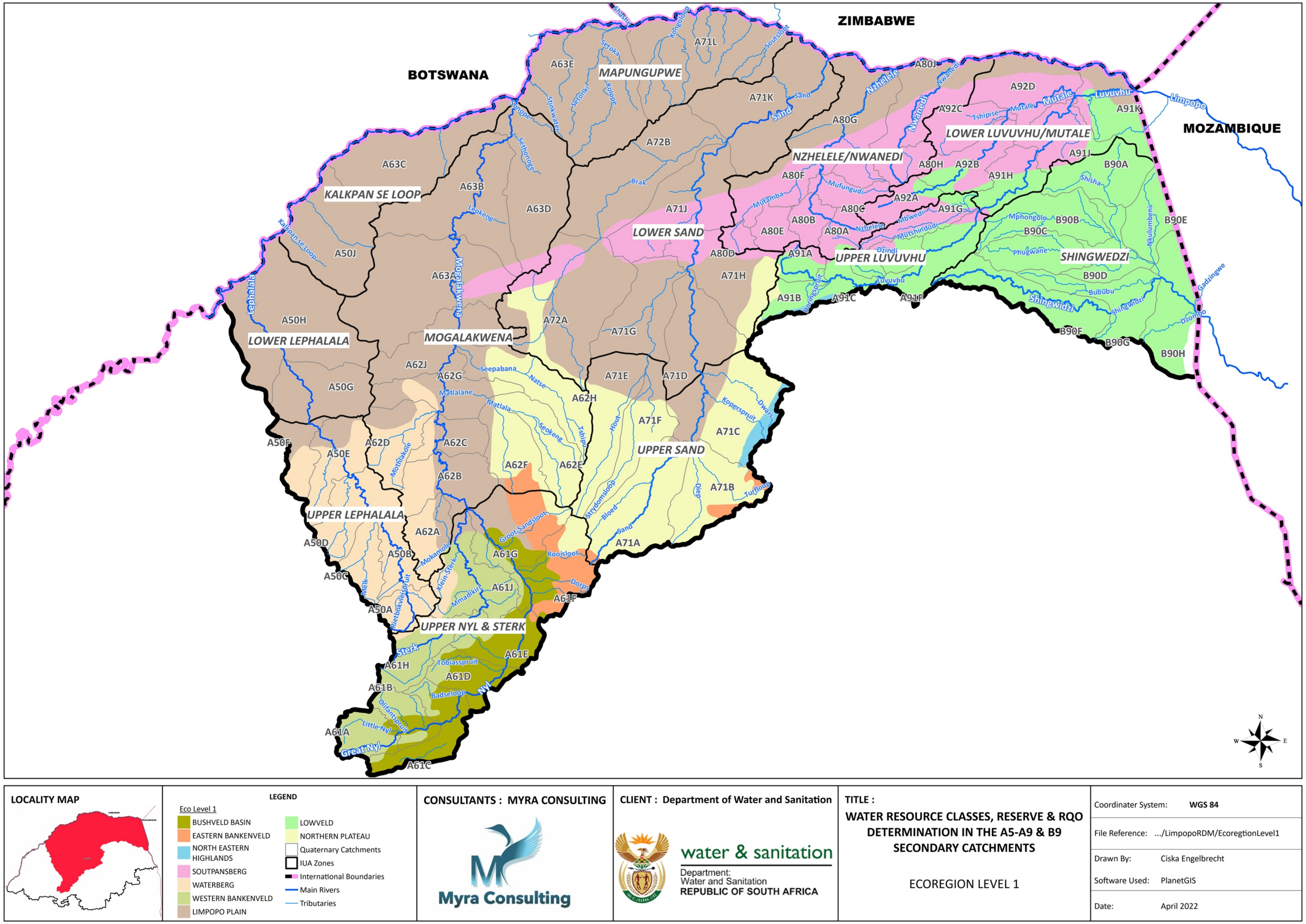


Figure 6-3. Ecoregion Level 1 areas within the IUAs

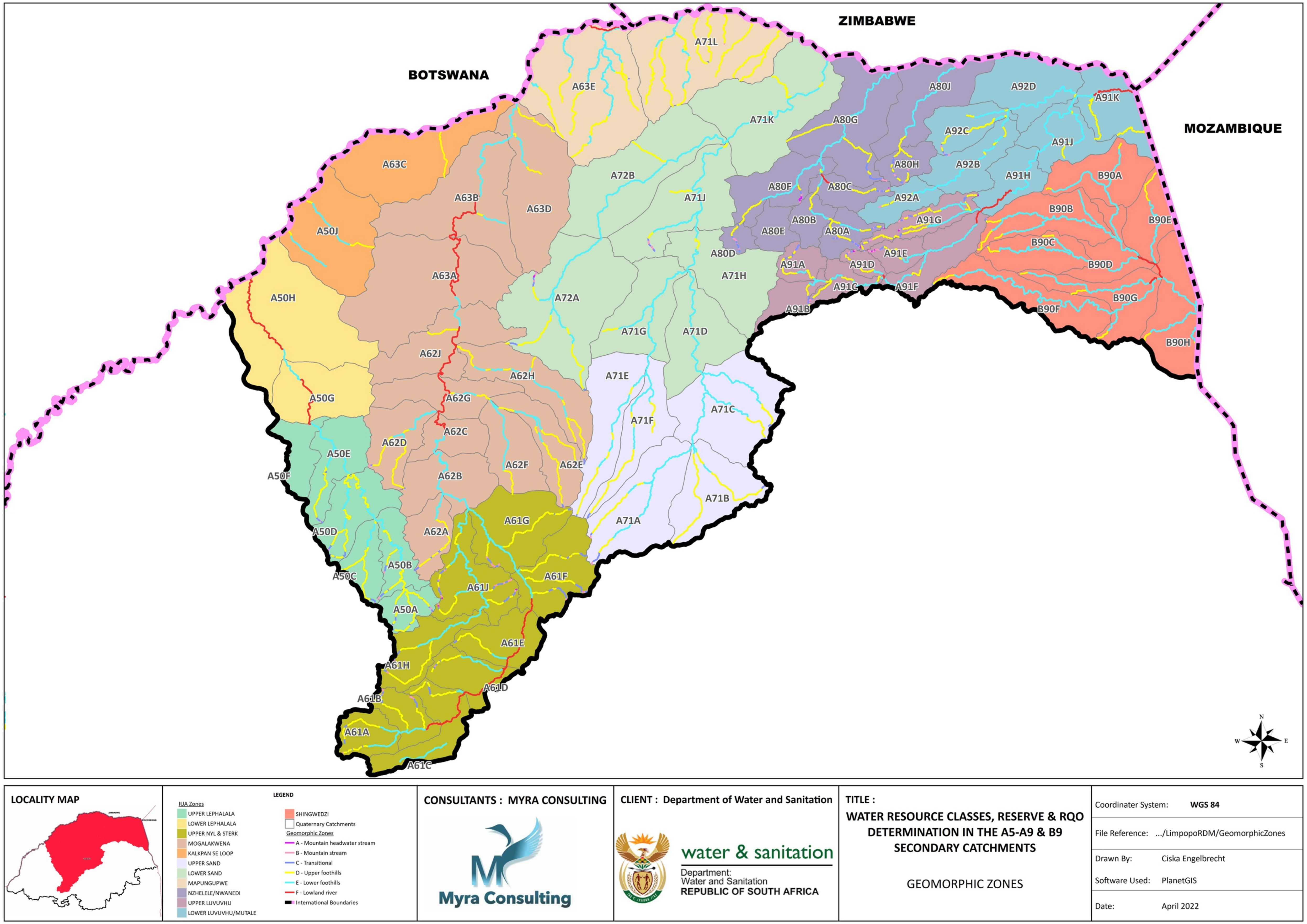


Figure 6-4. Geomorphic zones within the IUAs

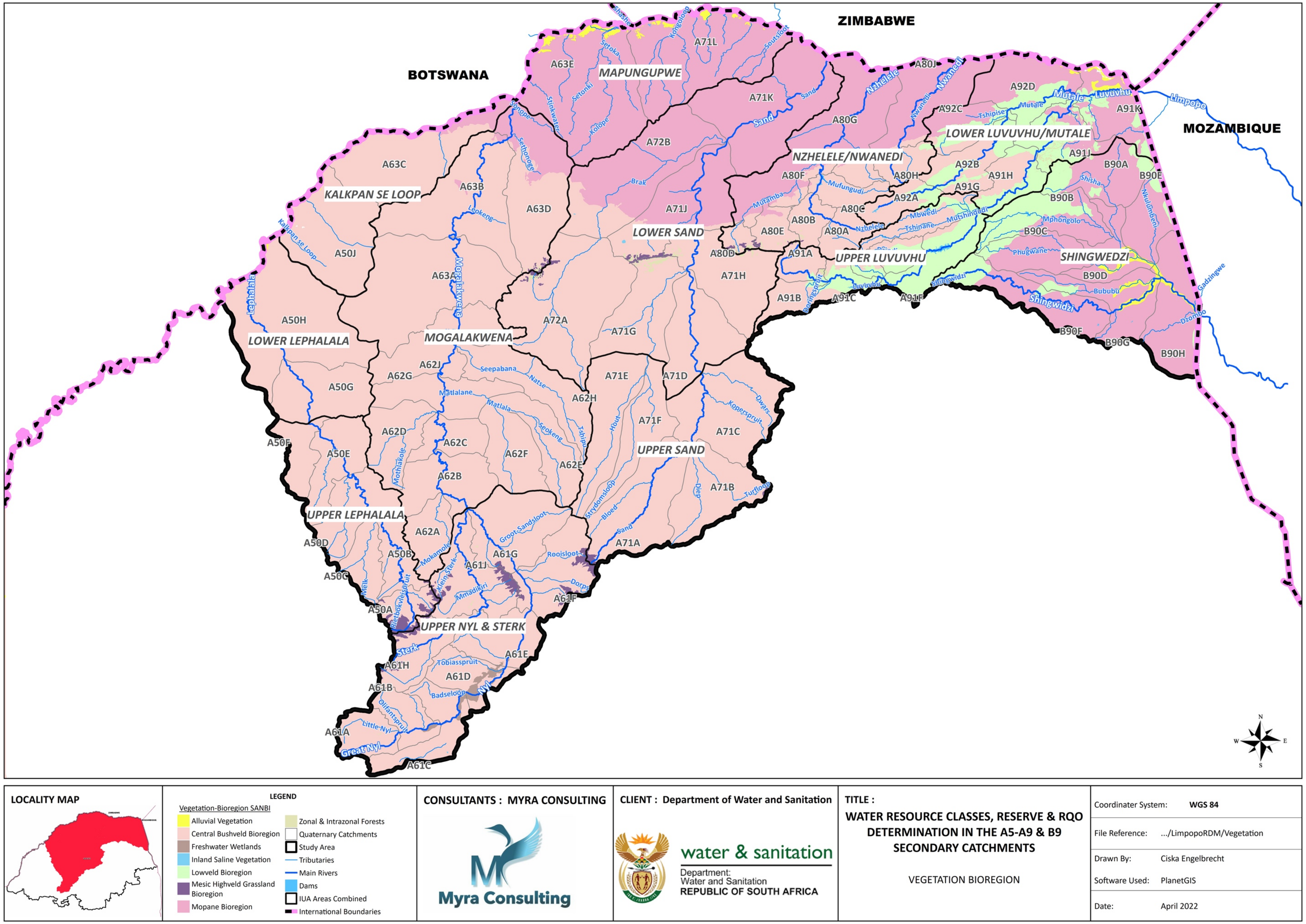


Figure 6-5. Vegetation Bioregions within the IUAs

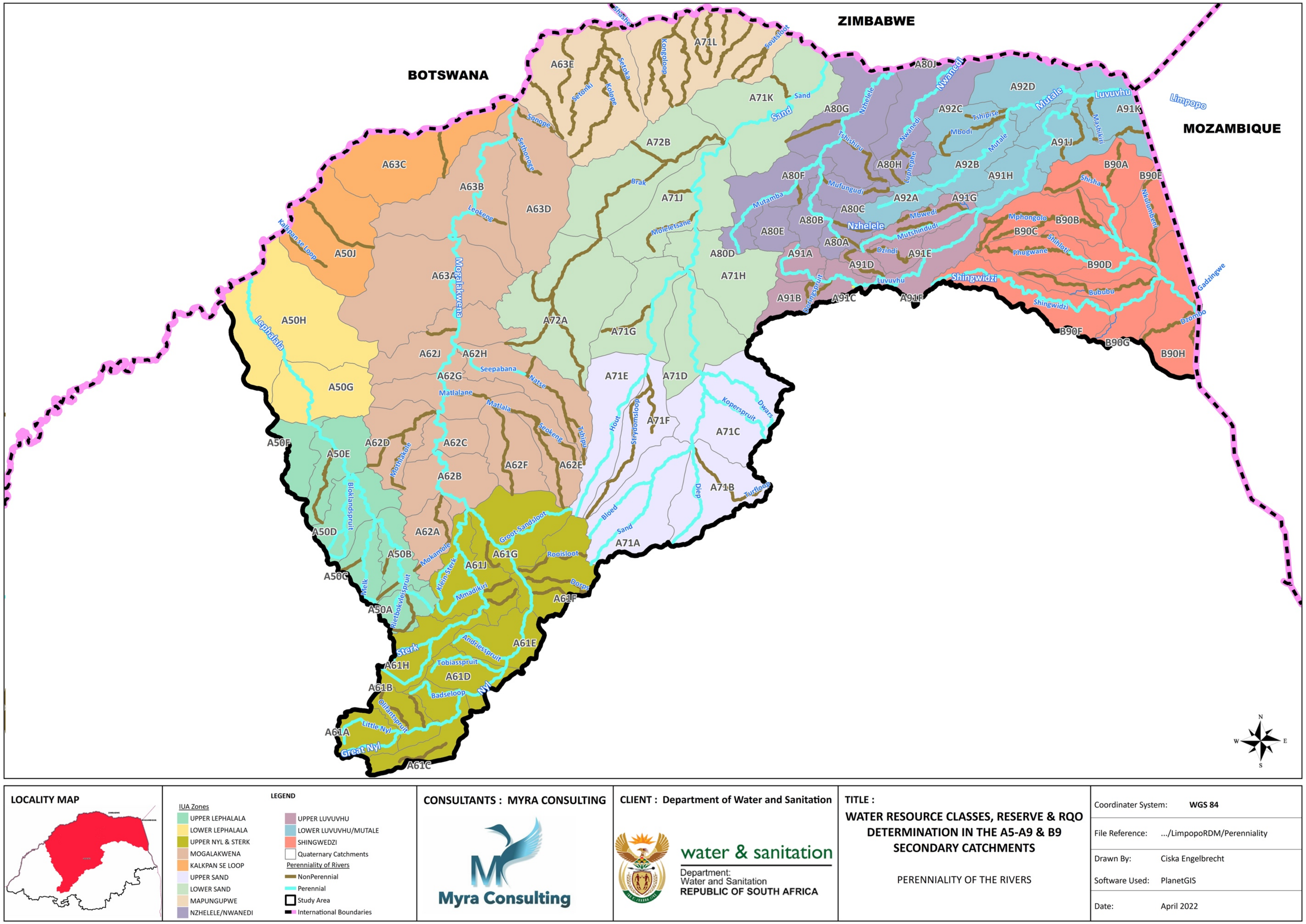


Figure 6-6. Perenniality of rivers within the IUAs

6.2.2.10 Upper Luvuvhu IUA

The source of the Luvuvhu River occurs in the Soutpansberg Level I Ecoregion, where it soon enters the Lowveld Ecoregion. The majority of the Luvuvhu Catchment occurs in the Soutpansberg and Lowveld Ecoregions, with a very small section of the Doringspruit Tributary occurring in the North-eastern Highlands Level I Ecoregion. Main tributaries include the Doringspruit, Latonyanda, Dzindi and Mutshinduḓi Rivers (DWS, 2014). All the larger tributaries as well as the mainstem Luvuvhu River comprise Mountain Headwater Stream and Mountain Stream at their source, followed by Transitional, Upper and Lower Foothills geomorphological zonation, with small sections of the IUA comprising Lowland River geomorphological zonation (Rowntree & Wadeson, 1999). The Luvuvhu River is perennial, with some of the smaller tributaries non-perennial in nature. The Central Bushveld and Lowveld Vegetation Bioregions are the predominant Bioregions in the IUA, (SANBI, 2018).

6.2.2.11 Lower Luvuvhu/Mutale IUA

This IUA is dominated by the Soutpansberg and Lowveld Level I Ecoregions and ends in the Limpopo Plain Level I Ecoregion before entering the Limpopo River. The largest tributary of the Luvuvhu River is the Mutale River, which is perennial in nature. Most of the rivers in this IUA occur within the Upper- and Lower Foothills geomorphological zones, with Mountain Headwater Stream and Mountain Stream at the source of some of the tributaries, including the Mutale River. The dominant Vegetation Bioregions in this IUA are the Lowveld, Central Bushveld and Mopani Bioregions, with the Alluvial Vegetation Bioregion occurring at the downstream section of the Luvuvhu River, for a short section upstream of - and at its confluence with the Limpopo River. Large sections of this IUA contain protected areas, including the Matshakatini Nature Reserve, Thengwe Nature Reserve, Mphaphuli Protected Environment, Pafuri Nature Reserve, and the Kruger National Park (Figure 6-12).

6.2.2.12 Shingwedzi IUA

The entire Shingwedzi River Catchment occurs in the Lowveld Level I Ecoregion, except for a fraction of the Mphongolo River tributary which has its source in the Soutpansberg Level I Ecoregion, and the Kumba River which occurs in the Lebombo Uplands Level I Ecoregion. Tributaries of the Luvuvhu River include the Tshange River, the Bububu River, the Mphongolo and Dzombo Rivers (DWS, 2014). The source of the Mphongolo River occurs within the Mountain Stream geomorphological zonation. The rest of the Luvuvhu Catchment occurring mainly within the Upper- and Lower Foothills geomorphological zonation, with a small portion occurring within the Lowland River zonation (Rowntree & Wadeson, 1999). The Shingwedzi mainstem river is perennial, as well as a portion of the Mphongolo River, upstream of its confluence with the Shingwedzi River. Many of the tributaries within the Catchment are non-perennial in nature. The Catchment is dominated by the Mopane, Lowveld and Central Bushveld Vegetation Bioregions, with lower regions of the Shingwedzi, Mphongolo and Bububu Rivers occurring in the Alluvial Vegetation Bioregions (SANBI, 2018). Most of the IUA is situated within the Kruger National Park (Figure 6-12).

6.2.3 Status Quo Assessment

6.2.3.1 Upper Lephalala IUA

The upper Lephalala River within the Waterberg Ecoregion is considered of high conservation importance with regards to its FEPA status (Figure 6-10). The Boklandspruit and two sections of the Lephalala River, upstream of the confluence with the Boklandspruit, are in a PES of a B Ecological Category, which is considered largely natural when compared to the reference condition for those sections of river (Figure 6-7). Most of the rivers in the IUA exhibit very high and high EI and ES status (Figure 6-8, Figure 6-9). The mainstem Lephalala River and many of its associated tributaries in quaternary catchments A50A, A50B and A50C, are important FEPA fish support areas, with some of the tributaries in these three quaternaries exhibiting full FEPA status. The Boklandspruit and Goud River in quaternary catchment A50D and A50E respectively, are also assigned full FEPA status.

6.2.3.2 Lower Lephalala IUA

The Lower Lephalala has no FEPA status, with the mainstem river in a D Ecological Category. The river is of high EI and ES.

6.2.3.3 Kalkpan se Loop IUA

The non-perennial tributaries, including the Kalkpan se Loop in quaternary catchment A50J, are assigned full FEPA status, with a B PES Category, and an unnamed tributary assigned a high EI (Figure 6-8).

6.2.3.4 Upper Nyl & Sterk IUA

Sections of the upper Mogalakwena Catchment are of conservation importance in terms of its FEPA status (Figure 6-10). The Badseloop, Tobiasspruit, Andriesspruit, Mmadikiri and Klein-Sterk Rivers are assigned full FEPA status, with the Great Nyl, Little Nyl and Sterk Rivers, assigned FEPA fish support areas. Most of the rivers in quaternary catchments A61E, A61F and A61G are assigned upstream FEPA areas. The ephemeral Nylsvley wetland is situated in the Nyl River and has RAMSAR status. Most of the rivers in this IUA have a C and D PES status, with two tributaries of the Sterk River showing a B PES status. Many of the rivers in the upper IUA have a high EI and ES, with the Great Nyl, Olifantspruit and Klein Sterk River exhibiting very high ES (Figure 6-9). The section of the Mogalakwena River in the Waterberg with its confluence with the Sterk River, is considered a Strategic Water Resource Area (Figure 6-11).

6.2.3.5 Mogalakwena IUA

The Mothlakole and Sethonoge Rivers are assigned full FEPA status, with sections of the mainstem Mogalakwena River assigned as fish support areas. Many of the tributaries in the upper IUA are assigned as FEPA support areas (Figure 6-10). The Mothlakole River is assigned an A PES Category and is thus regarded as a natural to near-natural river (Figure 6-7). The lower Mogalakwena River is considered as largely modified from its natural condition (D PES Category), with the Sethonoge River and some of its unnamed tributaries in a B PES Category, i.e., largely natural with few modifications to its habitat or biota. The upper Mogalakwena and mid-sections, as well as some of the upper tributaries, are assigned a high EI, with the Mokamole and Mothlakole and upper Mogalakwena Rivers showing a high ES.

6.2.3.6 Mapungubwe IUA

The Setongi, Kongoloop and Soutsloot are assigned full FEPA status, with the Stinkwater and two unnamed tributaries assigned Phase 2 FEPA status. The Kongoloop and Lower Soutsloot Rivers are assigned A PES Categories, meaning that they are considered unmodified/natural in ecological condition. Many of the tributaries including the Stinkwater, Setonki and Setoka Rivers are assigned a B PES Category (Figure 6-7). Most of the rivers are assigned a high EI.

6.2.3.7 Upper Sand IUA

Most of the Sand River catchment is considered an upstream FEPA, excluding the Hout River which is assigned Phase 2 FEPA status. Upstream FEPAs are rivers where human activities need to be managed carefully in order not to compromise downstream FEPAs and fish support areas (Nel *et al.,* 2011). The Hout River is assigned a Phase 2 FEPA, meaning that this is a river in a moderately modified condition (PES = C) and it is considered not possible to meet biodiversity targets for those rivers classified as an A or B PES. The Sand River and its tributaries in quaternary catchments A71A and A71F is classified as a Strategic Water Source Area (Figure 6-11). The upper Sand River is assigned a high EI.

6.2.3.8 Lower Sand IUA

Most of the rivers in the IUA are assigned as upstream FEPA rivers, with only one section of the mainstem Sand River and a portion of the non-perennial Brakspruit assigned full FEPA status (Figure 6-10). Three non-perennial tributaries of the lower Sand River, including the Moleletsane River, are assigned a B PES. Sections of the lower Sand River and a portion of the non-perennial Brak River tributary and the Moletsane River tributary, are considered ecologically important and are assigned a high EI (Figure 6-8).

6.2.3.9 Nzhelele/Nwanedi IUA

Two tributaries of the Nzhelele River are assigned full FEPA status, namely the non-perennial Mufungudi and Tshishiru Rivers, as well as the non-perennial Luphephe River in the Soutpansberg. The Nwanedi River is classified as a Fish Support Area, with the upper section of the river non-perennial in nature (Figure 6-6). Sections of the Catchment are classified as high EI and high ES, with the upper Mutamba River classified as very high ES. A small tributary of the Mutamba River in quaternary catchment A80F and a tributary of the Nzhelele in quaternary catchment A80G are in a B PES Category, with the remainder of the catchment mostly in C and D PES Categories (Figure 6-7). Two sites with recent macroinvertebrate data, were assigned a B/C Ecological Category when conducting the MIRAI (C. Thirion, *Pers. Comm.,* March 2022), namely the REMP (River Ecostatus Monitoring Programme) sites A8LUPH-GUMEL on the Luphephe River and site A8NWAN-GORGE, on the Nwanedi River.

6.2.3.10 Upper Luvuvhu IUA

The upper Luvuvhu River is considered an Upstream FEPA, meaning that human activities need to be managed in order not to compromise the downstream FEPA rivers. The upper Mutshindṷdi River is assigned a Phase 2 FEPA (Figure 6-10). The entire mainstem Luvuvhu River and lower Mutale River is classified as having high ES. Most of the rivers in the IUA are assigned a D PES Category, with some assigned a C PES Category. The upper Luvuvhu, Dzindi, upper Mutshindṷdi and Mbwedi Rivers are assigned a high ES, with the Dzindi, upper Mutshindṷdi, Tshinane and Mbwedi assigned a very high ES. The mainstem Luvuvhu, including the Doringspruit tributary are assigned a high ES (Figure 6-9).

6.2.3.11 Lower Luvuvhu/Mutale

The lower Luvuvhu and Mutale Rivers are assigned full FEPA status, with the Mbodi and Tshipise Rivers assigned Fish Support FEPA status. The lower Luvuvhu River in quaternary A91J and A91K have unnamed tributaries in a B PES Category, with the lower Luvuvhu in an A PES Category before it enters the Limpopo River. This section of the river is a floodplain wetland system, the Makuleke Wetland and Pafuri floodplain. Sections of the lower Luvuvhu catchment in quaternary catchments A91H, A91J and A91K comprise a Strategic Water Source Area (Figure 6-11). The lower Luvuvhu River and lower Mutale Rivers are considered rivers of high EI, with the upper Mutale classified as having a very high ES (Figure 6-9).

6.2.3.12 Shingwedzi IUA

The mainstem Shingwedzi River, the Bububu and Nkulumbeni Rivers are assigned full FEPA status, with unnamed tributaries in catchments B90A, B90B and B90C classified as Upstream FEPAs (Figure 6-10). Sections of the Shingwedzi and Bububu Rivers in quaternary catchments B90F and B90G are situated in Strategic Water Source Areas (Figure 6-11). Most of the Shingwedzi Catchment is assigned a high EI, with the lower Shingwedzi River assigned a high ES. The lower Shingwedzi River as well as many of its tributaries, including the Nkulumbeni, Shisha, Shihloti and Bububu Rivers are currently in an A or B PES Ecological Category (Figure 6-7).

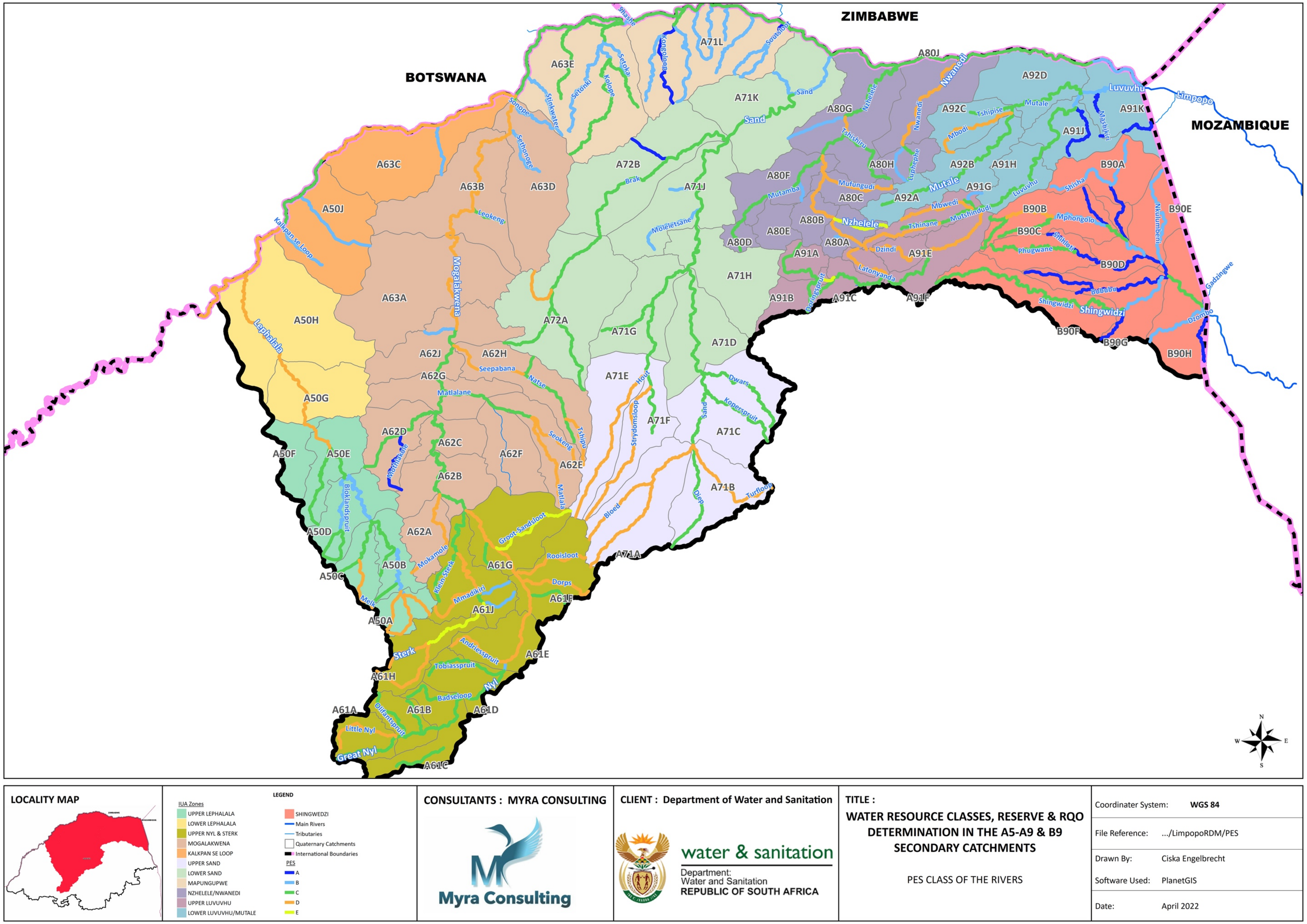


Figure 6-7. PES of the rivers within the IUAs (DWS, 2014)

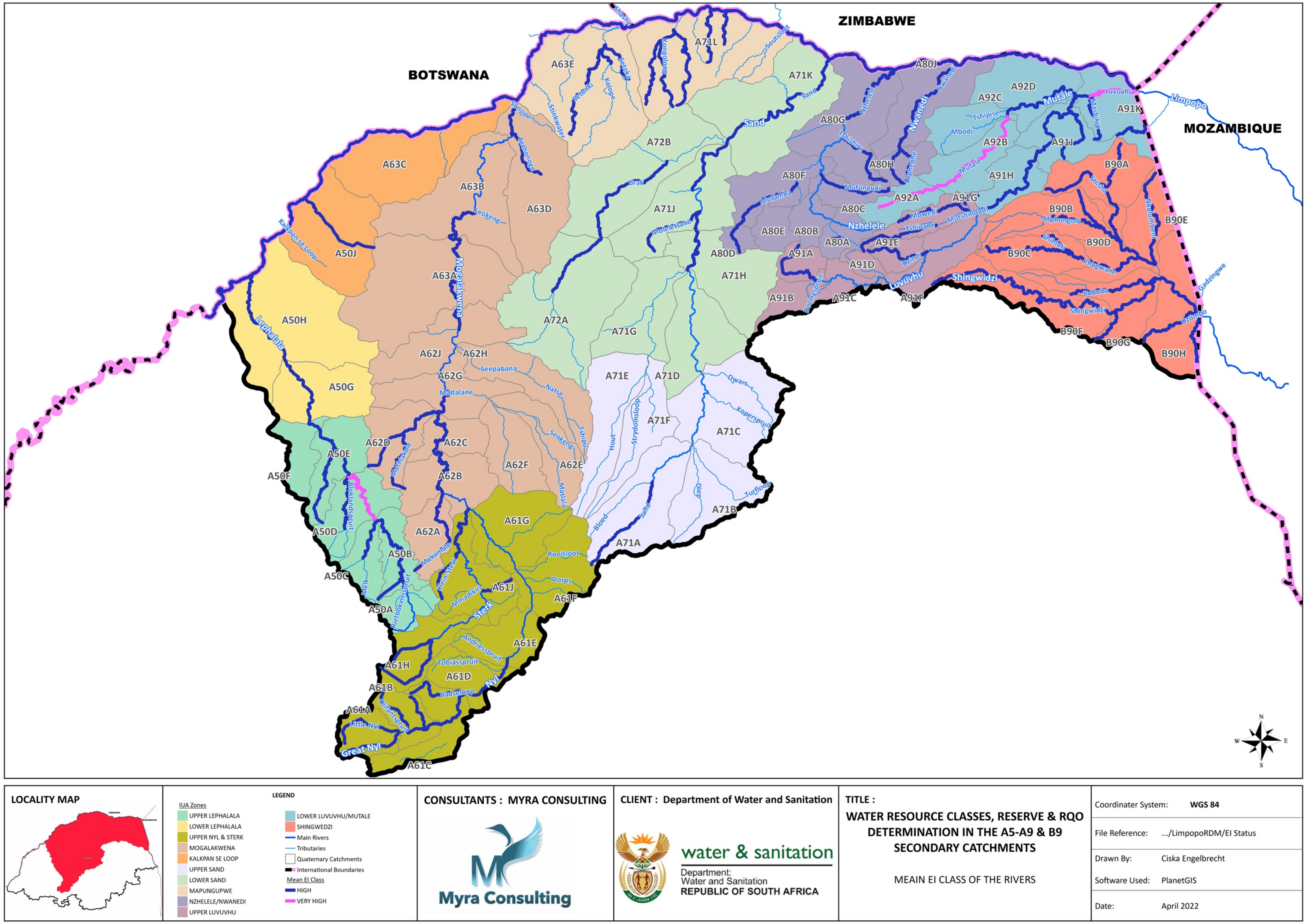


Figure 6-8. Mean EI of the rivers within the IUAs (DWS, 2014)

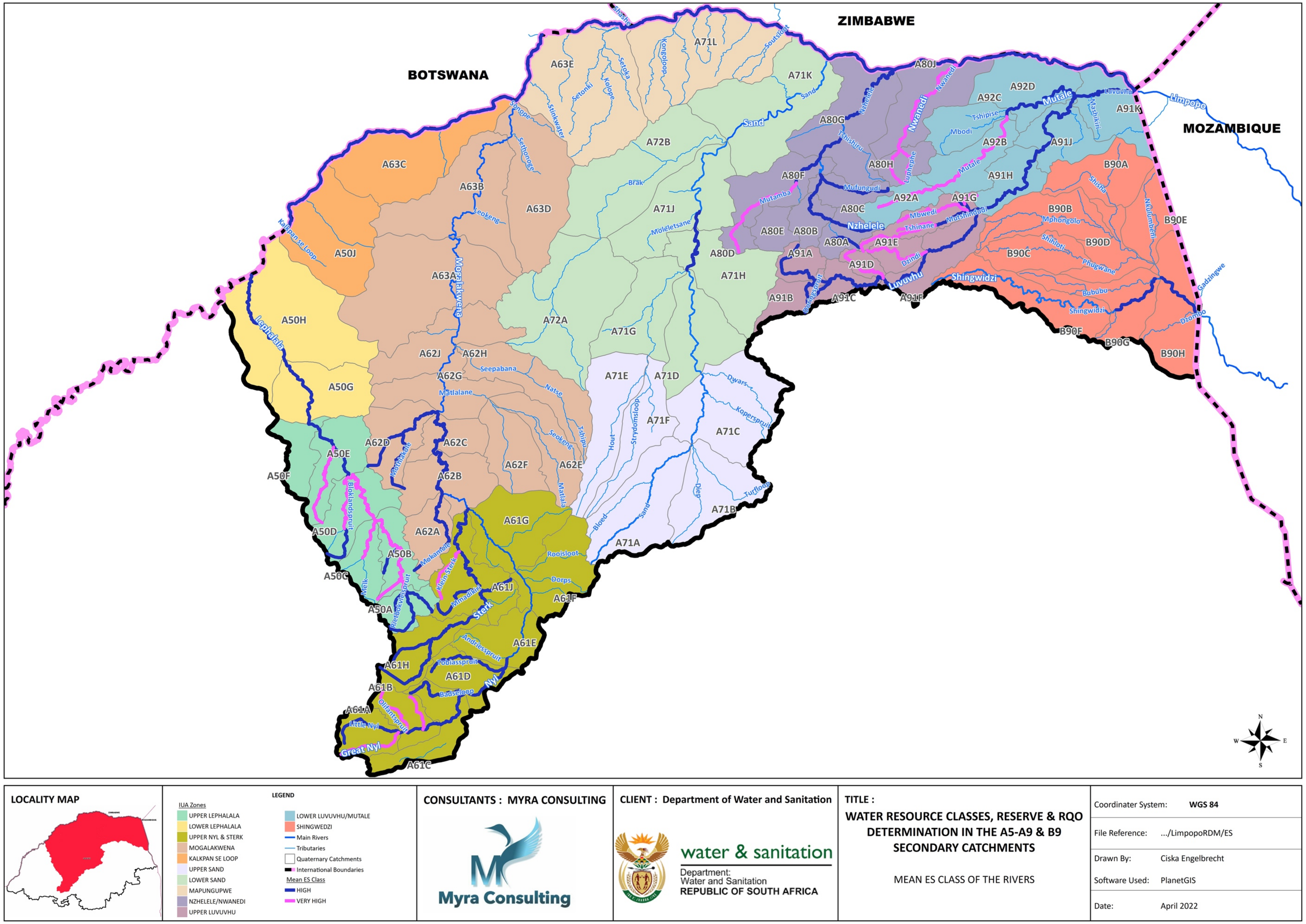


Figure 6-9. Mean ES of the rivers within the IUAs (DWS, 2014)

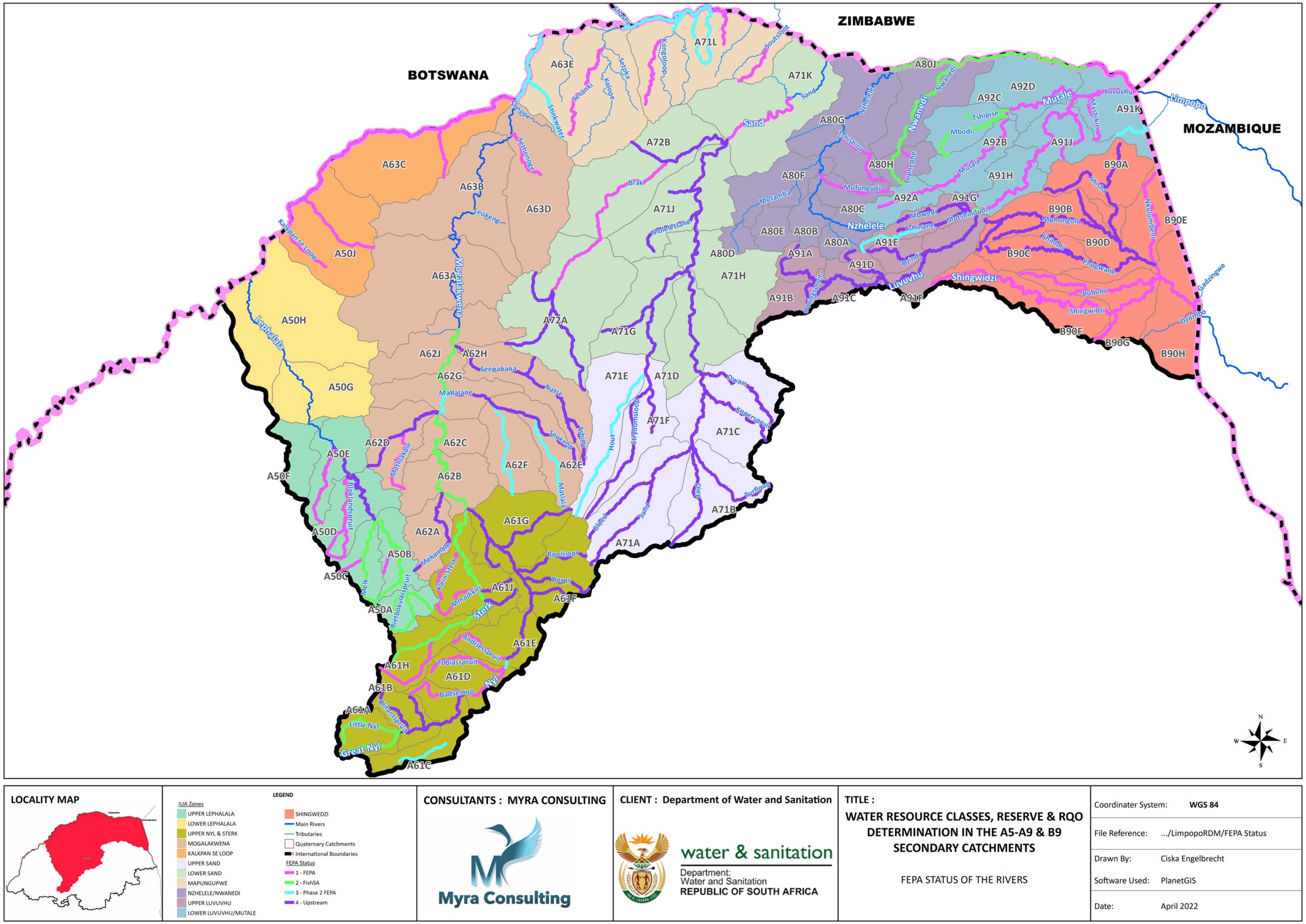


Figure 6-10. FEPA Status of the rivers within the IUAs

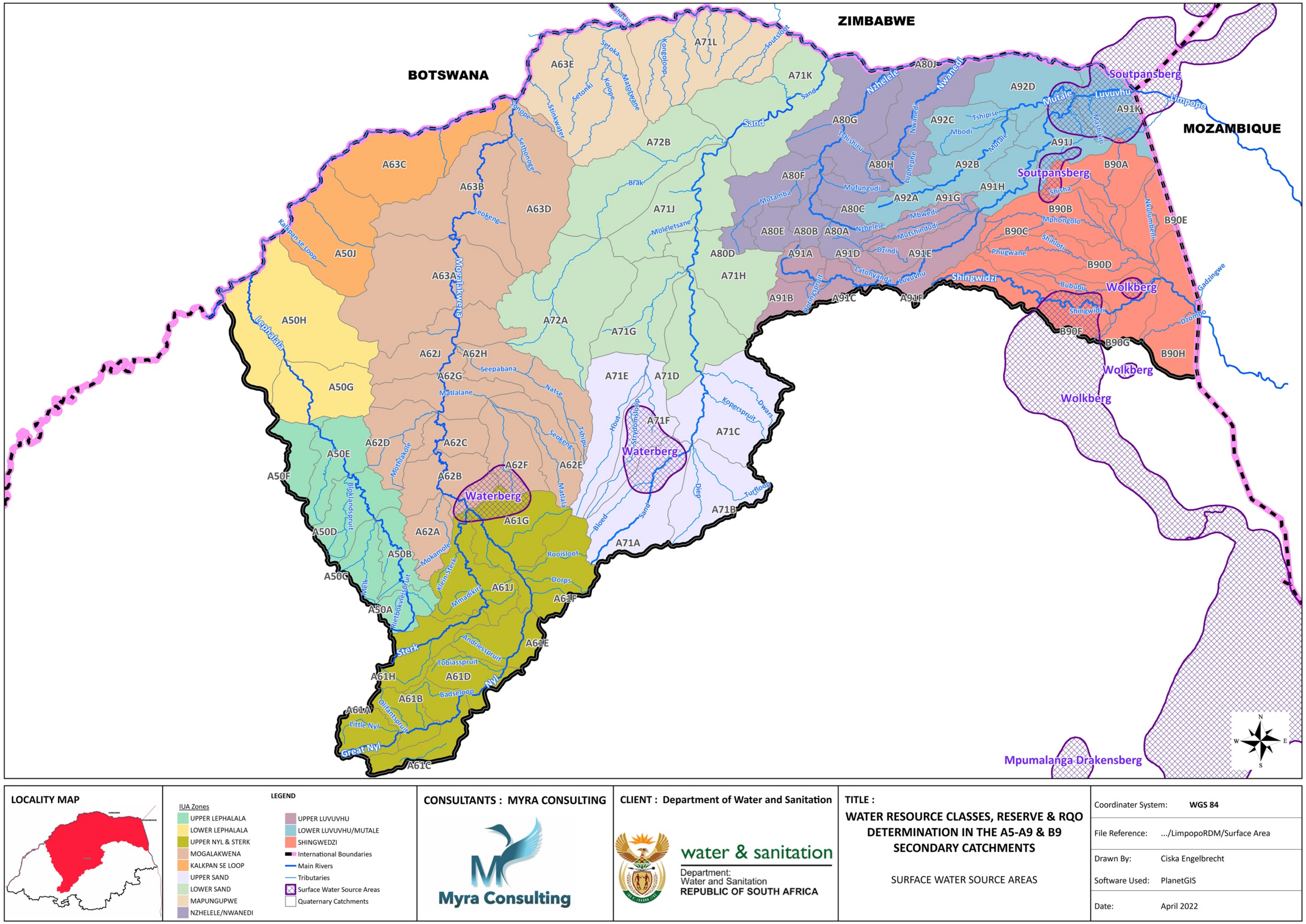


Figure 6-11. Strategic Water Source Areas – Surface water within the IUAs

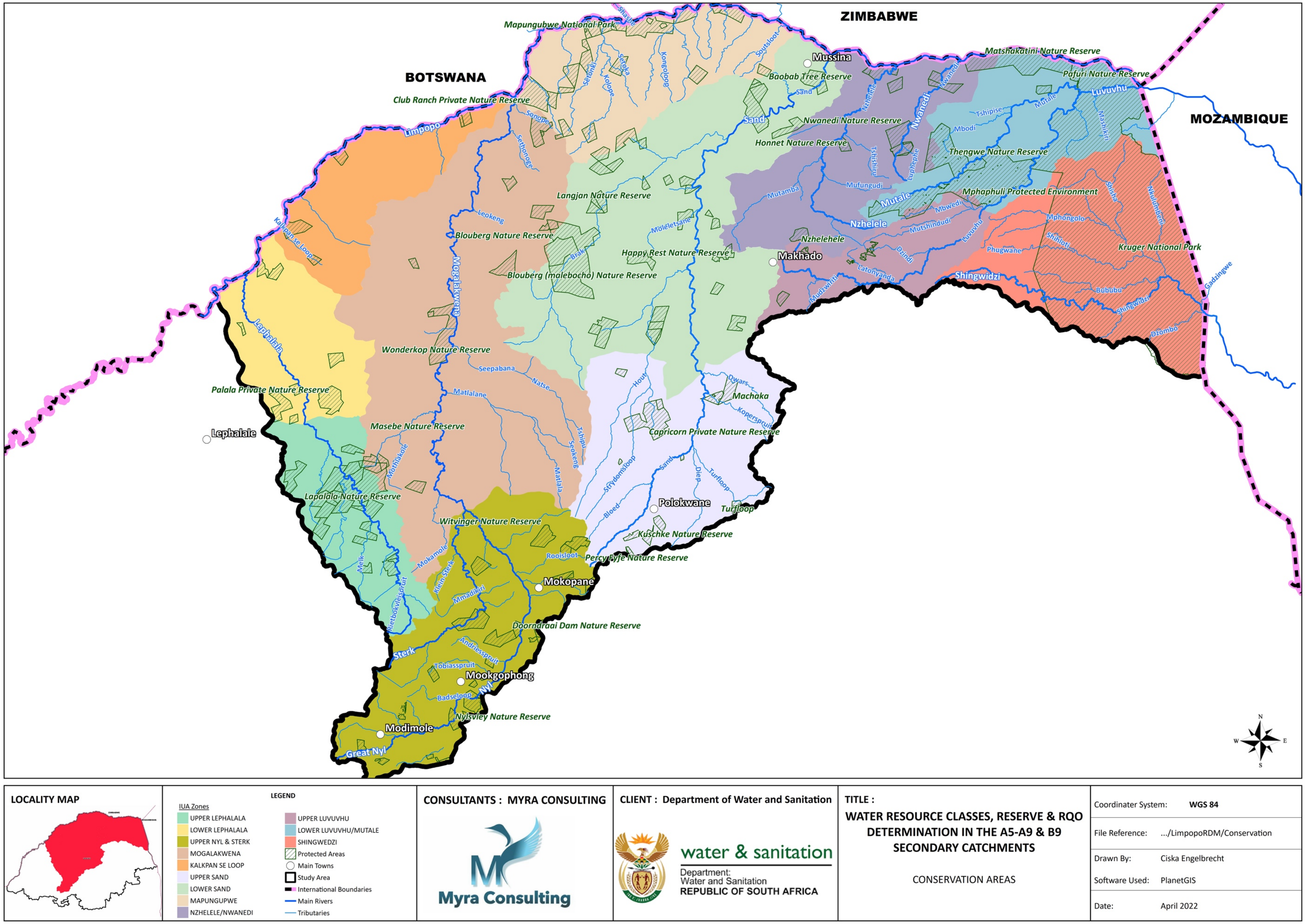


Figure 6-12. Conservation areas within the IUAs

6.3 Groundwater

6.3.1 Approach

The groundwater status quo assessment includes a description of key groundwater characteristics (recharge, discharge, groundwater use and groundwater quality) across the groundwater resources units/groundwater unit of analysis. A detailed status quo and trend analysis of groundwater level and groundwater quality per groundwater unit of analysis is documented separately.

All available point data (borehole geology, abstraction, groundwater level, groundwater quality) was collated (Refer to Information & Gap Analysis Report), and interrogated for the trend analysis, and points with sufficient time-series including recent data are analysed to provide a current status quo. Sources of data used to populate the tables included in the trend analysis per GUA include:

- National Groundwater Archive.
- GRIP data (2011).
- Hydro-informatics database (HYDSTRA) database.
- Water management System (WMS) datasets.
- Water Use Authorisation and Registration Management System (WARMS) data.
- Data from DWS project All Towns Reconciliation project.
- Various existing groundwater reports.

6.3.2 Description

6.3.2.1 Geology

The geomorphology features found in the study area are the results of geological evolution of the Swazian aged Greenstone belts and granites forming the Kaapvaal Craton, collision between the Kaapvaal and Zimbabwean cratons forming the Limpopo Mobile Belt, granite and basaltic intrusions, sedimentary deposition forming the Blouberg, Waterberg, Soutpansberg and Karoo groups. The study area is delineated by the Archaean Basement rocks, Bushveld Complex, Karoo Supergroup, and the Waterberg, Blouberg and Soutpansberg groups (Figure 6-13). The geological sequencing is shown in Table 6-8.

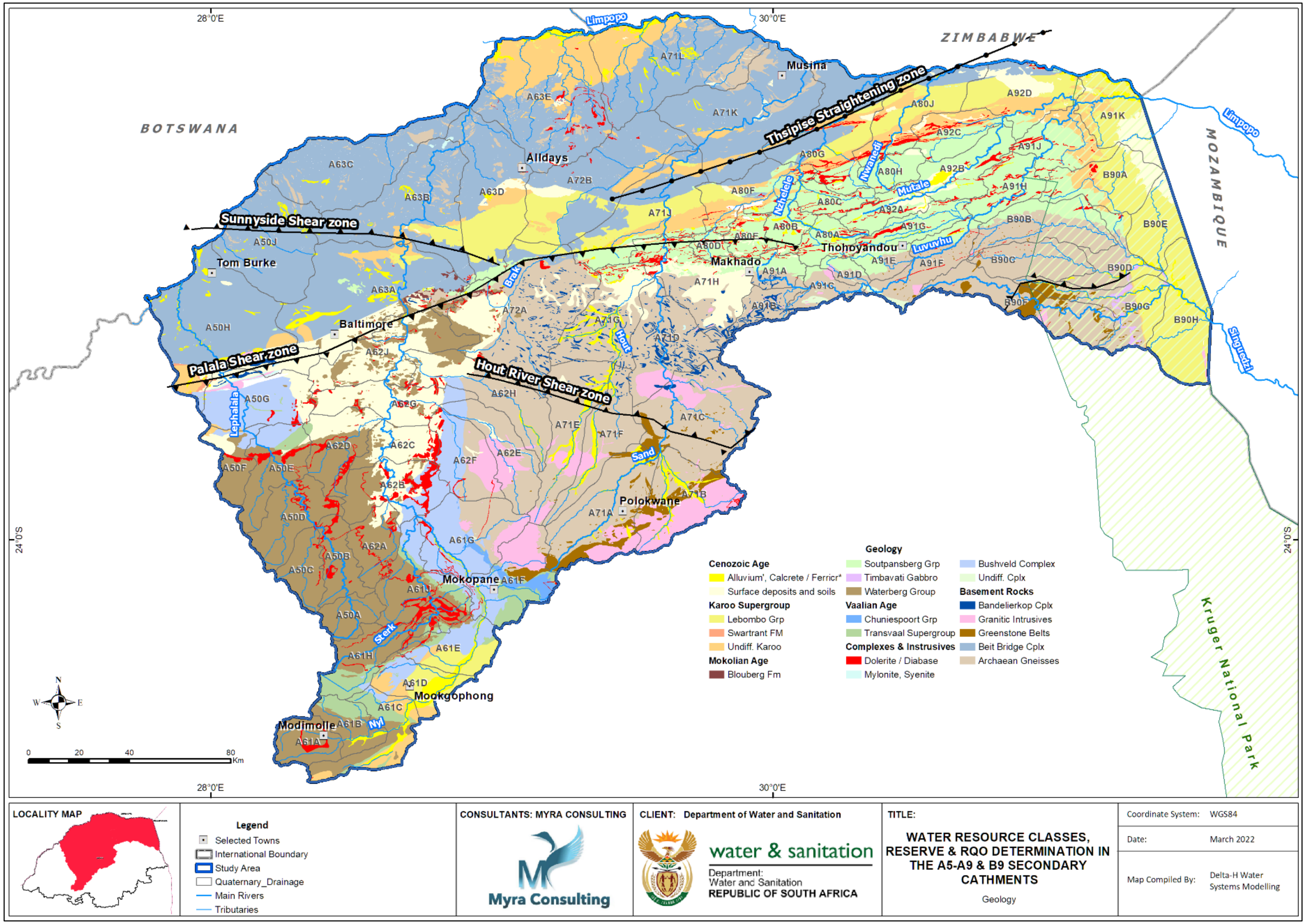


Figure 6-13. Regional geology

Table 6-8. Geological sequence of region.

Era	Lithostratigraphy Unit	Rock Types
Cenozoic (<65 Ma)	Quaternary deposits	Sand, soil, alluvial, calcrete
Mesozoic (250 – 65 Ma)	Karoo Supergroup	Sandstone, shale, mudstone, coal, intrusive dolerite
Mokolian (2050-1000 Ma)	Blouberg Formation	Sandstone, feldspathic granulestone, breccia, conglomerate, quartzite and gneiss
	Waterberg Group	Granulestone, conglomerate and sandstone
	Soutpansberg Group	Basalt, andesite, shale, greywacke, conglomerate and lava
Vaalian (2650 – 2050 Ma)	Bushveld Igneous Complex	Gabbro norite
	Transvaal Supergroup	Quartzite, dolomite, chert,
Swazian (>3100 Ma)	Archaean Granitiods Intrusion	Granitic rock
	Archaean Greenstone Belt	Gneiss, schist, quartz-carbonate rock, amphibolite, komatiite and basalt
	Goudplaats-and Houriver gneiss	Gneiss (basement rock)

6.3.2.1 Aquifer types

A description of the main aquifer types (refer to Figure 4-9) within the study area are provided below:

Intergranular aquifer (alluvial aquifer)

An alluvial aquifer is described as “an aquifer comprising unconsolidated material deposited by water, typically occurring adjacent to rivers and buried palaeochannels.” (DWS, 2011). The distribution of alluvial deposits (aquifers) is determined by the river gradient, geometry of the channel, fluctuation of stream power as a function of decreasing discharge downstream due to evaporation and infiltration losses, as well as rates of sediment input due to erosion (Moyce et al., 2006). The most predominant alluvial aquifer system is the Limpopo River. The aquifers comprise mainly unconsolidated Quaternary sequences of clay, sand and gravel beds (CSIR, 2003; Gomo and van Tonder, 2013), and are sources of groundwater abstraction for multiple communities due to their high permeabilities (Owen and Madari, 2010) and good water quality (CSIR, 2003; Moyce et al., 2006). The alluvial aquifers along the Limpopo River are considered to have the potential for high yields, whereas those along tributaries such as the Luvuvhu River display much lower potential due to limited aquifer extent and less than optimum hydraulic characteristics (CSIR, 2003).

Intergranular and fractured aquifer system

An aquifer system in crystalline material such as the norites and pyroxenites of the Bushveld Igneous Complex as well as the Basement Complex rocks comprise of (a) an in-situ weathered overburden or saprolite (often collectively with the soil zone referred to as regolith), partially replaced or overlain by alluvial or hill wash material, (b) an unweathered and intact rock matrix with negligible matrix porosity and permeability, and (c) planes of discontinuity in the rock matrix, including layers/reefs, faults and joint planes (collectively here referred to as fractures in the hydrogeological meaning). The fractured bedrock comprising of the intact rock matrix and fractures is commonly referred to as saprock. The degree/intensity of chemical weathering or more specifically the spatial and depth variations thereof, control the geometry of the shallow weathered aquifer profile. The weathered overburden is considered to have low to moderate transmissivity, but high storativity. The weathered aquifer is recharged by rainfall or by leakage from perennial and non-perennial surface water drainages and dams. Direct recharge from rainfall is limited, as the mafic rocks of the BIC tend to weather to a swelling clay rich soil (black turf), which has low permeability and considered to reduce infiltration unless preferential flow paths are opened by vertical desiccation cracks. The dominant rock types in the study area are the Goudplaats-, Hout River-, Alldays- and Sand River Gneiss as well as the Beit Bridge complex including the number of granitic intrusions.

With the presence of the Karoo Supergroup located in the weathered zone of the Karoo sediments hosts the unconfined or semi-confined shallow weathered Karoo aquifer or hydro-stratigraphic zone. Due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments, the water quality is expected to be generally good, but in the absence of an overlying confining layer also vulnerable to pollution. Localised perched aquifers may occur on clay layers or lenses. Water intersections in the weathered aquifer are mostly above or at the interface to fresh bedrock (sandstone or sills), where less permeable layers of weathering products and capillary forces limit the vertical percolation of water and promote lateral water movement.

Karst aquifer

The kart / dolomitic aquifer consists of chert-rich dolomite and chert breccias with boreholes yields exceeding 5 L/s. Water bearing properties of the dolomite stem from carbonate dissolution along structural and lithological discontinuities (such as faults, fractures, and joints). Storativities of South African dolomite aquifers generally vary between 1 and 5 % but this property depends greatly on the extent of weathering and dissolution. Transmissivities can be several hundred m^2/day or more. The aquifer can be regarded as a water-table aquifer with mostly unconfined conditions. Groundwater levels varies, however typically shallow in natural conditions, and generally show an immediate response to rainfall. The karst aquifer system is limited to the Malmani Dolomites found around Mokopane area.

6.3.2.2 Strategic Water Source Areas – Groundwater (SWSA-gws)

Groundwater source areas can be defined as an area with high groundwater availability and where this groundwater forms an important resource. A *strategic* groundwater source area (SWSA-gw) can therefore be defined as an area with a high source of groundwater and where this groundwater forms a nationally important resource. There are 57 groundwater source areas which cover about 11% of South Africa, with 37 of these being nationally strategic (Le Maitre, et al., 2018). The study area hosts six (6) SWSA-gw areas (Figure 6-14) of which all except the Blouberg groundwater resource area is considered of National importance.

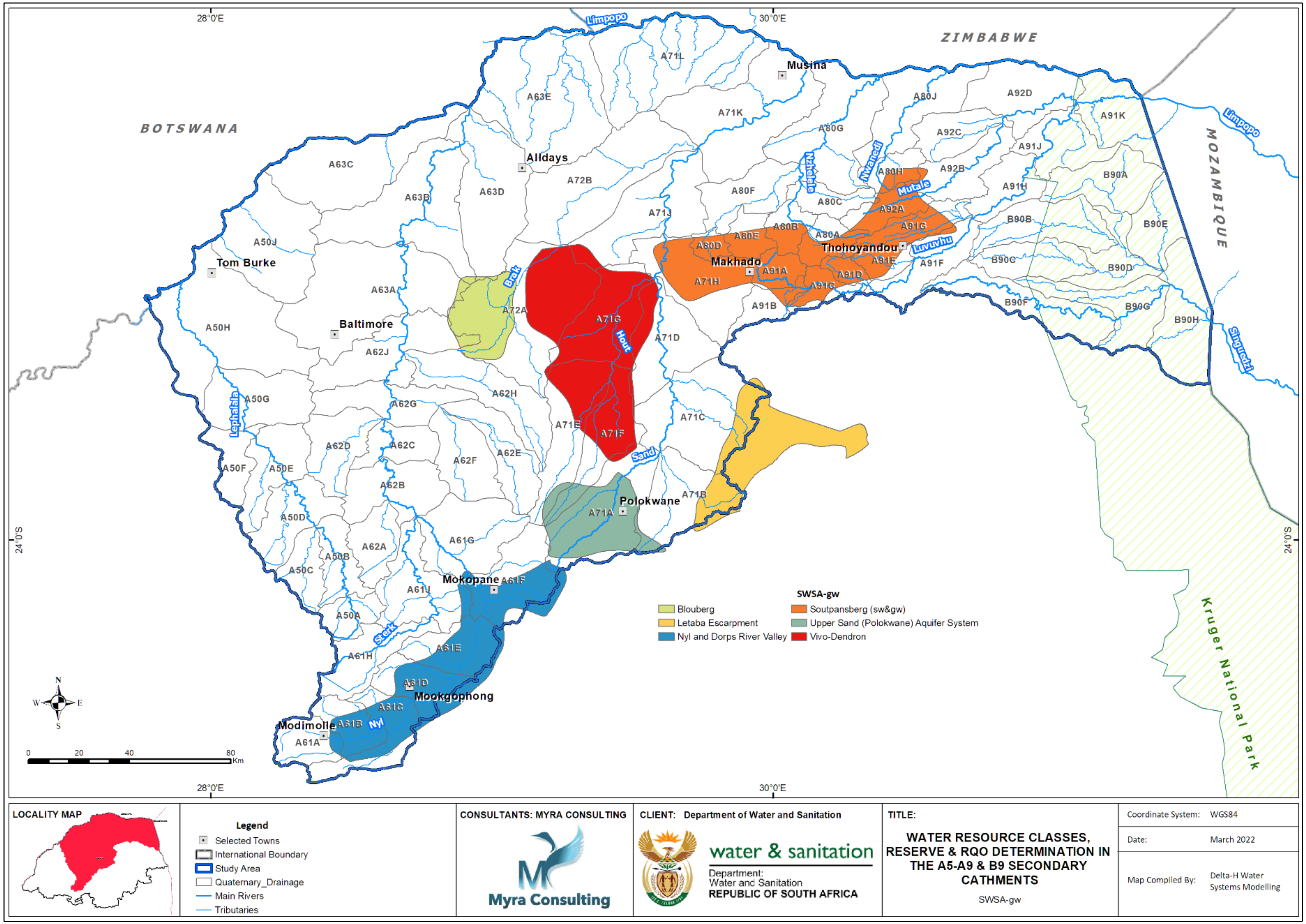


Figure 6-14. SWSA-gw for the study area.

6.3.3 Status Quo Assessment

6.3.3.1 Recharge

The nationally available recharge dataset, GRAII (DWAF, 2004) is shown in in Figure 6-16, and summed in Table 6-9 (per GUA). The recharge distribution is largely controlled by the precipitation distribution, which in turn is related to the topography. At the broadest scale, areas of high rainfall largely correspond (at least in the theoretical datasets) to areas of high recharge. In certain areas the correlation is not direct and the underlying geology, and aquifer type, influences the recharge.

A study from Sorensen et al., (2021) statically investigated the response of groundwater levels over time (hydrographs) with geomorphological conditions within the Mogalakwena and Sand River catchments. The study found rainfall and aridity are driving factors for groundwater level responses with either a string or subdued reflection from rainfall (recharge) with seasonal fluctuations observed, however some boreholes only showed rainfall response to large recharge events. Groundwater abstraction has an impact on correlation of rainfall, recharge, and groundwater responses such as at clustered groundwater abstraction sites (well fields) used for large scale water supply and should be taken with consideration within such areas.

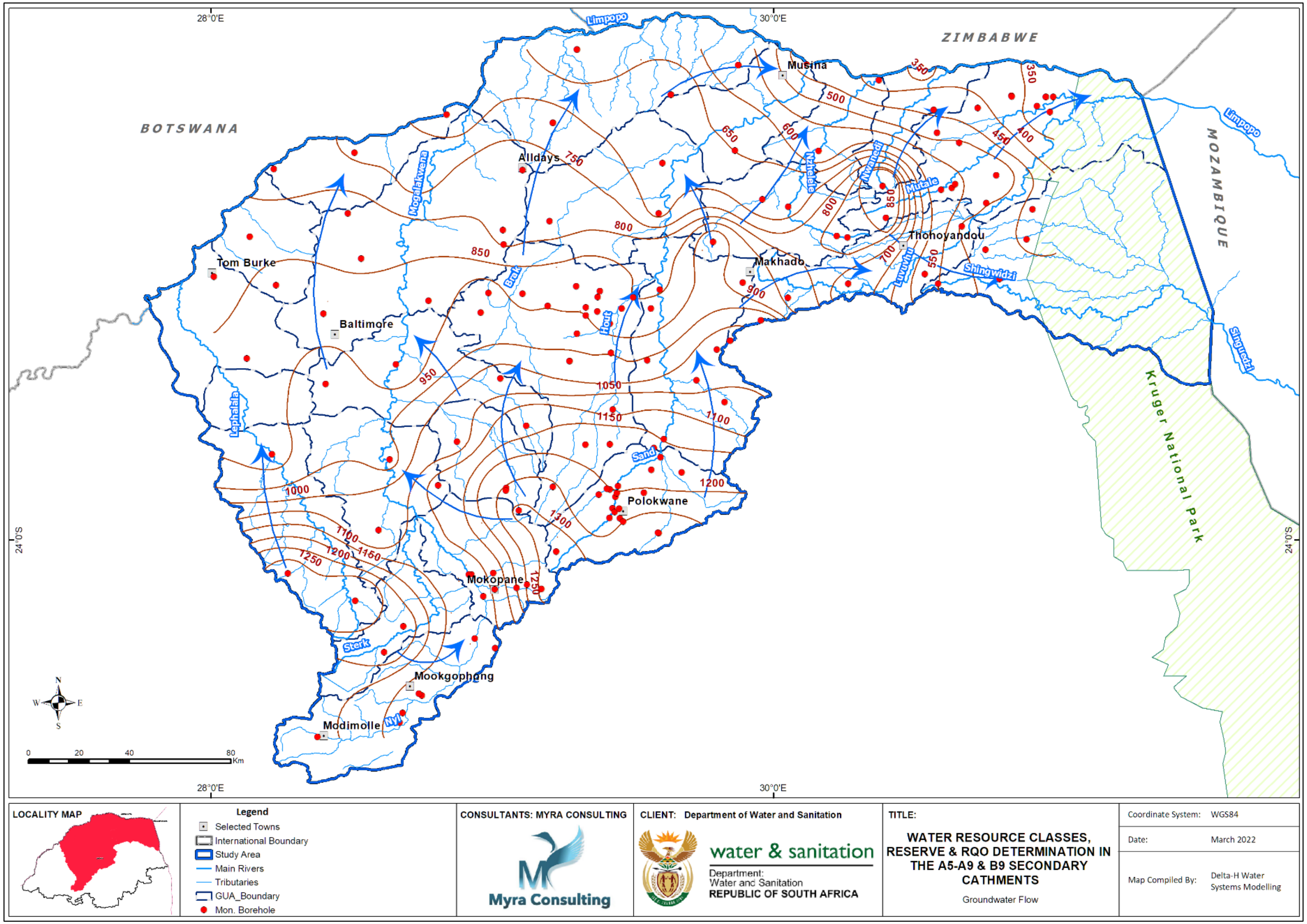


Figure 6-15. Regional groundwater levels and flow direction.

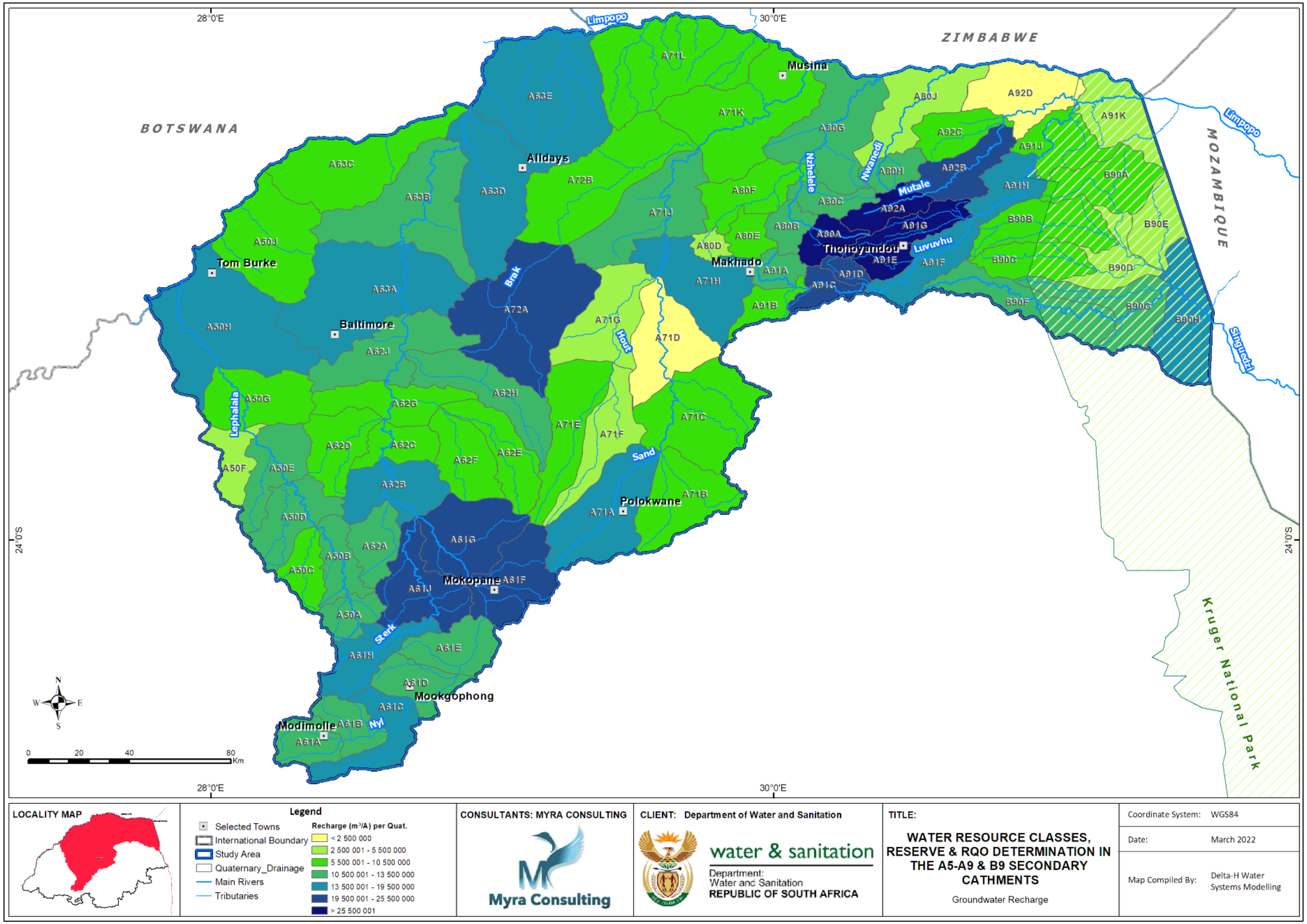


Figure 6-16. Groundwater recharge per quaternary catchment.

Table 6-9 Groundwater recharge estimates per GUA.

Description	GUA	Area (km^2)	GRA II		Vegter (1995)
			(Wet) Mm^3	(Dry) Mm^3	Mean Mm^3
Upper Lephalala	A50-1	2 704	62.6	44.5	140.4
Middle Lephalala	A50-2	821	9.2	6.3	3.2
Lower Lephalala	A50-3	1 943	15.1	9.9	2.6
Nyl River Valley	A61-1	2 333	62.1	44.7	113.2
Sterk	A61-2	1 403	42.4	30.7	54.6
Upper Mogalakwena	A61-3	1 716	43.2	30.9	28.4
Klein Mogalakwena	A62-1	2 125	42.0	29.5	62.8
Matlala	A62-2	1 240	17.8	12.2	12.2
Steilloop	A62-3	2 428	31.6	21.6	13.4
Lower Mogalakwena	A63-1	4 751	43.5	29.4	10.8
Upper Sand	A71-1	2 026	26.7	18.3	10.9
Middle Sand	A71-2	3 235	27.9	19.0	17.2
Hout	A71-3	4 359	35.4	24.2	18.7
Sandbrak	A71-4	2 716	21.9	14.5	5.4
Lower Sand	A71-5	1 669	9.5	6.1	0.9
Limpopo Tributaries	A63/71-3	3 750	23.3	15.0	3.0
Kalkpan	A50-4/A63-2	2 572	16.98	11.24	29.00
Nzhelele	A81-1	1 837	71.7	52.7	116.2
Lower Nzhelele	A81-2	1 228	11.8	7.8	1.7
Nwanedi	A81-3	1 133	15.2	10.5	10.2
Upper Luvuvhu	A91-1	2 098	170.2	131.9	451.1
Mutale/Luvuvhu	A91-2	3 838	113.5	83.7	94.8
Shingwedzi	B90-1	5 301	70.5	48.4	40.4

6.3.3.1 Discharge

One groundwater discharge mechanism is through discharge to surface water, as groundwater contribution to baseflow (river baseflow, springs and seeps). The available baseflow information for the region is a national dataset derived from the GRAII assessment at quaternary catchment scale (DWAF, 2004), shown in (Figure 6-17). The distribution of groundwater contribution to baseflow closely correlates with the distribution of recharge. Rainfall has a dominant control on recharge, and aquifers with high recharge, can also be reasonably expected to have high groundwater discharge, given a state of dynamic equilibrium in the long term.

This dataset is often the only or major (natural) discharge considered from groundwater. It is simply the only one for which there is a spatial dataset available. Interflow between aquifers, direct evapotranspiration, are discharge mechanisms for which there is not readily available spatial data at regional scale. A widely applied equation for groundwater availability equates availability to recharge minus use (existing abstraction and groundwater contribution to baseflow) minus the reserve. This equation simply yields un-quantified groundwater discharge. All-natural discharge (and some enhanced recharge) may be available, or only a small portion of it, depending on the ability to capture this yield.

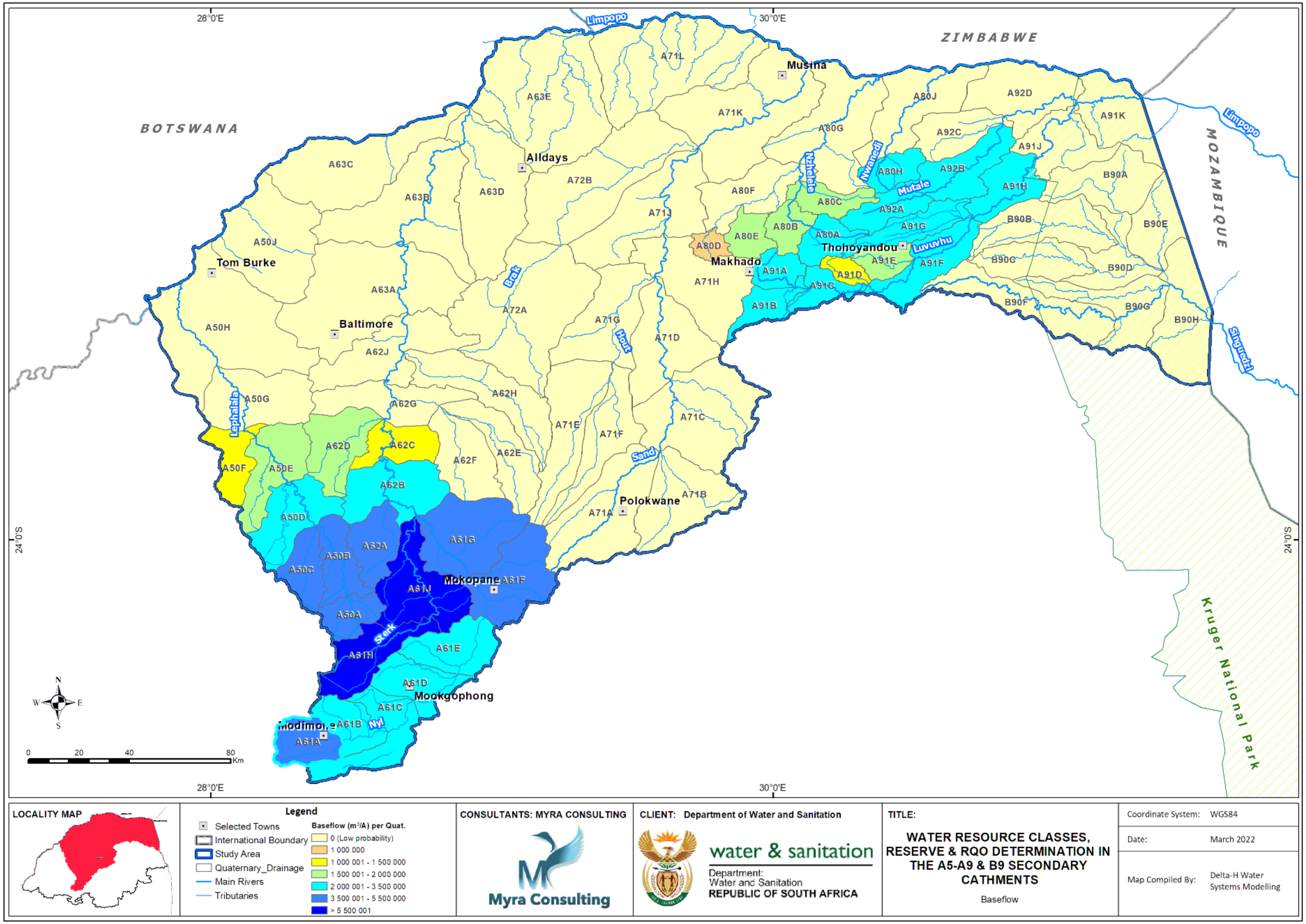


Figure 6-17. Baseflow distribution, per quaternary catchment.

6.3.3.1 Groundwater levels and flow direction

Average water levels for the study area are 20 metres below groundwater level (mbgl). The deepest average water strikes are observed within the Waterberg Karoo Coal Basin, i.e. 89 mbgl, with all other geological setting similar with an average of approx. 40 mbgl (Table 4-2). This is also reflected in the groundwater levels, as the Waterberg Karoo Coal Basin has an average water level of 34 mbgl, whereas the other geological setting of approx. 15-20 mbgl. The deeper water recorded water strikes and water levels may be because of deep drilling into the underlying confined Waterberg Group strata. The reflection of shallow water levels and water strikes observed at the other geological setting could imply that the weathered aquifer system is targeted, rather than the deeper aquifer systems.

Based on the hydrographs (obtained from the HYDSTRA data) majority of groundwater levels indicate a decrease in groundwater levels. Recharge events are observed for most monitoring boreholes, with groundwater levels recovering to long-term average levels (during periods of above average rainfall). Aecom (2015) provided a series of groundwater level heat maps for certain periods from 1960 to present which shows the areas affected by abstraction over the Limpopo WMA over time.

A large-scale groundwater contour map based on the latest HYDSTRA groundwater levels is shown in Figure 6-15. Regionally groundwater levels mimic surface topography and shallow groundwater flow is from higher lying ground towards surface drainages. The main flow direction is towards (and along) the Limpopo River towards the north and northeast.

6.3.3.2 Groundwater use

The sum of registered groundwater use (WARMS) per GUA is shown in Table 6-10 and to assess the current exploitation of the units the volumes was compared to recharge as well as the harvest and exploitation potential.

> Groundwater Availability (GRA II)
>
> The volume of water that may be abstracted from a groundwater resource based on the concept of an 'exploitability factor' and yield (borehole) distribution which relates to the **Groundwater Exploitation Potential (GEP)**. The volume of water that may be abstracted from a groundwater resource may ultimately be limited by anthropogenic, ecological and/or legislative considerations, which ultimately is a management decision that will reduce the total volume of groundwater available for development – referred to as the **Utilisable Groundwater Exploitation Potential (UGEP)**, which accounts for the Reserve by prescribing a fixed-level below which the groundwater level may not decline.

A map showing the distribution of registrations is in Figure 6-18. This map also illustrates a density function which sums the groundwater registration (L/s) per km^2, emphasising clustered use and high registrations. The three largest groundwater use sectors are large scale irrigation from farmlands, water services to communities and towns/cities and mining, as illustrated in Table 6-10.

Groundwater use in terms of distribution, is significantly higher along the Nyl river system, following downgradient northwards the sand river system. Large clusters of groundwater use are observed at the Bela-Bela/Modimolle towns, Polokwane and downgradient from Albasini dam (farmland irrigation). Widespread groundwater use is mostly associated with local communities and irrigation use. Groundwater use clustering is less in the central west and far east (Kruger National Park). Using the present groundwater utilisation data and comparing it with the exploitable volumes shows that the Lephalala (A50-3), Upper Mogalakwena (A61-3), Upper Sand (A71-1; A71-2), Sandbrak (A71-4), Nzhelele (A81-2), Nwanedi (A81-3) and Luvuvhu (A91-1) GUAs are heavily exploited while the Lower Sand and Limpopo Tributaries (comprising of abstraction from the Limpopo Alluvial Aquifers) exceed the exploitation potential.

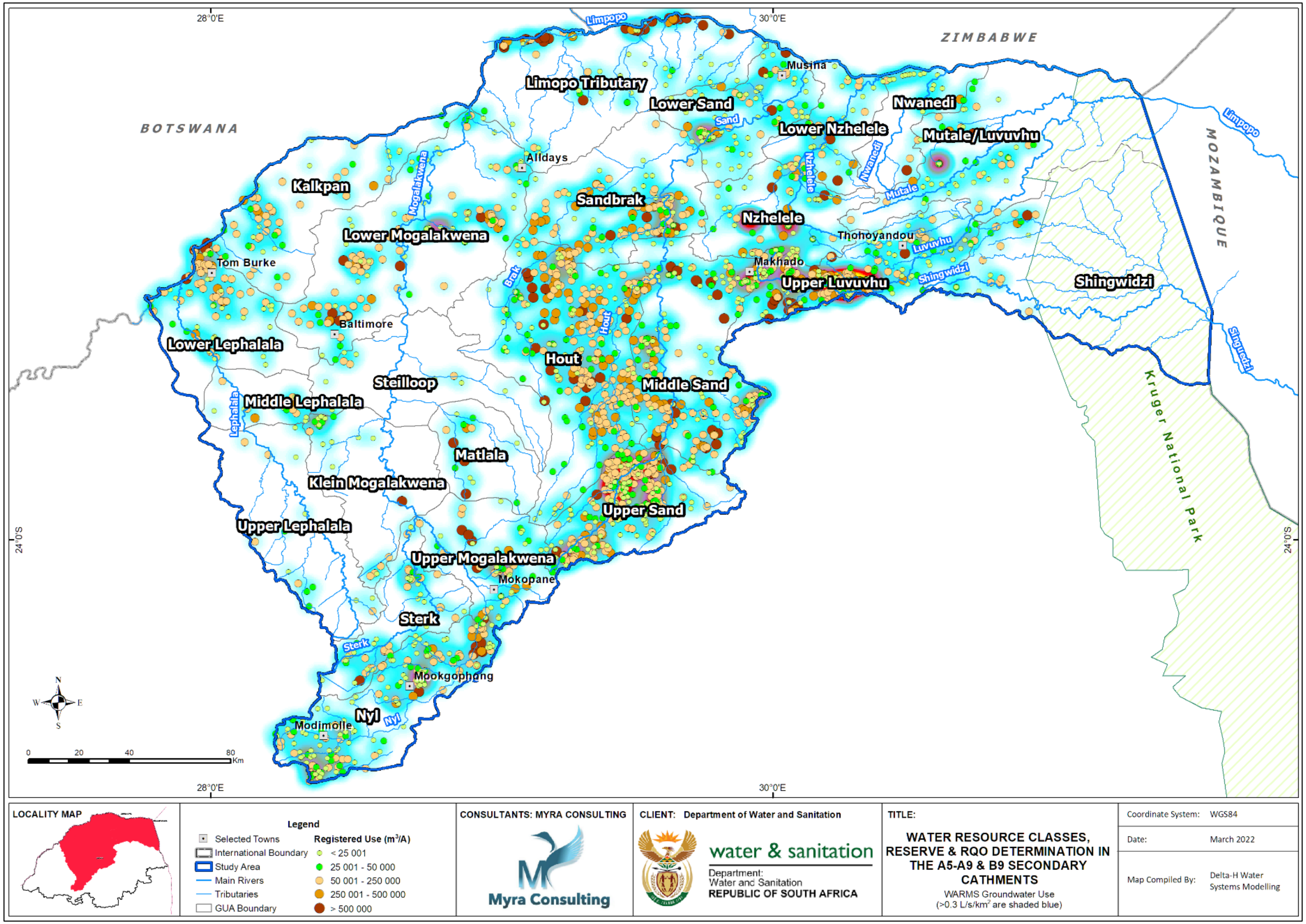


Figure 6-18. Map showing distribution of registered groundwater abstractions and areas with groundwater use >0.3 L/s/km² shaded.

Table 6-10. Groundwater use (WARMS) compared to the exploitation potential of the GUA.

Drainage system	GUA	Groundwater Use (Mm³/a)	Harvest Potential (Mm³/a)	Groundwater Exploitation Potential (Mm³/a)	Utilisable Groundwater Exploitation Potential (Mm³/a)	Exploit % (Use vs. GEP)
Lephalala	A50-1	0.71	34.35	249.83	40.83	0.3%
	A50-2	1.29	5.82	11.30	6.06	11.4%
	A50-3	11.55	12.17	20.77	10.30	55.6%
	A50-4	4.25	13.04	12.28	7.43	34.6%
Upper Mogalakwena	A61-1	15.17	42.01	102.19	15.93	14.8%
	A61-2	4.14	20.37	94.69	8.94	4.4%
	A61-3	12.49	10.85	18.15	8.07	68.8%
Middle- and Lower Mogalakwena	A62-1	1.75	26.03	193.56	26.77	0.9%
	A62-2	3.82	14.30	29.93	15.35	12.7%
	A62-3	1.01	21.48	140.09	48.07	0.7%
	A63-1	15.98	37.48	73.42	33.99	21.8%
	A63-2	1.58	14.75	14.86	8.35	10.6%
Upper Sand	A71-1	37.65	21.11	45.27	11.46	83.2%
	A71-2	40.63	31.10	74.53	25.81	54.5%
	A71-3	44.82	46.68	119.67	16.95	37.5%
Sandbrak	A71-4	19.39	17.41	27.73	14.25	69.9%
Lower Sand	A71-5	13.97	5.32	8.33	4.21	167.7%
Limpopo Tributaries	A63-3/71-3	46.97	16.87	19.89	9.35	236.1%
Kalkpan	A50-4/A63-2	5.83	27.79	27.15	15.77	21.5%
Nzhelele	A81-1	8.40	14.76	55.13	33.61	15.2%
	A81-2	5.50	5.24	9.81	5.68	56.0%
Nwanedi	A81-3	5.97	5.01	11.92	6.40	50.1%
Levuvhu	A91-1	61.10	27.15	102.65	66.75	59.5%
Mutale /Levuvhu	A91-2	3.70	27.65	82.35	49.14	4.5%
Shingwedzi	B90-1	2.24	47.32	82.22	31.89	2.7%

Table 6-11. Groundwater use (WARMS) per groundwater use sector.

Groundwater Use Sector	Registered Use (Mm3/a)
Agriculture: Aquaculture	0.35
Agriculture: Irrigation	284.01
Agriculture: Wearing Livestock	2.13

Groundwater Use Sector	Registered Use (Mm3/a)
Industry (Non-Urban)	5.41
Industry (Urban)	4.89
Mining	19.99
Power Generation	0.004
Recreation	0.06
Schedule 1	0.60
Water Supply Service	46.66
TOTAL	364.09

However, not all groundwater use is registered, even use by water services providers and/or municipalities. Domestic water supply was informed by the first and second phase of the DWS All Towns Reconciliation Strategy Study (DWA, 2012a). Through the merging of datasets and application of several assumptions, a dataset of the current water supply makeup to all settlements (towns and villages) was generated (Le Maitre et al., 2018). All those with a groundwater supply of greater than 50% of the total available water supply are shown in Figure 6-19. A groundwater supply of greater than 50% is classified as “sole supply” from groundwater, according to (DWA, 2011).

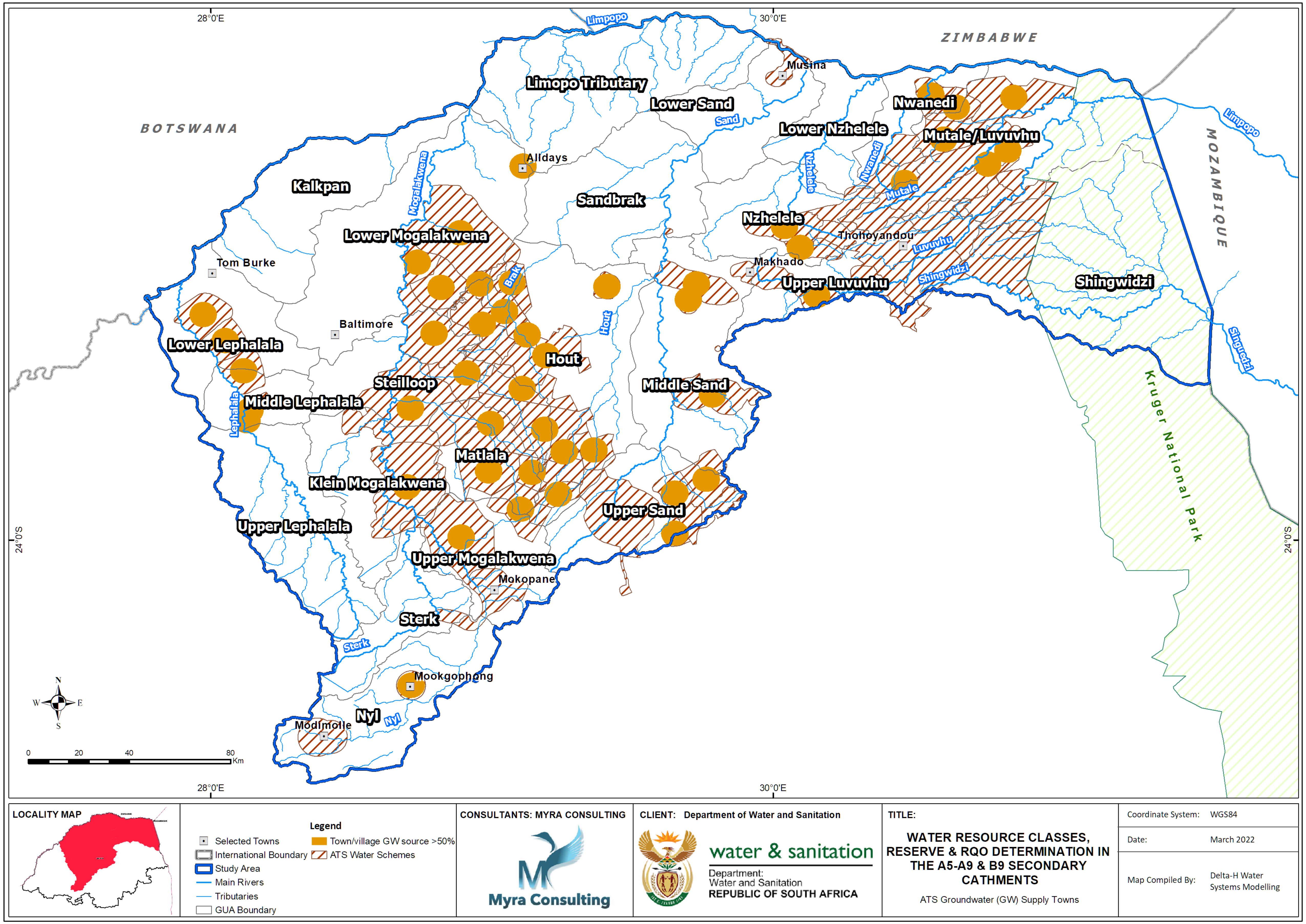


Figure 6-19. Towns and villages where groundwater is >50% of the water supplied.

6.3.3.1 Groundwater quality

The median groundwater quality for selected parameters was calculated for each GUA, as shown in Table 6-12. Approximately 2100 groundwater quality samples were collated from the available databases (e.g. GRIP and WMS). Major elements (pH, EC, Ca, Mg, Na, K, SO_4 Cl, NO_3 as N and F) were compared to the water quality guidelines for acceptable drinking water specified by the Department of Water and Sanitation, inclusive of three water quality classes. The most noticeable elements of concern for water consumption are nitrate (measured as nitrogen (N), with some exceedances observed for fluoride, and sodium.

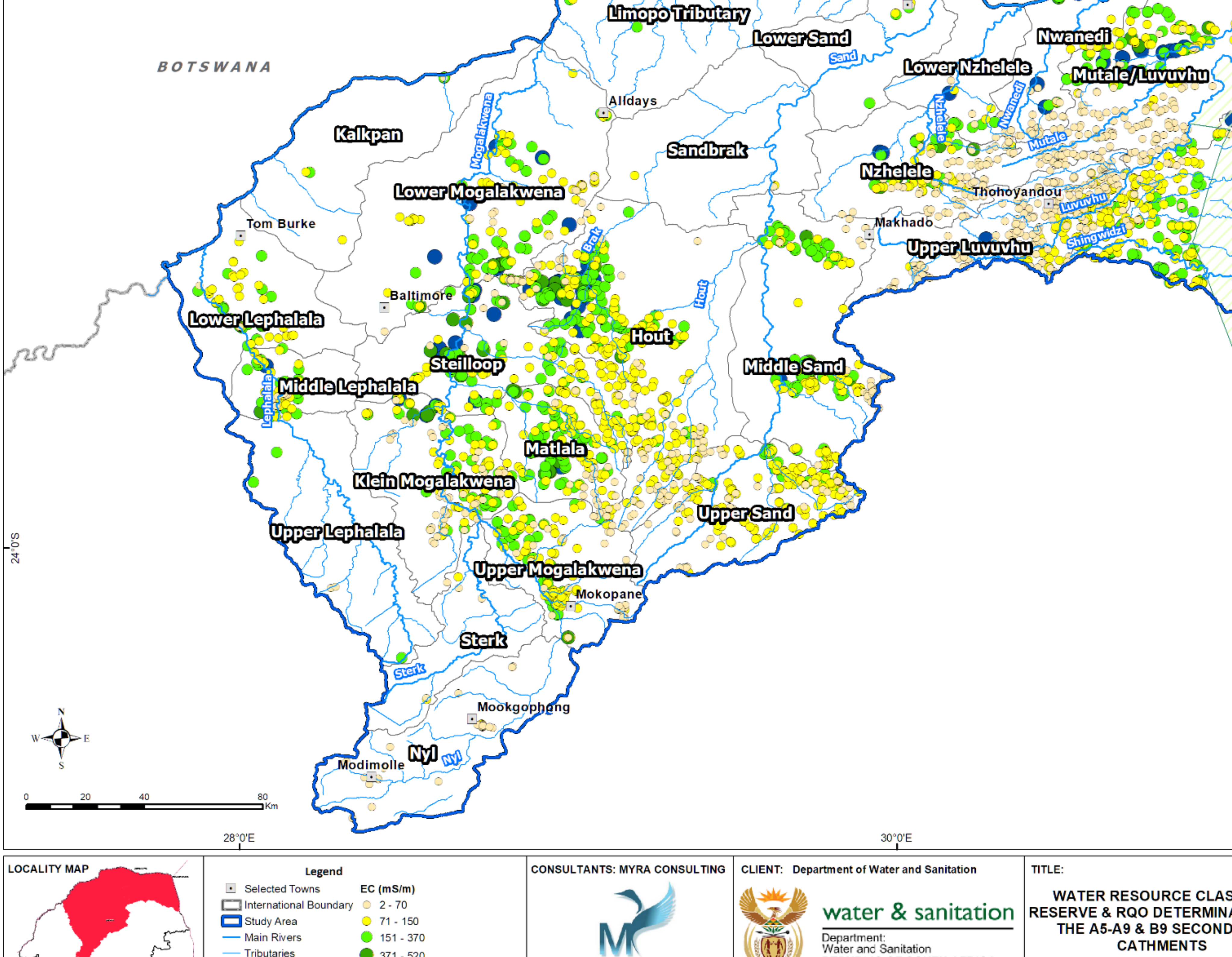
The main inputs of nitrate to groundwater in rural environments are derived from anthropogenic activities such as inappropriate on-site sanitation and wastewater treatment, improper sewage sludge, drying and disposal, and livestock concentration at watering points near boreholes. However, the extensive occurrence of nitrate in groundwater in uninhabited regions may suggest non-anthropogenic sources possibly related to evaporative enrichment of dry and wet deposition, biogenic point sources through N-fixing organisms, or to a geogenic origin (Tredoux and Talma, 2006). Several samples show major ion concentrations (i.e. Na and F) with elevated salts. This can mostly be related to evaporative concentration of elements in discharge areas or due to low recharge values as well as long residence times for selected samples. The occurrence of fluoride is primarily controlled by geology and climate. Therefore, there are no preventative measures under the given spatial limits of water supply to avoid contamination.

The spatial distribution of the collated (last analysed) Electrical Conductivity (EC) concentrations (in mS/m) is shown in Figure 6-20. While it may not reflect a specific point in time it does provide an overall indication of the salt loads for comparison purposes. The EC intervals is based on the DWAF (1996) domestic use water quality classification/guideline. Most notable hotspots occur in the Steilloop GUA as well as Lower Lephalala GUA, Upper Mogalakwena GUA, Hout GUA along the Brak River and the Mutale/Luvuvhu GUA.

Table 6-12. Median water quality for selected parameters (in mg/l) per GUA, compared to DWAF drinking water guidelines (red text exceeds Class III).

GUA	GUA	Stat.	pH	EC (mS/m)	TDS	Ca	Mg	Na	K	SO_4	Cl	NO_3 as N	F
DWAF Class I			5-6 or 9-9.5	70-150	450-1000	80-150	30-70	100-200	-	200-400	100-200	6-10	0.7-1
DWAF Class II			4-5 or 9.5-10	150-370	1000-2000	150-300	70-100	200-600	-	400-600	200-600	10-20	1-1.5
DWAF Class III			3.5-4 or 10-10.5	370-520	2000-3000	>300	100-200	600-1200	-	600-1000	600-1200	20-40	1.5-3.5
Lephalala	A50-1	Median	7.8	143.0	738	90.5	38.0	170.1	2.8	25.7	175.9	0.6	1.6
		N	5	5	4	5	5	5	5	5	5	1	5
	A50-2	Median	8.1	127.0	993	72.0	48.7	137.8	2.9	39.4	157.8	115.1	1.2
		N	61	65	56	67	67	67	67	67	67	11	64
	A50-3	Median	8.1	125.2	952	69.3	58.5	103.2	9.0	30.5	107.0	48.9	1.0
		N	45	45	33	47	47	47	47	47	47	13	45
	A50-4	Median	7.4	102.0		75.6	60.9	69.2	10.1	16.9	74.5	81.4	0.2
		N	1	1	0	1	1	1	1	1	1	1	1
Upper Mogalakwena	A61-1	Median	7.8	37.5	133	28.2	11.5	34.7	1.3	11.2	16.8	0.9	0.3
		N	19	20	7	21	21	21	21	17	20	13	20
	A61-2	Median	8.1	58.0	469	51.8	19.0	24.2	1.2	12.1	21.3	-	0.4
		N	5	5	5	5	5	5	5	5	5	0	4
	A61-3	Median	8.1	106.7	865	60.0	69.6	60.3	2.0	30.2	75.3	76.0	0.3
		N	132	124	121	135	134	134	128	130	124	12	123
Middle- and Lower Mogalakwena	A62-1	Median	8.1	109.5	761	74.4	39.2	89.7	1.9	12.1	123.9	63.5	0.6
		N	130	143	131	153	152	153	150	136	153	21	147
	A62-2	Median	8.1	124.5	943	54.9	38.0	149.0	8.7	26.5	172.2	59.1	0.6
		N	143	137	144	155	155	154	154	155	155	11	148
	A62-3	Median	8.1	116.0	865	57.3	47.1	130.9	8.5	24.6	164.0	35.9	0.4
		N	155	158	149	170	171	171	171	169	170	18	150
	A63-1	Median	8.1	120.6	884	70.6	58.8	97.8	2.5	25.3	119.1	83.4	0.4
		N	127	128	123	140	139	140	137	127	141	15	132
	A63-2	Median	-	-	-	-	-	-	-	-	-	-	-
		N	0	0	0	0	0	0	0	0	0	0	0
Upper Sand	A71-1	Median	8.1	87.5	650	41.0	35.6	86.5	6.2	26.1	68.5	24.9	0.4

GUA	GUA	Stat.	pH	EC (mS/m)	TDS	Ca	Mg	Na	K	SO_4	Cl	NO_3 as N	F
DWAF Class I			5-6 or 9-9.5	70-150	450-1000	80-150	30-70	100-200	-	200-400	100-200	6-10	0.7-1
DWAF Class II			4-5 or 9.5-10	150-370	1000-2000	150-300	70-100	200-600	-	400-600	200-600	10-20	1-1.5
DWAF Class III			3.5-4 or 10-10.5	370-520	2000-3000	>300	100-200	600-1200	-	600-1000	600-1200	20-40	1.5-3.5
		N	178	180	167	204	201	203	203	198	204	32	179
	A71-2	Median	8.1	125.3	962	57.3	54.4	129.5	7.6	34.8	122.7	44.9	0.3
		N	156	143	136	164	165	164	164	150	166	29	142
	A71-3	Median	8.1	109.6	826	47.8	46.4	111.5	10.0	27.7	140.5	23.8	0.3
		N	320	322	347	389	387	386	385	384	389	39	287
Sandbrak and Lower Sand	A71-4	Median	7.7	110.0	541	66.1	45.0	99.1	2.8	30.1	109.0	34.7	0.5
		N	3	3	2	3	3	3	3	3	3	1	3
	A71-5	Median	8.2	177.5	1330	102.0	82.0	159.4	5.1	104.8	223.8	36.2	0.8
		N	4	4	3	4	4	4	4	4	4	1	4
Limpopo Tributaries	A63/71-3	Median	8.1	131.4	964	95.4	79.6	37.6	1.6	41.0	76.7	-	0.5
		N	2	2	2	2	2	2	2	2	2	0	2
Kolope	A50-4/A63-2	Median	7.4	102.0		75.6	60.9	69.2	10.1	16.9	74.5	81.4	0.2
		N	1	1	0	1	1	1	1	1	1	1	1
Nzhelele	A81-1	Median	7.8	54.7	409	29.6	25.3	30.4	0.7	7.9	34.6	3.1	0.2
		N	142	141	132	146	145	142	120	104	137	10	106
	A81-2	Median	8.0	177.0	1178	73.9	63.1	140.0	1.3	60.3	208.2	-	0.4
		N	15	15	14	15	15	15	15	15	15	0	15
Nwanedzi	A81-3	Median	7.8	70.0	485	18.3	20.2	54.9	1.5	16.8	57.0	16.6	0.2
		N	52	53	45	53	54	53	51	40	52	7	47
Levuvhu	A91-1	Median	8.0	56.3	453	42.0	29.2	23.7	1.0	7.3	29.4	10.9	0.2
		N	288	275	262	329	332	329	282	265	328	62	221
Mutale /Levuvhu	A91-2	Median	7.9	49.1	378	24.1	20.0	38.4	0.9	7.1	38.0	8.4	0.2
		N	228	239	213	257	254	251	227	179	257	28	174
Shingwedzi	B90-1	Median	8.1	121.1	939	67.8	59.6	103.1	2.2	14.3	102.4	71.5	0.4
		N	150	138	124	159	161	160	156	151	161	36	134


BOTSWANA
Limopo Tributary
Lower Sand
Sand
Nwanedi
Lower Nzhelele
Mutale/Luvuvhu
Alldays
Kalkpan
Mogalakwena
Sandbrak
Nzhelele
Nwanedi
Mutale
Nzhelele
Lower Mogalakwena
Thohoyandou
Luvuvhu
Tom Burke
Makhado
Upper Luvuvhu
Shingwidzi
Brak
Baltimore
Hout
Lower Lephalala
Hout
Steilloop
Middle Sand
Middle Lephalala
Lephalala
Matlala
Klein Mogalakwena
Upper Sand
Upper Lephalala
24°0'S
Upper Mogalakwena
Mokopane
Sterk
Sterk
Mookgophong
N
W
E
S
Nyl
Nyl
Modimolle
0
20
40
80
Km
28°0'E
30°0'E
LOCALITY MAP
Legend
Selected Towns
International Boundary
Study Area
Main Rivers
Tributaries
EC (mS/m)
2 - 70
71 - 150
151 - 370
371 - 520
CONSULTANTS: MYRA CONSULTING
CLIENT: Department of Water and Sanitation
water & sanitation
Department:
Water and Sanitation
TITLE:
WATER RESOURCE CLAS
RESERVE & RQO DETERMINA
THE A5-A9 & B9 SECOND
CATHMENTS

6.4 Water Quality

6.4.1 Approach

Assessment of the present surface water quality status quo was based on assessing the fitness for use of the water for key water user sectors, namely irrigation water use, domestic water use, and aquatic ecosystems. The assessment was aligned with the methodology that was used in the Olifants WMA classification study (DWA, 2011). The water quality targets used for the assessment (Table 6-13) were derived using the Resource Water Quality Objectives (RWQOs) Model (Version 4.0) (DWAF, 2006) which uses as its basis the South African Water Quality Guidelines (DWAF, 1996), Quality of Domestic Water Supplies: Assessment Guide, Volume 1 (WRC, 1998) and Methods for determining the Water Quality Component of the Reserve (DWAF, 2008) and are based on the strictest water user criteria (thus represent fairly conservative limits). The fitness for use is described using four water quality categories, namely Ideal (blue), Acceptable (green), Tolerable (yellow), and Unacceptable (red) for concentrations greater than the upper boundary of the Tolerable range. The more blue and green colours are visible in the classification tables, the better the water quality. The more yellow and red visible in the classification tables, the poorer the water quality.

Table 6-13. Water quality criteria used to assess the present surface water quality status

Variable	Units	Bound	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Alkalinity ($CaCO_3$)	mg/l	Upper	20	AAq	97.5	AAq	175	AAq
Ammonia (NH_3-N)	mg/l	Upper	0.015	Eco	0.044	Eco	0.073	Eco
Calcium (Ca)	mg/l	Upper	10	Dom	80	BHN	80	BHN
Chloride (Cl)	mg/l	Upper	40	In2	120	In2	175	In2
EC	mS/m	Upper	30	In2	50	In2	85	Eco
Fluoride (F)	mg/l	Upper	0.7	Dom	1	Dom	1.5	Dom
Magnesium (Mg)	mg/l	Upper	70	Dom	100	Dom	100	Dom
NO_3 (NO_3-N)	mg/l	Upper	6	AIr	10	AIr	20	AIr
pH	units	Upper	≤ 8	In2	<8.4	In2		
		Lower	≥6.5	Air, Aaq, In2	>8.0	Air, Aaq, In2		
Potassium (K)	mg/l	Upper	25	Dom	50	Dom	100	Dom
PO_4-P (Rivers)	mg/l	Upper	0.025	Eco	0.075	Eco	0.125	Eco
PO_4-P (Dams)	mg/l	Upper	0.005	Eco	0.015	Eco	0.025	Eco
SAR	mmol/l	Upper	2	AIr	8	AIr	15	AIr
Sodium (Na)	mg/l	Upper	70	AIr	92.5	AIr	115	AIr
Sulphate (SO_4)	mg/l	Upper	80	In2	165	In2	250	In2
TDS	mg/l	Upper	200	In2	350	In2	800	In2

Variable	Units	Bound	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Si	mg/l	Upper	10	In2	25	In2	40	In2
Chlorophyll *a*	µg/l	Upper	10	Eco	20	Eco	30	Eco

Note on sensitive users column: Air – Agriculture: Irrigation users, AAq – Agriculture: Aquaculture users, BHN – Basic human needs users, Dom – Domestic users, Eco – Aquatic ecosystems, In2 – Industrial 2 users

6.4.2 Description

The primary source of data for the surface water quality analysis was the Directorate Resource Quality Information Services of the Department. Historical data for surface water quality monitoring points in the study area were obtained from the national monitoring network (WMS). The monitoring network and routine river and reservoir water quality monitoring points for the study area are listed in the Water Resources Information and Gap Analysis Report . Monitoring by the Department was paused towards the end of 2017/early 2018 due to budget constraints. At the time of writing this report, sampling and sample analysis was slowly being restored.

The surface water quality status assessment was based on the routine monitoring data collected by the Department in the 10-year period of 2008 up to 2018. The present-day surface water quality status at key points was assessed by categorising the current surface water quality state using the fitness for use criteria (Figure 6-15). For each sampling point the median (50th percentile), 75th percentile, and 95th percentile statistics were calculated for nine water quality variables that are of concern to the key water user sectors in the study area. The median statistic is representative of average water quality conditions, the 75th percentile statistic means that 75 percent of the concentrations were lower or equal to the statistic, and the 95th percentile represents the high concentrations observed at the sampling point but excluding outliers that invariably occur in water quality data sets.

The variables that were selected for the assessment were Electrical conductivity (EC), Total dissolved solids (TDS), Orthophosphate (PO_4-P), Ammonia (NH_3-N), Nitrate (NO_3+NO_2-N), Chloride (Cl), Sulphate (SO4), Sodium adsorption ratio (SAR) and pH.

The selection of the variables was based on the following reasoning:

- EC and TDS provide an indication of the salinity of water resources;
- Orthophosphate (PO4-P) and Nitrate plus nitrite nitrogen (NO3+NO2-N) are indicators of the nutrient enrichment (eutrophication potential) of water resources;
- Sulphate (SO4) is an indicator of mining and industrial mining impacts;
- Chloride (Cl) in an indicator of agricultural impacts, domestic sewage effluent discharges and industrial effluent impacts;
- Unionised ammonia (NH3-N) is an indicator of aquatic ecosystem toxicity;
- SAR is a measure of the effects of irrigation water on soil physical conditions, and
- pH (pH units) is an indicator of acidity/alkalinity, particularly mining impacts as well as natural variability.

In the sub-catchment descriptions colour coded tables are used to indicate the fitness for use category of the median, and the 95th percentile concentration.

The trophic status of the reservoirs monitored as part of the National Eutrophication Monitoring Programme (NEMP) was assessed for the same period (2008-2018) using Chlorophyll *a* data obtained from WMS. The terms *Oligotrophic* (unenriched with plant nutrients, Ideal), *Mesotrophic* (moderately enriched with plant nutrients, Acceptable), *Eutrophic* (enriched with plant nutrients, Acceptable), and *Hypertrophic* (highly enriched with plant nutrients, Unacceptable) were used to describe the trophic status of a reservoir.

6.4.3 Status Quo Assessment

6.4.3.1 Lephalala River in Secondary Catchment A5

The current surface water quality of the Lephalala River is either acceptable or ideal with the exception of pH, phosphates and sulphates which are unacceptable. The land use of the Lephalala River is mainly agriculture. Witpoort is a small town with the wastewater treatment not operating efficiently. The Lepalale River has a deteriorating water quality trend due to agricultural runoff and mining activities in the catchment.

Bruyns (2016) investigated the impacts of pollution for coal fired power stations in the Waterberg District Municipality on water quality in the Lephalala, the Mokolo and the Matlabas rivers. For the Lephalala River it was concluded that the sulphate fluxes within the Lephalala River were found to be significantly related to the amount of coal burned at the Matimba power station. It was further stated that Lephalala and Mokolo River Catchments were highly developed catchments, with a continual influx of people seeking employment at the mines and power stations. The current population size already exceeded the capacity of the existing sewerage, housing and power supply infrastructure as many households do not have access to these basic services. Leaching of ions from sewerage, waste water and household and agricultural chemicals may be the principal driver of water quality degradation within these rivers.

In 2018 a baseline aquatic biomonitoring assessment for a proposed sand mining project was undertaken in Lephalala River in Abbottspoort Village in the A50G quaternary catchment. It was concluded, inter alia, that the chemical parameters in the Lephalala River were all within Target Water Quality Ranges (TWQR's) for aquatic ecosystems except for the Dissolved Oxygen which was slightly below TWQR, but not considered to be sub-lethal or lethal. Potential impacts related to the alteration of water quality – due to increases in nutrients and from toxic contaminants during dredging and construction activities - are of a high significance before mitigation measures but rated as medium after mitigation measures.

Oberholster et al. (2010) reported the first record of *Ophrydium versatile,* a symbiotic ciliate that forms gelatinous colonies, in the middle Lephalala River. They found the river to be in an oligotrophic state (unenriched with plant nutrients) with low salinity (recorded as electrical conductivity). They found water quality in the middle reaches of the Lephalala River to be in a good state but expressed concerns about return flows containing agrochemicals from areas of irrigated agriculture located upstream of their study site which could pose potential risks to water quality.

A baseline assessment that was done in 2012 by the CSIR for Eskom to determine the long-term impacts of coal-based power generation in the Waterberg coalfields areas found that water quality in the Lephalala River to be very good in the upper reaches and good in the middle reaches. They found the presence of the benthic algal genus *Zygnema* to be a good indicator of unpolluted waters because it is intolerant to heavy metal and nutrient pollution (Annon).

<u>Rivers</u>

Water quality in the upper third of the Lephalala River as recorded at A5H004Q01 (Lephalala at Muisvogelkraal) (A50B quaternary), just upstream of the EWR Site R-IV-11, is very good and in an Ideal[1] category for all the constituents assessed. Occasional (< 5% of the time) elevated orthophosphate concentrations were observed in an Acceptable category. At the Susandale sampling point (A50G quaternary), upstream of the Susandale Dam, water quality is in an Ideal category except for orthophosphate that is classified as Unacceptable. However, this is an anomaly of the water testing laboratory that had a lower detection limit of 0.2 mg/l. Just downstream of that water tests at RQIS found that PO4-P concentrations is in an Ideal category for rivers. In the lower reaches at sampling point A5H008Q01 (Ga-Seleka Village Bossche Diesch 53 LQ R572 Bridge) (A50H quaternary), about 8km upstream of EWR Site R-I-8 near the confluence with the Limpopo River, water quality is Ideal for the parameters assessed although elevated phosphate concentrations are observed from time to time that falls within Acceptable (75th percentile) or Unacceptable (95th percentile) categories. This could be due to agricultural return flows, domestic wastewater discharges and/or runoff from villages near the lower Lephalala River.

In general, water quality in the Lephalala River is good with low salinity, sulphates etc., but some elevated nutrients observed in the lower reaches of the river.

Table 7-4: Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Lephalala River (A5)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A5H004Q01	A50B	85	5.700	9.061	57	19.976	36.144	87	4.400	7.300	85	0.000	0.001	88	0.050	0.216	88	0.010	0.030	75	0.402	1.188	85	1.500	3.000	90	7.028	7.597
MELK RIVE	A50B	12	4.800	91.360	0			12	3.080	32.800	1	0.002	0.002	7	0.200	1.380	9	0.050	3.160	6	0.516	1.120	12	1.470	87.280	13	7.500	8.110
SHONGWANE	A50D	34	10.475	86.000	0			43	6.840	61.800	8	0.001	0.134	13	0.200	29.530	14	0.200	0.200	23	0.815	1.554	38	5.000	30.000	42	7.200	7.800
SUSANDALE	A50G	33	11.000	48.100	0			42	11.050	36.100	9	0.001	0.004	11	0.360	2.190	17	0.200	0.200	23	0.873	1.467	36	5.000	39.000	41	7.500	8.000
A5H003Q01	A50H	2	54.462	57.400	2	238.810	268.719	2	36.150	39.600	2	0.005	0.007	2	0.703	1.356	2	0.010	0.010	2	1.375	1.386	2	11.072	12.800	2	8.100	8.399
A5H008Q01	A50H	56	11.797	29.600	20	56.281	133.743	67	10.800	21.910	44	0.001	0.014	42	0.210	0.955	44	0.010	0.200	40	0.762	1.248	55	3.090	18.000	65	7.626	8.300
GROBLERSB	A50H	36	46.300	113.060	0			47	40.400	79.300	10	0.002	0.009	17	0.200	11.310	22	0.200	0.200	23	1.494	1.920	40	34.460	61.090	46	7.950	8.600
HERENBERG	A50H	28	16.920	39.200	0			37	12.700	30.300	7	0.001	0.003	9	0.320	37.340	15	0.200	0.200	22	0.852	1.493	32	5.000	31.000	36	7.400	8.100
A5H006Q01	A50J	52	51.755	99.802	22	296.284	528.143	53	48.600	78.000	53	0.004	0.018	46	0.093	0.829	46	0.010	0.110	35	1.485	2.611	45	45.168	81.363	54	8.120	8.600

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable[6]

[6] The water quality categories "Ideal", "Acceptable", "Tolerable" and "Unacceptable" are used to describe the water quality status. These terms are defined in DWAF (2011), and it describes the fitness for use ranging from ideal with no impacts on any water uses, to unacceptable for a quality where the water becomes unfit for most uses.

Dams

Water quality in the Vischgat Dam (A5R001Q01) (A50E quaternary) and the Susandale Dam (A5R002Q01) (A50H quaternary) is in a very good state with respect to all the parameters that were assessed except for orthophosphate concentrations and pH values greater than 8 being observed occasionally. The median orthophosphate concentrations are in an Acceptable category, but occasionally (95th percentile) elevated P concentrations are observed that falls within an Unacceptable category for dams. This implies that short duration algal blooms may develop when the other growth controlling factors such as water temperature and water clarity are favourable. These dams are not part of the National Eutrophication Monitoring Programme and no chlorophyll data exists for them to assess their actual trophic status.

Table 7-5: Present day "fitness for use" categories for selected water quality variables at selected reservoir water quality sampling points in the Lephalala River (A5)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	-Unio	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A5R001Q01	A50E	53	9.029	19.278	33	40.404	134.558	55	7.100	17.070	54	0.001	0.003	55	0.050	0.202	54	0.010	0.032	44	0.698	1.225	53	1.500	5.312	56	7.466	8.225
A5R002Q01	A50H	49	10.377	30.566	34	55.249	117.655	50	8.355	23.400	50	0.001	0.004	50	0.050	0.451	50	0.010	0.028	39	0.766	1.416	49	1.500	6.565	50	7.563	8.080

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

6.4.3.2 Mogalakwena River in Secondary Catchment A6

The drivers of water quality in this catchment are the towns of Modimole, Dimune, Nylsvley, Mokopane and Mookgophong all of which have the challenges of wastewater treatment works (WWTWs). Furthermore, there are large platinum mines in the upper catchment with nitrate problems from blasting as well as seasonal elevated turbidity levels from runoff from mining activities. Glen Alpine Dam is used for commercial agriculture of potatoes and tomatoes.

Baker (2018) undertook water quality sampling in the Nyl River floodplain system as well as the Mogalakwena River up to confluence with the Limpopo as part of a MSc study into aquatic macroinvertebrate diversity. It was concluded that water quality in the upper reaches of the Nyl River was mostly natural, with elevated levels of some metals (e.g. Mn and Fe) being attributed to geo-chemical processes. It was also found that despite its recent infrastructural and capacity upgrades to the Modimolle WWTW 2016 the works was found to be the primary contributor of allochthonous nutrients entering the upper Nyl River system. This resulted in a significant decline in aquatic integrity. The results showed that the sewage effluent discharge was impacting the sediment composition, water quality and macroinvertebrate community assemblages at the point of discharge and downstream of the site. Downstream of the discharge severe organic pollution was evident, highlighted by elevated nutrients, EC, COD, and depleted dissolved oxygen concentrations. The decreased levels of most of the tested variables downstream of the wetland indicated that it acted as a ‘filter’, purifying the waters from polluted streams, and allowing macroinvertebrate community assemblages to recover. The overall water quality of the Mogalakwena River was determined to be good, with only Fluoride, Aluminium and Vanadium showing elevated concentrations.

Sekwele (2008) studies metal concentrations in the rivers upstream of the Nyl floodplain and the floodplain itself. Previous studies in the study area have shown that there were heavy metals occurring at elevated concentrations. These were cadmium, lead, zinc, copper and chromium. The study focused on Naboom Spruit and Tobias Spruit, both tributaries of the Mogalakwena River. The objective was to determine the levels of selected metals within the system and to prove the hypothesis that wetlands act as pollutant filters. The study was also undertaken to further assess levels of those metals which have been recorded to be occurring at high concentration in certain areas within the Mogalakwena River system. A supplementary fish exposure laboratory experiment to determine the rate of uptake of cadmium and zinc by Clarias gariepinus in vitro under controlled conditions was also undertaken. Clear evidence was found to support the hypothesis that sediment tend to have increased free and compound heavy metals, and there was increase in metal concentrations in sediment samples at sites where there was low or no flow as a result of lower turbulence.

Phungula (2018) evaluated the use of diatoms to assess water quality in the Nyl and Mogalakwena River system in partial fulfilment of a MSc qualification. She also found that the Modimole WWTW had a major influence on the system as the peaks in chemical constituents are observed at this site and the site below the WWTW. The nutrient levels decreased in a downstream direction. The WWTW was not functioning properly. The indices used the study showed declining water quality along the Nyl and Mogalakwena river systems, and that the declining water quality was observed during the high flow periods.

Rivers

Salinity in the upper Mogalakwena catchment (A61A) (A6H006Q01, A6H011Q01, and A6H018Q01) is in an Ideal category for most of the constituents evaluated. The median orthophosphate concentrations are in an Ideal category, but slightly elevated concentrations (Acceptable category) are measured from time to time. High salinity, unionised ammonia, nitrogen and phosphates are recorded downstream of the Modimole WWTW at the PHAGAMENG sampling point. This support finding of studies quoted above that the WWTW is not complying with effluent discharge standards. Water quality in the A61B catchment (A6H002Q01, A6H012Q01, A6H019Q01 and A6H020Q01) is mostly in an Ideal category although slightly elevated phosphates have been recorded in the catchment. This could be due to minor irrigation return flows. In the A61C catchment at sapling point A6H037, elevated salts, unionised ammonia and phosphates are measured. On average concentrations are in an Ideal category but occasional elevated concentrations take it into Tolerable/Unacceptable categories. It is not clear why this should be the case as this sampling point at Vogelfontein falls within the Nylsvley wetland. Water quality in the A61F catchment, in and around Mokopane, is poor with elevated salts, unionised ammonia, and phosphate concentrations in the Unacceptable category. High sulphate concentrations are also recorded in the Dorps River at SEKGAKGAP. This could be due to runoff from the industrial area upstream of the sampling point. Water quality in the Pholotsi River downstream of the Mogalakwena platinum mines at sampling point GA-MAPELA is poor with high salts, high phosphates and high sulphate concentrations, all in an Unacceptable category. Water quality in the lower Mogalakwena River upstream of the Limpopo confluence (A6H035Q01) is mostly in an Acceptable category due to elevated salts, pH values and some elevated phosphate concentrations.

Table 7-6: Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Mogalakwena River (A6)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A6H006Q01	A61A	60	8.722	13.399	38	76.681	123.119	59	11.750	18.100	58	0.001	0.007	59	0.040	0.077	59	0.006	0.032	49	0.446	0.990	60	1.500	4.102	60	7.811	8.179
A6H011Q01	A61A	83	5.978	10.500	60	34.326	53.342	85	6.100	9.300	83	0.001	0.001	83	0.318	1.198	83	0.010	0.056	75	0.281	0.672	82	1.500	3.000	85	7.461	7.700
A6H018Q01	A61A	90	5.316	9.700	66	32.396	44.367	89	5.910	8.100	88	0.001	0.003	94	0.196	0.515	94	0.010	0.069	77	0.231	0.660	91	1.500	3.000	89	7.444	7.800
NYLSTROOM	A61A	33	10.800	29.400	1	142.568	142.568	28	14.895	29.500	2	0.007	0.012	13	0.200	8.580	21	0.200	0.200	17	0.666	1.194	29	5.000	32.000	33	7.200	8.000
PHAGAMENG	A61A	25	39.600	84.710	1	151.572	151.572	19	59.000	101.000	3	0.021	0.029	13	0.810	7.700	20	1.665	10.910	9	1.158	2.360	21	18.000	48.040	24	7.260	7.700
A6H002Q01	A61B	12	22.670	37.300	7	123.211	169.912	12	18.630	25.060	12	0.002	0.003	13	0.050	0.415	12	0.010	0.031	8	1.145	1.526	12	1.431	3.900	13	7.851	8.074
A6H012Q01	A61B	80	4.919	9.045	48	43.875	57.440	82	6.775	9.900	80	0.001	0.002	79	0.050	0.212	80	0.010	0.073	66	0.303	0.637	80	1.500	3.559	82	7.651	7.817
A6H019Q01	A61B	65	5.001	9.983	38	33.868	100.806	63	5.413	10.030	61	0.001	0.003	64	0.050	0.365	63	0.006	0.016	55	0.264	0.948	66	1.500	4.227	64	7.392	7.968
A6H020Q01	A61B	57	5.364	8.953	41	39.676	60.671	54	7.000	11.330	54	0.001	0.003	57	0.050	0.100	57	0.010	0.031	42	0.502	0.763	57	1.500	4.900	57	7.600	7.906
A6H037 VO	A61C	27	24.118	53.776	18	130.854	388.345	28	18.540	44.999	27	0.002	0.074	27	0.050	3.426	27	0.035	0.544	19	1.076	1.476	27	1.500	25.900	28	7.661	8.007
A6H010Q01	A61C	71	9.600	20.962	45	94.622	150.002	72	14.675	25.600	71	0.002	0.004	72	0.907	5.178	71	0.010	0.040	59	0.830	1.122	68	3.899	11.176	73	7.900	8.100
A6H021Q01	A61C	14	4.484	5.592	10	28.658	38.935	14	5.650	7.700	14	0.001	0.006	13	0.050	0.126	13	0.010	0.012	10	0.439	1.153	14	1.500	8.850	14	7.281	7.700
A6H024Q01	A61E	19	8.926	11.500	14	84.150	136.139	20	12.555	17.535	20	0.003	0.004	20	0.050	0.337	20	0.010	0.010	15	0.587	1.446	20	1.500	2.016	20	8.000	8.239
A6H001Q01	A61E	12	12.927	35.671	6	123.034	325.985	12	18.950	57.500	11	0.002	0.029	12	0.025	0.050	11	0.028	0.085	9	0.760	1.068	12	1.500	25.279	12	8.008	8.465
MADAHENI	A61F	13	14.600	72.000	0			12	16.150	21.700	0			2	3.025	5.390	7	0.050	0.220	9	0.974	1.089	13	6.320	72.000	12	7.950	9.200
SEKGAKGAP	A61F	23	126.500	247.000	0			22	153.150	335.000	0			1	1.600	1.600	10	6.465	54.200	16	3.204	9.913	20	107.185	1593.550	22	7.550	8.600
MACALACAS	A61F	38	81.950	133.400	1	293.615	293.615	34	127.150	182.600	4	0.041	0.191	14	1.990	43.800	25	0.940	21.300	19	2.585	4.331	34	62.500	295.440	48	7.800	8.260
LEKALAKAL	A61F	67	48.000	73.800	0			61	91.800	115.100	4	0.008	0.014	19	1.720	15.000	39	0.200	3.200	39	1.319	1.746	60	22.985	45.000	79	8.300	8.700
MADIBA MA	A61F	8	44.000	52.000	0			6	86.850	94.200	2	0.008	0.014	6	1.525	15.000	8	0.200	1.000	2	1.034	1.329	7	14.000	28.160	9	8.300	8.800
GA-MAPELA	A61G	16	102.000	305.100	0			16	170.650	242.600	1	0.004	0.004	2	1.875	3.700	7	0.300	3.400	14	2.021	4.220	16	307.205	672.710	16	8.500	9.600
A6H036Q01	A61J	3	11.063	14.500	2	78.018	92.298	2	10.880	12.040	2	0.001	0.001	3	0.050	0.084	3	0.010	0.030	3	0.891	0.931	3	1.500	1.500	2	7.710	7.781

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

<u>Dams</u>

Water quality in Doorndraai Dam on the Sterk River (A6R001Q01) (A61J quaternary) is in an Ideal category except for except for orthophosphate concentrations (95th percentile). The median orthophosphate concentrations are in an Acceptable category, but occasionally (95th percentile) elevated P concentrations are observed that falls within an Unacceptable category for dams. This implies that short duration algal blooms may develop when the other growth controlling factors such as water temperature and water clarity are favourable. However, chlorophyll *a* data collected for the National Eutrophication Management Programme (NEMP) indicate that Doorndraai Dam is consistently in an Oligotrophic (unenriched with plant nutrients) state.

In Glen Alpine Dam in the middle reaches of the Mogalakwena River (A6R002Q01) (A62J quaternary) the average water quality is in an Ideal category but elevated salts and nutrients are observed. pH is mostly in an Acceptable category (> 8 pH units) for most of the time but on occasion pH values greater that 8.5 pH units are observed. Elevated orthophosphate concentrations are observed in the dam with median concentrations falling in an Acceptable category, 75th percentile concentration in a Tolerable category and the 95th percentile concentration in an Unacceptable category. The implication is that algal blooms can occur regularly in Glen Alpine Dam. Chlorophyll a data collected for the NEMP indicate that for at least 75% of the time the dam is in an Oligotrophic state, but occasionally the dam may be in a Mesotrophic (moderately enriched with plant nutrients.

Table 7-7: Present day "fitness for use" categories for selected water quality variables at selected reservoir water quality sampling points in the Mogalakwena River (A6)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A6R001Q01	A61J	50	6.700	8.600	43	67.409	76.476	56	10.010	12.400	51	0.002	0.009	56	0.050	0.132	55	0.010	0.050	46	0.602	1.093	50	1.500	3.200	51	7.850	8.000
A6R002Q01	A62J	127	26.795	74.500	81	171.147	512.609	130	24.982	75.700	126	0.004	0.026	128	0.050	0.448	127	0.010	0.319	93	0.981	2.490	128	6.048	16.604	131	8.144	8.500

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

6.4.3.3 Sand River in Secondary Catchment A7

In general, water quality in the A7 catchment is impacted by effluent from WWTWs in the area. There are also many areas of sand and aggregate mining in the A7 catchment, brick making factories and one silica mine and factory. However, there are no coal mining activities in the catchment. There is also intensive agricultural activities near the rivers which could contribute to the nutrient levels in the river.

In the A71A catchment, Seanego and Moyo (2013) and Seanego (2014) investigated the impacts of wastewater effluent discharges from the Polokwane and Seshego WWTWs on the ecological and water quality status of the Sand River up to the confluence with the Diep/Turfloop rivers. The study indicated that due increased population in the city of Polokwane, the Polokwane WWTW was discharging effluent which was substandard. The sewage treatment works was not well maintained, evidence of this was seen in the quality of the effluent from the maturation ponds. Nitrogen and phosphorus concentrations were above the South African effluent discharge limits. The coliform counts posed a potential threat to the downstream communities and could result in contamination of the Polokwane aquifer. The macroinvertebrate communities were greatly affected by the deteriorating water quality as there was an absence of pollution sensitive species and a decline in the diversity in a downstream direction. Despite the deterioration in water quality, the Sand River was still able to maintain a good assimilative capacity and the water was still regarded as suitable for irrigation purposes.

<u>Rivers</u>

The water quality sampling points in the A71A catchment are located on the Sand River and Bloedrivier within the urban areas of Polokwane and Seshego. Their water quality therefore reflects the impacts of urban runoff, agricultural return flows upstream of Polokwane, and perhaps the Witkop Silica Mine. The mine is some distance away from the Sand River on the watershed with the A71B catchment. At many of these sampling points high salts were recorded, high phosphate concentrations and elevated pH values, often in Unacceptable categories. High unionised ammonia concentrations were also recorded in the Sand and Bloedrivier. At A7H010Q01 in the A71H catchment near EWR Site R-I-23, water quality is mostly in an Ideal category and slightly elevated phosphate and pH values occasionally taking the Sand River into an Acceptable category. The lower reaches of the Sand River is poorly monitored with most sampling points located downstream of WWTW outflows. Sampling at A7H005Q01 at EWR Site R-I-25 stopped in 1981, probably in response to the nonperennial nature of the lower reaches.

Table 7-8: Present day "fitness for use" categories for selected water quality variables at reservoir water quality sampling points in the Sand River catchment (A7)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A7H007Q01	A71A	77	59.300	74.700	53	570.537	739.966	79	73.200	93.700	77	0.007	0.092	79	0.377	6.807	78	0.113	1.024	67	1.749	2.263	76	38.579	55.487	81	8.400	8.720
F4 SESHEG	A71A	16	136.800	163.000	0			13	116.000	144.000	2	0.140	0.168	3	1.400	3.900	0			6	4.213	4.409	11	45.000	62.000	13	8.100	8.320
F5 WATERV	A71A	27	20.000	70.830	0			25	30.000	49.600	2	0.020	0.035	5	0.700	3.100	7	0.050	4.560	15	1.777	2.075	22	7.780	52.270	25	7.800	8.200
F6 PIETER	A71A	38	55.000	80.000	0			36	69.000	94.100	2	0.094	0.117	10	0.770	2.870	13	0.190	0.530	20	1.961	2.505	31	42.550	62.000	36	7.800	8.400
F8 POLOKW	A71A	9	19.520	96.240	0			8	36.000	93.100	0			4	0.180	0.510	3	0.220	0.380	4	1.558	1.703	7	5.390	81.000	8	7.695	7.900
F10 NEW P	A71A	30	112.235	154.300	0			28	112.400	142.800	5	0.101	0.338	8	8.510	71.160	9	3.680	9.380	16	3.876	5.496	25	50.640	135.000	29	7.700	8.000
F14 PIETE	A71A	31	23.960	157.000	0			29	58.000	77.900	1	0.003	0.003	8	0.735	2.230	11	0.050	0.310	18	1.042	1.522	26	11.085	31.720	29	7.900	8.500
PILGRIMSH	A71A	18	78.315	162.490	0			18	86.350	142.800	0			2	0.695	1.340	11	0.300	10.810	14	2.029	2.607	18	41.620	56.620	18	8.200	8.500
RAMAGOEP	A71A	17	200.000	342.400	0			16	138.500	255.500	0			2	6.625	8.400	9	0.050	15.080	12	3.404	4.183	16	60.165	131.000	16	8.250	9.100
BLOED RIV	A71A	11	20.400	82.400	0			11	32.800	87.600	0			2	0.050	0.050	5	0.020	0.050	7	1.715	2.027	11	7.640	49.360	11	7.700	8.100
F1 PIETER	A71A	28	63.500	82.000	0			27	74.000	94.600	2	0.052	0.068	6	0.735	2.500	11	0.120	0.740	16	1.733	2.363	24	41.590	59.240	28	8.200	9.100
F9 VAALKO	A71E	5	44.000	204.000	0			3	51.400	144.000	0			2	0.700	0.800	0			1	2.373	2.373	2	42.800	78.000	3	8.000	8.190
A7H010Q01	A71H	74	9.202	16.300	50	66.697	131.933	77	10.400	19.570	77	0.002	0.008	77	0.050	0.232	76	0.010	0.068	62	0.399	0.547	71	1.500	4.625	77	7.830	8.174
MAKHADO -	A71H	15	29.200	72.500	0			14	34.750	89.100	0			4	0.690	2.800	9	0.050	4.630	9	0.544	2.430	15	6.940	30.000	14	7.465	8.000
A7H001Q01	A71J	1	8.769	8.769	1	34.687	34.687	1	8.080	8.080	1	0.001	0.001	1	0.050	0.050	1	0.010	0.010	1	0.133	0.133	1	1.500	1.500	1	7.608	7.608
A7H008Q01	A71K	75	77.653	244.453	24	324.093	771.606	84	59.650	131.400	51	0.006	0.046	54	0.050	0.870	63	0.026	0.230	55	1.769	5.196	67	45.667	109.363	85	8.200	9.100
MESSINA -	A71K	21	168.000	310.290	0			39	123.900	152.400	8	0.444	0.827	21	0.340	10.400	36	2.620	23.780	3	1.953	1.975	22	99.000	172.000	42	7.500	8.000
NANCEFIEL	A71K	22	139.600	202.000	0			40	155.850	183.550	8	1.836	8.162	21	0.200	1.100	38	4.455	12.420	3	2.439	2.450	24	85.830	130.000	43	7.500	7.900
MOKOPANE	A71K	9	29.000	190.780	1	264.222	264.222	11	29.700	157.500	4	0.004	0.006	6	0.295	2.240	10	0.230	10.360	3	1.544	2.179	10	53.630	180.050	11	7.700	8.200

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Dams

There are no dams in the Sand River secondary catchment where the DWS monitors in-lake water quality.

6.4.3.4 Nzhelele River in Secondary Catchment A8

Madilonga et al. (2021) undertook a water quality assessment and evaluation of human health risk in the Mutangwi River, a small tributary of the upper Nzhelele River, near the village of Tshikombani. They found, amongst other, that some of the trace metals (Mn, Ca, Fe, and Mg) were found below the guideline values, while others (Pb and Cd) exceeded the threshold limit. The counts for E. coli (814.5–2169 cfu/100 mL) and Enterococci (333–9396 cfu/100 mL) in the study did not comply with the regulatory guidelines. The water quality status using the water quality index (WQI) indicated that on the average, the water quality from Mutangwi River was poor (WQI > 100). They recommended that water from the river should be adequately treated prior to domestic and agricultural use.

Kori and Mathada (2012) investigated the increase sand mining activities in the Nzhelele valley in response to an increase in demand for sand and gravel for construction purposes. Impacts such as

collapsing river banks, habitat destruction, land use changes and floodplain ponding were identified. Water quality impacts include an increase in total suspended sediment concentrations in the receiving river from sand washing activities.

A PhD thesis by Mokgoebo (2019) used water quality, aquatic species composition and aquatic habitat conditions to assess the River Health Condition of the Nzhelele River upstream of Nzhelele Dam. Here the river transcends six tribal villages. The results indicated that water quality parameters significantly differed among the six sampling sites which explained the variations in diversity of macroinvertebrates that were sampled from the six sampling sites. Pollution tolerant organisms constituted a total of 46.7% and the remaining 53.3% represented pollution sensitive organisms. Water quality modification across the six sampling sites ranged from minimal to moderate, suggesting that the effect of indigenous agricultural activities and other activities did not severely affect the quality of water. Solid waste disposal was only serious at Dopeni and Musekwa villages and minimal at other villages sampling sites.

Olivier et al (2011) investigated the thermal and chemical features of 8 thermal springs located in the northern part of the Limpopo Province. These included Evangelina, Tshipise, Sagole, Môreson, Siloam, Mphephu, Minwamadi and Die Eiland. The springs are associated with faults and impermeable dykes and are assumed to be of meteoric origin. The mineral composition of the thermal waters reflects the geological formations found at the depth of origin. None of the spring waters were fit for human consumption since they contain unacceptably high levels of bromide ions. Six springs did not conform to domestic water quality guidelines with respect to fluoride levels. Unacceptably high values of mercury were detected at Môreson and Die Eiland. Spring water at Evangelina is contaminated with selenium and arsenic. The researchers felt it was important to keep such limitations in mind when determining the ultimate use of the thermal springs.

Odiyo and Makungo (2012) reviewed research into human health related water quality problems and management in rural areas of Limpopo Province. They concluded that land use activities such as effluent released by the growing industrial sectors, domestic and commercial sewage, acid mine drainage, faecal contamination linked to insufficient infrastructure and leaking sewers, improperly sited sanitation systems, domesticated animals grazing too close to water sources, agricultural runoff, and litter and natural sources such as geology contribute to water pollution. Cases of acute diarrhoea and dental fluorosis in rural areas have been shown to result from significant levels of faecal coliforms and fluorides respectively. Household treatment of water for domestic use has been found as an alternative way for providing potable drinking water.

Angliss (2007) undertook a biomonitoring field survey of the Nwanedzi (Nwanedi) River Catchment (A80H and A80J) in 2006-2007. They assessed water quality using handheld meters. They found that at all sites the water was clear and had a low conductivity, indicating a low salt content. This concluded that this was indicative of near natural water quality, due to the absence of industry and formal agriculture in the catchment. Their water quality results indicated that the water quality of the Nwanedzi River was comparable to most lowveld rivers. Only the conductivity in the lower river shows elevated levels. The team postulated that an abrupt rise in the salt load could be attributed to the geological influence of the Tshipise Fault, as well as a significant number of un-rehabilitated mine dumps, lying in close proximity to the river, which could be contributing towards the increase in salinity.

<u>Rivers</u>

Water quality in the Mutshedzi River (A80A) at A8H011Q01 (Mutshedzi Dam on Mutshedzi River: Downstream Weir) and at A8H014Q01 (Beaconsfield 212 MT - on Mutshedzi) is in an Ideal category except some elevated phosphates (Acceptable category). In the Tshitavha at Tshedza Tshitavha Bridge on Tshikhwikhwikhwi (CORDON 21), a tributary of the Mutshedzi River, water quality is in an Ideal category except for elevated phosphates (Acceptable category). These rivers are surrounded by villages and subsistence agriculture close to the river. Grey water runoff and agricultural seepage could account for the elevated nutrient concentrations in the rivers.

In catchment A80B of the Nzhelele River, at HA-RABALI (Nzhelel at Ha-Rabali at Dzanani to Rabali Road Bridge), water quality is in a poorer state. Salts are elevated in Acceptable and Tolerable categories, elevated pH values occur (Unacceptable category) and elevated phosphate concentrations are recorded (median in an Acceptable category, 95th percentile in an Unacceptable category). Here the Nzhelele River is surrounded by villages and subsistence agriculture up to the edge of the river. Grey water runoff and agricultural seepage could account for the elevated salt and nutrient concentrations in the rivers. From there the river flows through the mountain into Nzhelele Dam (see dams description below).

The water quality of the outflow from Nzhelele Dam is in an Ideal category except for slightly elevated pH values (Acceptable category).

There are no monitoring points in the Mutamba River with any long-term data records. The registered sampling points in the river were part of a survey undertaken in the late 70's when two samples were collected.

There are no further water quality sampling points on the Nzhelele River downstream of the Mutamba River confluence where any long-term data record exists. There are a number of citrus irrigation schemes near the river that receives irrigation water from Nzhelele Dam. Water quality impacts in these reaches can be expected to be impacted by return flows with elevated salts and agrochemicals.

In the Nwanedzi (Nwanedi) River (A80H and A80J) water quality monitoring is poor. The only good monitoring points are located at Ṅwanedi Dam and Luphephe Dam or their downstream weirs. Other registered sampling points mostly have one or a few samples collected. The catchment downstream of the two dams are poorly monitored up to confluence with the Limpopo River.

Table 7-9: Present day "fitness for use" categories for selected water quality variables at river water quality sampling points in the Nzhelele River catchment (A8)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A8H011Q01	A80A	3	11.502	12.819	0			3	17.000	17.200	2	0.001	0.001	2	1.309	1.506	2	0.042	0.042	3	0.134	0.270	3	0.375	3.000	3	7.557	7.909
CORDON 21	A80A	36	5.000	10.170	0			37	6.800	13.000	8	0.001	0.003	17	0.440	1.000	21	0.050	0.200	21	0.330	0.357	38	1.845	6.600	42	7.300	7.700
A8H014 BE	A80A	47	10.450	15.700	35	88.569	138.283	50	12.885	20.000	49	0.003	0.018	50	0.541	1.297	49	0.010	0.065	36	0.397	0.617	44	1.250	2.700	50	8.000	8.256
SILOAM 19	A80A	15	44.000	132.740	0			31	42.100	58.800	5	0.010	1.744	18	0.225	29.000	31	0.050	3.100	1	5.149	5.149	17	16.000	69.000	35	7.900	10.700
HA-RABALI	A80B	41	21.000	52.100	0			42	30.600	66.100	8	0.004	0.036	18	0.465	1.000	29	0.050	0.210	25	1.108	1.791	43	5.000	9.900	47	8.000	8.410
A8H008Q01	A80C	1	21.600	21.600	1	196.928	196.928	1	29.300	29.300	1	0.002	0.002	1	0.040	0.040	1	0.020	0.020	1	0.982	0.982	1	5.832	5.832	1	8.165	8.165
KONDOA 19	A80C	8	45.550	148.500	0			8	45.900	221.500	0			4	0.195	1.940	8	0.020	13.870	0			8	2.545	10.250	8	7.900	8.340
A8H009Q01	A80H	80	15.767	26.300	48	62.203	119.181	82	10.915	17.700	82	0.002	0.017	82	0.132	0.737	83	0.010	0.053	58	0.773	1.052	79	1.500	5.300	83	7.676	8.000
A8H010Q01	A80H	79	13.642	22.325	57	57.303	89.872	80	9.690	14.600	79	0.004	0.036	80	0.114	0.433	80	0.010	0.049	66	0.715	1.064	79	1.500	3.000	81	7.586	7.900
TSHAMULUN	A80H	5	6.660	8.700	0			5	4.010	5.000	0			2	0.095	0.140	5	0.020	0.100	0			5	0.500	0.500	5	7.980	8.580
SAVHANI R	A80H	6	10.550	16.220	0			6	5.900	11.290	0			2	0.050	0.050	6	0.020	0.120	0			6	0.945	3.000	6	8.115	8.640
TSHIKAKAV	A80H	5	7.940	10.040	0			5	4.770	6.270	0			2	0.110	0.170	5	0.020	0.090	0			5	0.500	3.650	5	7.700	8.170
TSHINANE	A80H	27	5.100	6.950	0			29	9.600	11.810	1	0.002	0.002	13	0.310	1.200	17	0.050	0.200	15	0.361	0.396	28	1.470	9.300	28	7.750	8.210
MULALA DR	A80J	7	380.610	727.380	0			8	165.400	225.400	0			3	0.200	0.300	7	0.050	0.220	4	4.677	6.814	7	95.940	177.230	8	8.070	8.500
LUPEPE RI	A80J	6	18.760	149.320	0			6	12.965	14.000	0			2	0.585	0.650	6	0.020	13.630	0			6	0.500	19.590	6	7.645	8.220
NWANEDI R	A80J	14	11.975	121.680	0			14	24.150	74.500	0			4	0.235	0.500	14	0.020	0.310	0			14	1.790	39.350	14	7.655	8.770

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

<u>Dams</u>

In Mutshedzi Dam on the Mutshedzi River (A8R004Q01) water quality is in an Ideal category except for elevated phosphate concentrations that are generally in an Acceptable category although high concentrations in the Unacceptable category occur infrequently. Chlorophyll a data collected for the NEMP indicate that Mutshedzi Dam is mostly in an Oligotrophic state (unenriched with plant nutrients) but occasionally in a Mesotrophic state (moderately enriched). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

Water quality in Nzhelele Dam on the Nzhelele River (A8R001Q01) has elevated salt concentrations in an Acceptable category, elevated pH values in Acceptable/Tolerable categories and elevated phosphate concentrations, mostly in an Acceptable category but infrequently elevated to an Unacceptable category. Chlorophyll a data collected for the NEMP indicate that Nzhelele Dam is consistently in an Oligotrophic state (unenriched with nutrients). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

Luphephe Dam on the Luphephe River (A8R002Q01) generally has good water quality (Ideal category) with low salinity although elevated phosphate concentrations have been observed that was classified in an Acceptable category but high concentrations occurring from time to time. Chlorophyll a data collected for the NEMP indicate that Luphephe Dam is consistently in an Oligotrophic state (unenriched with nutrients). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

Ṅwanedi Dam on the Nwanedi River (A8R003Q01) is in a similar water quality state as Luphephe Dam. Chlorophyll a data collected for the NEMP indicate that Ṅwanedi Dam is an Oligotrophic state for at least 50% of the time, but for 25% of the time in is in a Mesotrophic state, and from time-to-time algal blooms occur that is characteristic of Hypertrophic conditions (highly enriched with nutrients).

Table 7-10: Present day "fitness for use" categories for selected water quality variables at reservoir water quality sampling points in the Nzhelele River catchment (A8)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A8R004Q01	A80A	88	6.997	9.667	53	57.450	87.568	87	9.110	12.500	87	0.002	0.011	89	0.108	0.564	88	0.010	0.091	66	0.440	0.679	87	1.500	3.251	89	7.800	8.000
A8R001Q01	A80C	88	24.214	38.100	56	211.526	306.690	91	28.900	39.800	91	0.005	0.016	91	0.050	0.455	90	0.010	0.050	64	0.965	1.381	88	3.626	7.000	91	8.357	8.518
A8R002Q01	A80H	84	18.787	26.800	52	77.047	129.635	87	11.570	18.600	85	0.001	0.007	85	0.317	0.830	86	0.010	0.232	58	0.859	1.263	84	1.500	5.438	88	7.658	8.000
A8R003Q01	A80H	87	19.008	29.200	59	75.312	260.963	89	12.040	30.500	89	0.002	0.011	89	0.115	0.541	89	0.010	0.333	59	0.856	1.290	87	1.500	8.100	89	7.700	8.200

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

6.4.3.5 Luvuvhu River in Secondary Catchment A9

The water quality status of the Luvuvhu River is driven by intensive agriculture of sub-tropical fruits and afforestation in the upper catchment, the urban sprawl of Thohoyandou in the middle catchment and the KNP in the lower end of the catchment. The unacceptable phosphate values that occur all the way into the KNP are as a result of the use of fertilizers for the intensive agriculture, a lesser extent due to wastewater treatment plant effluent from Thohoyandou and the lack of formal treatment for the dense urban sprawl outside the KNP. The water quality trends in the middle to lower Luvuvhu River indicate a deterioration of the phosphates, nitrates and ammonia levels. This deterioration in water quality is a result of the intense agriculture and domestic wastes associates with Thohoyandou and the un-serviced intense dense settlements upstream of the KNP. The Luvuvhu River is subject to ongoing research into the human health and fish impacts associated to the use of DDT for malaria control in the catchment.

Venter et al. (2010) investigated the distribution of the southern barred minnow, *Opsaridium peringueyi* (Pisces: Cyprinidae) in amongst other, the Luvuvhu River. They stated that some of the impacts on the Luvuvhu River include subsistence and commercial farming, sewerage run-off from urban and rural settlements, sand mining, forestry, grazing and poor land-use practices.

The Luvuvhu Letaba ISP (DWAF, 2004) stated that there were two mines within the catchment; the Tshikondeni Coal Mine and the Geocapro Magnesite Mine. These were reported to have no significant impact on the hydrology or water quality in the catchment. Water use by the mines was also very limited. The ISP reviewed water quality in the Luvuvhu and Mutale catchments and it was found that, based on an assessment of the water quality from DWAF data and information from the State of the Rivers Report: Letaba and Luvuvhu River Systems (WRC report no. TT165/01), it was established that the water in the Luvuvhu/Mutale river catchments was of good quality and not adversely affected by the activities in the catchment. The water quality parameters generally do not exceed the SA Water Quality Guidelines. The predominant water quality problem across the catchment was a tendency towards eutrophication.

In the upper Luvuvhu River to the confluence with the Mutshindṷdi River (DWAF, 2004) it was found that water quality was adequate for agricultural purposes throughout the catchment. Water quality assessments indicate that water is of adequate quality for human consumption, however increased nutrients from washing and bathing in rivers does stimulate algal growth. Clay from the river banks is used for brick making, resulting in increased erosion of the banks. The riparian zone is also damaged by clearing of vegetation for firewood and by overgrazing. Lack of adequate solid waste disposal facilities also results in increased litter and pollution of surface water resources. It was reported that at the time, there were a number of sewage treatment plants in the catchment: Thohoyandou WWTW, Malamulele WWTW, and Venda Prison sewage treatment plant. It was found that there was no monitoring data available to assess the sewage treatment plant discharges and that they remained potential sources of pollution. In the Mutale River catchment (DWAF, 2004) there were no water quality gauging stations. The predominant land uses were rural settlements and subsistence agriculture. There were two WWTWs in the catchment namely the Donald Fraser WWTW and the William Earl WWTW. Coal mining takes place in the lower Mutale catchment. The Sambandou Wetland is of ecological importance and threatened by agricultural development.

Monyai et al. (2016) investigated water quality of the Luvuvhu River and its tributaries within the Thulamela Local Municipality. Their study found that the concentration of fluoride, pH, sulphate, Nitrate, and TDS were within the recommended levels for domestic water use in South Africa. However, a high concentration of total acidity was found at Dzindi, Luvuvhu and Mutshindṷdi during the dry sampling period. The level of total alkalinity, nitrates and TDS were found to be high at Lukunde River.

Fouche (2009) studied aspects of the ecology and biology of the Lowveld largescale yellowfish (*Labeobarbus marequensis*) in the Luvuvhu River over a period of three years. It was found that during the sampling period certain physico-chemical water quality parameters fell outside the acceptable ranges for the protection of aquatic life. Despite this, the species was found at all the sites throughout the survey.

Fouche et al. (2013) investigated the establishment of the fishery potential of Ṋanḓoni Dam in the Luvuvhu River. They found that water quality issue in the dam should be addressed as a matter of urgency. The results of their project showed that pollution in the Dzindi and Mvudi river catchment existed and that this was reflected by the decline of water quality at the inflow. They felt that the decline in water quality would extend throughout the dam if no action is taken. They recommended that water quality monitoring, and plans for corrective actions, should form part of any management plan for Ṋanḓoni Dam.

Rivers

There are no water quality monitoring points in the upper Luvuvhu River catchment (A91A Luvuvhu River and A91B Doringspruit River) where long data records exist to assess the water quality in these catchments. Water quality in the Doringspruit River is expected to be impacted by urban runoff from Elim and effluent from the Elim hospital WWTW. The two rivers flow into Albasini Dam.

The median water quality in the outflow from Albasini Dam (A9H020Q01) is in an Ideal category but elevated salts in the Acceptable category are observed infrequently, as elevated phosphate concentrations in the Unacceptable category (95th percentile). There are no sampling points in the Luvuvhu River from downstream of the Albasini Dam (A91C) up the confluence with the Latonyanda River (A91D).

Water quality in the middle reaches of the Latonyanda River (A91D) at A9H027, is in an Ideal category for all the parameters assessed. The 95th percentile for phosphates fall within the Acceptable category. This sampling point is located upstream of the villages of Tshakuma and Mulangaphua, and the irrigation schemes. There is no further sampling point up to confluence with the Luvuvhu River where recent data (2008-2018) is available. Water quality in this river reach could be affected by urban runoff and irrigation return flows.

Downstream of the confluence, in the upper reaches of the A91F catchment, water quality regarded at Ideal at sampling point A9H001Q01 with slightly elevated phosphate concentrations (Acceptable category). At the Luvuvhu sampling point KA-HASANE just upstream of the inflow into Ṋanḓoni Dam, the median water quality is an Ideal category except for salts which could increase to a Tolerable category and elevated phosphate concentrations (Acceptable & infrequent Unacceptable categories).

In the Dzindi River (A91E) water quality is very much impacted by urban runoff and WWTW effluents. At sampling point DZINDI RI located at EWR R-IV-18, the median water quality is in an Ideal category but elevated salts (Tolerable category) and elevated unionised ammonia concentrations (Tolerable category) are observed. This could be due to urban runoff and other impacts. Effluents from the Thohoyandou WWTW is discharged into the Mvudi River. Water quality in the Mvudi River S2-THUS downstream of the WWTW discharge show very high unionised ammonia concentrations (Unacceptable category) and very high phosphate concentrations (Unacceptable category), as well as slightly elevated pH values (Acceptable category).

The outflow from Ṋanḓoni Dam at A9H030Q01, just upstream of EWR R-VII-24, shows the median water quality to be in an Ideal category but with occasional high salts (Acceptable category) and elevated phosphate concentrations (Acceptable and Unacceptable categories).

In the Mutshinduḓi River (A91G) at the Vonḓo Dam outflow, A9H026Q01, the median and 95th percentile water quality is in an Ideal category although slightly elevated phosphate concentrations (Acceptable category) occur from time-to-time. At A9H002Q01 (Mutshinduḓi River at Chibase/Sibase), just upstream of the confluence with the Tshinane River, water quality is in an Ideal category. Water quality in the Tshinane River at A9H003Q01 is in an Ideal category with infrequent elevated phosphates (Acceptable category). Water quality in the middle Mbwedi River at sampling point TSHIVHASE is mostly in an Ideal category although high phosphate concentrations are recorded infrequently at this site. In the Mutshinduḓi River upstream of the Luvuvhu confluence, at EWR R-I-30, at sampling point A9H025, water quality is in an Ideal category for all the constituents assessed.

In the Lower Luvuvhu (A91H to A92D), upstream of EWR site R-I-32, at sampling point A9H012Q01 (Luvuvhu River at Mhingas) water quality is in an Ideal category for all the constituents assessed although elevated phosphates in the Acceptable category is recorded infrequently. At sampling point A9H008Q01 (Luvuvhu River at Shidzivane/Kruger National Park) water quality is in an Ideal category for all the constituents assessed although elevated phosphates in the Acceptable category is recorded infrequently.

Water quality monitoring in the Mutale River catchment (A92A-D) is poor with most sampling points concentrated in the upper reaches of the A92A catchment. Water quality in the upper Mutale is in an Ideal category except for elevated phosphate concentrations (median Acceptable and 95th percentile in an Unacceptable category). Elevated phosphate concentrations are also recorded at TSANDAMA sampling point, on the border with the A92B catchment. In the Sambandou River at Tshitavha Village Bridge (TSHIAVHA sampling point), a tributary of the middle Mutale River, all constituents assessed are in an Ideal category except for slightly elevated phosphate concentrations (Acceptable category). There are no further monitoring points on the Mutale River until you reach Sanari Village in the A92D catchment. At the SANARI VI sampling point, water quality is in an Ideal category for salts but for elevated phosphate concentrations (median Acceptable and 95th percentile in an Unacceptable category). In the Mutale River just upstream of the confluence with the Luvuvhu River, at EWR site R-I-34, at sampling point A9H013Q01, water quality is in ideal category and only slightly elevated phosphate concentrations are recorded in an Acceptable category.

In the Luvuvhu River at Pafuri/Kruger National Park (A91K) at sampling point A9H011Q01 water quality is in ideal category and only slightly elevated phosphate concentrations are recorded in an Acceptable category.

Table 7-11: Present day "fitness for use" categories for selected water quality variables at river water quality sampling points in the Luvuvhu River catchment (A9)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	
DOPENI -	A91B	38	7.825	11.520	0			39	10.800	17.340	7	0.001	0.022	18	0.295	4.900	25	0.100	0.200	23	0.481	0.550	41	2.650	12.000	44	7.400	8.280	
DOORNSPRU	A91B	0			0			1	18.600	18.600	0			1	0.200	0.200	1	0.200	0.200	0			0			1	7.700	7.700	
A9H020Q01	A91C	4	13.126	16.914	3	141.871	221.279	4	22.135	35.510	4	0.003	0.004	3	0.025	0.350	4	0.005	0.200	3	0.430	0.724	4	1.500	5.000	4	7.878	8.523	
STYLDRIFT	A91C	12	14.750	26.000	0			14	27.300	112.000	1	0.001	0.001	2	0.250	0.300	8	0.200	0.870	7	0.573	0.814	10	4.370	33.000	11	7.400	8.100	
NOOITGEDA	A91C	2	15.000	21.000	0			2	15.850	18.000	0			2	0.255	0.310	4	0.200	0.200	0			3	5.000	9.200	2	7.450	7.600	
MUDZWIRIT	A91C	26	22.600	51.000	0			29	38.200	61.800	0			5	1.100	4.800	16	0.650	7.630	18	0.895	1.259	24	9.505	44.400	26	7.410	8.300	
A9H007Q01	A91D	2	5.380	5.489	1	61.163	61.163	2	9.725	10.840	2	0.003	0.005	1	0.111	0.111	2	0.006	0.006	1	0.379	0.379	2	1.750	2.000	2	7.691	7.873	
A9H027 AT	A91D	88	5.277	7.500	57	62.094	79.203	91	9.070	11.320	89	0.002	0.005	91	0.242	0.430	90	0.010	0.039	74	0.363	0.529	88	1.500	3.000	93	7.845	8.022	
KLEIN AUS	A91D	2	6.550	6.800	0			2	7.755	8.140	1	0.001	0.001	2	0.320	0.440	4	0.200	0.200	0			4	5.000	15.000	2	7.450	7.500	
MANITOBA	A91E	1	32.000	32.000	0			1	48.600	48.600	0			1	0.200	0.200	1	0.200	0.200	0			1	11.000	11.000	1	7.300	7.300	
MPHAPHULI	A91E	55	12.000	21.440	0			60	18.150	26.430	4	0.012	0.049	18	1.185	7.100	40	0.235	1.880	29	0.549	0.876	51	3.940	8.930	51	7.500	7.800	
THOHOYAND	A91E	6	11.870	15.490	0			6	19.495	20.690	0			6	1.200	2.320	6	0.020	0.130	0			6	0.500	4.360	6	7.585	7.880	
MANINI VI	A91E	44	17.150	26.200	0			50	29.600	42.300	6	0.005	0.047	20	0.400	1.700	34	0.200	1.100	17	0.553	1.190	37	5.000	33.000	37	7.400	8.100	
DZWERANI/	A91E	0			0			13	20.200	22.500	0			13	0.050	0.200	13	0.050	0.100	0			0			0			
S1 - THUS	A91E	1	8.834	8.834	0			1	14.430	14.430	1	0.010	0.010	1	0.603	0.603	1	0.005	0.005	1	0.447	0.447	1	1.500	1.500	1	7.984	7.984	
S2 - THUS	A91E	1	13.067	13.067	0			1	18.120	18.120	1	0.089	0.089	1	1.653	1.653	1	0.262	0.262	1	0.633	0.633	1	1.500	1.500	1	8.126	8.126	
DZINDI RI	A91E	49	9.800	15.910	0			50	16.900	81.900	1	0.066	0.066	17	0.290	2.110	32	0.050	0.230	29	0.462	0.529	46	1.470	5.190	46	7.700	8.100	
MVUDI RIV	A91E	17	9.640	12.500	0			17	16.000	143.500	0			7	0.420	1.080	15	0.050	0.990	10	0.507	0.553	17	1.470	8.320	17	7.400	8.110	
A9H001Q01	A91F	4	9.803	10.008	2	84.779	86.448	4	13.295	15.300	4	0.002	0.004	4	0.130	0.199	4	0.009	0.071	2	0.486	0.491	3	1.500	2.000	4	7.738	7.850	
VONDO DAM	A91F	3	4.933	4.991	1	36.166	36.166	3	4.220	4.250	3	0.000	0.001	3	0.156	0.681	3	0.010	0.010	2	0.604	0.660	3	1.500	1.500	3	7.186	7.300	
LWAMONDO	A91F	9	7.410	10.080	0			9	13.600	18.800	0			6	0.195	0.350	8	0.050	1.000	3	0.360	0.510	9	0.500	5.000	9	7.660	7.950	
SEGALOS @	A91F	7	10.990	13.050	0			6	15.755	17.100	1	0.004	0.004	6	0.155	0.390	8	0.035	0.200	0			8	0.855	5.000	6	7.765	8.710	
A9H030 NA	A91F	46	9.730	13.000	9	102.145	128.360	46	14.745	44.800	11	0.001	0.014	25	0.200	0.650	36	0.050	0.200	26	0.504	0.700	44	1.660	6.000	42	7.900	8.111	
KA-HASANE	A91F	26	9.400	27.720	0			26	13.450	71.500	0			6	0.135	1.710	15	0.050	0.210	19	0.521	0.570	26	1.725	19.990	26	7.800	8.200	
S3 - DIDI	A91F	1	8.233	8.233	0			1	11.730	11.730	1	0.001	0.001	1	0.053	0.053	1	0.005	0.005	1	0.495	0.495	1	1.500	1.500	1	7.908	7.908	
S6 - MOLE	A91F	1	119.468	119.468	0			1	12.180	12.180	1	0.005	0.005	1	0.025	0.025	1	0.012	0.012	1	0.297	0.297	1	22.741	22.741	1	7.911	7.911	
TSHINO BR	A91F	26	8.850	11.900	0			26	13.050	78.700	0			6	0.145	1.380	14	0.050	0.050	20	0.506	0.560	26	1.470	3.920	26	7.800	8.200	
LUVUVHU R	A91F	14	10.150	53.100	0			14	14.550	81.300	0			5	0.480	0.810	12	0.050	1.640	9	0.550	1.821	14	1.850	13.160	14	7.605	8.800	
UITZICHT	A91G	0			0			2	1059.500	1092.000	1	0.012	0.012	0			2	0.200	0.200	2	45.220	45.356	2	510.000	570.000	2	8.850	9.000	
A9H002Q01	A91G	3	5.949	6.230	2	52.054	52.808	3	11.370	11.510	3	0.001	0.002	3	0.129	0.511	3	0.005	0.005	2	0.471	0.491	3	1.500	1.500	3	7.986	7.998	
A9H003Q01	A91G	92	6.186	8.100	56	77.373	97.202	91	10.800	13.230	89	0.002	0.004	88	0.379	0.662	92	0.010	0.052	68	0.366	0.523	94	1.500	3.000	97	7.897	8.114	
A9H025Q01	A91G	11	8.372	11.710	11	83.859	111.019	10	11.790	15.500	10	0.001	0.005	11	0.150	0.394	11	0.005	0.014	11	0.457	0.572	11	1.500	1.500	11	7.825	8.300	
A9H026 TS	A91G	92	4.449	6.714	57	30.566	47.830	95	5.410	10.700	88	0.001	0.003	92	0.127	0.500	93	0.010	0.042	68	0.267	0.660	92	1.500	3.800	95	7.500	7.935	
TSHIVHASE	A91G	6	7.340	11.290	0			6	5.655	17.000	0			6	0.240	0.810	6	0.020	0.200	0			6	0.500	6.200	6	7.645	8.390	
A9H012Q01	A91H	90	10.206	14.500	56	103.184	131.397	94	14.805	17.700	93	0.002	0.009	93	0.123	0.349	94	0.010	0.056	70	0.521	0.693	91	1.500	2.700	94	7.986	8.300	
TRIBUTARY	A91H	18	8.600	14.650	0			18	13.100	16.030	0			2	0.215	0.320	5	0.050	0.050	15	0.487	0.618	18	2.245	9.330	18	7.800	8.300	
A9H008Q01	A91J	53	10.334	14.970	31	105.883	128.206	53	16.090	19.400	49	0.001	0.006	51	0.050	0.689	51	0.006	0.030	52	0.527	0.887	52	1.500	4.910	55	7.933	8.200	
A9H010Q01	A91K	1	6.600	6.600	1	48.792	48.792	1	8.100	8.100	1	0.002	0.002	1	0.313	0.313	1	0.010	0.010	1	0.624	0.624	1	0.600	0.600	1	7.800	7.800	
A9H011Q01	A91K	59	13.500	20.138	36	116.426	162.979	60	16.075	22.900	59	0.002	0.009	53	0.050	0.250	59	0.010	0.055	53	0.588	0.855	59	1.500	4.600	60	7.980	8.336	
KRUGER NA	A91K	38	58.797	125.646	21	329.703	434.700	39	52.500	85.000	38	0.003	0.012	33	0.040	0.765	38	0.024	0.398	34	1.551	2.675	37	35.338	54.433	39	8.250	8.700	
TSHIDZIVH	A92A	16	4.300	15.380	0			16	2.950	8.170	0			1	0.050	0.050	10	0.050	0.050	15	0.403	0.481	15	1.470	2.930	16	6.700	7.500	
TSHAPASHA	A92A	25	8.000	11.980	0			29	3.780	7.420	4	0.000	0.000	8	0.200	1.200	19	0.050	0.200	20	0.700	0.957	27	1.640	31.000	29	6.400	7.400	
TSHITAVHA	A92B	40	5.900	16.500	0			41	7.790	12.000	7	0.001	0.003	19	0.200	1.300	25	0.080	0.200	24	0.359	0.413	43	2.290	8.600	46	7.400	7.970	
TSHANDAMA	A92B	84	7.200	11.000	0			95	5.200	7.960	10	0.000	0.001	32	0.200	1.000	57	0.050	0.200	62	0.704	0.907	87	1.470	26.000	93	6.800	8.050	
SAMBANDOU	A92B	45	11.300	22.000	0			51	4.720	21.700	6	0.000	0.000	16	0.200	1.360	32	0.050	0.200	29	0.975	1.232	47	2.100	29.000	50	6.200	7.730	
TSHITAVHA	A92B	27	11.700	16.000	0			30	6.255	13.420	3	0.000	0.001	10	0.200	4.510	21	0.050	0.200	18	0.857	1.196	28	1.470	6.600	29	6.900	8.080	
TENGWE 25	A92B	47	10.000	13.300	0			59	7.300	10.800	9	0.000	0.001	17	0.200	14.800	31	0.050	0.200	40	0.812	1.035	51	1.710	30.000	57	6.700	7.300	
A9H013Q01	A92D	57	15.793	31.181	36	91.987	195.000	57	14.800	26.440	55	0.002	0.007	55	0.040	0.323	55	0.010	0.066	51	0.764	1.087	56	1.578	6.512	57	7.863	8.326	
SANARI VI	A92D	25	11.000	29.000	0			29	8.700	17.200	4	0.001	0.015	9	0.200	1.100	20	0.050	4.000	17	0.721	1.534	27	2.350	39.000	26	7.800	8.590	
BILENI TS	A92D	22	12.700	23.000	0			24	9.750	18.000	2	0.007	0.010	7	0.200	3.450	16	0.050	7.600	16	0.757	1.513	24	2.730	31.000	22	7.800	8.080	

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Dams

Water quality in Albasini Dam on the Luvuvhu River (A9R001Q01) in terms of salinity is mostly in an Ideal category with concentrations in the Acceptable category occurring infrequently. Elevated pH values in the Acceptable and Tolerable category are record in the dam. Chlorophyll a data collected for the NEMP indicate that Albasini Dam is consistently in an Oligotrophic state (unenriched with plant nutrients). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

At Vonḓo Dam on the Mutshinduḓi River (A9R002Q01) is in an Ideal category for all the constituents assessed except for phosphate concentrations which is in an Acceptable category for most of the time with infrequent concentrations in the Unacceptable category. Chlorophyll a data collected for the NEMP indicate that Vonḓo Dam is consistently in an Oligotrophic state (unenriched with plant nutrients). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

At Ṋanḓoni Dam on the Luvuvhu River (A9R004) is in an Ideal category for all the constituents assessed except for phosphate concentrations which is in an Acceptable category for most of the time with infrequent concentrations in the Unacceptable category. Elevated pH values in the Acceptable category are observed. Chlorophyll a data collected for the NEMP indicate that Ṋanḓoni Dam is consistently in an Oligotrophic state (unenriched with plant nutrients). The potential for short term algal blooms do exist due to elevated phosphate concentrations.

Table 7-12: Present day "fitness for use" categories for selected water quality variables at reservoir water quality sampling points in the Luvuvhu River catchment (A9)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
A9R001Q01	A91B	111	14.863	23.502	66	169.213	219.536	115	22.700	32.900	109	0.005	0.014	109	0.050	0.270	113	0.010	0.070	82	0.503	0.668	112	1.500	5.729	116	8.257	8.430
A9R004 MO	A91F	118	10.318	16.200	72	107.958	130.696	121	15.020	18.600	119	0.003	0.013	121	0.126	0.356	120	0.010	0.069	88	0.543	0.799	120	1.500	5.500	122	8.064	8.200
A9R002Q01	A91G	45	4.800	6.900	23	31.323	42.226	48	5.040	8.340	48	0.001	0.008	48	0.188	0.437	46	0.010	0.027	25	0.433	0.777	45	0.600	1.900	48	7.427	7.721

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

6.4.3.6 Shingwedzi River in Secondary Catchment B9

The majority of the catchment of the Shingwedzi River's catchment falls within the KNP. Outside the land use is mainly subsistence agriculture and informal urban settlements. The unacceptable pH, phosphates and EC values are due to runoff from these land use practises that take place into the flood plain of the river.

Fouche and Vlok (2010) undertook a comprehensive survey of the impacts of water quality on instream biota of the Shingwedzi River. The system was monitored in 2007/2008 to determine the present status of the system. Possible water pollution sources were identified by aerial survey. It was found that water quality parameters frequently exceeded the threshold of potential concern values set by SANParks. The SASS scores were generally low, due mainly to organic pollution as a result of the lack of sanitation infrastructure in the catchment. Fish responses indicated a general ecological decline to a 'category C' river: moderately modified. Of concern was the absence of some fish species that historically occurred in this system. Sources of pollution such as acid mine drainage from abandoned mines, inadequate sewerage infrastructure and habitat destruction due to siltation and sand mining were identified. They concluded that a lack of infrastructure with respect to stormwater drainage and sewage, poor land-use practices and a lack of town planning in human settlements were observed and could have contributed to organic and solid waste pollution in the rivers. Most villages in the catchment did not have formal sewage treatment facilities and their pit latrines could be considered to be the main source of organic pollution. In the larger towns, where WWTWs were present, they were inadequate to handle the existing sewage volumes and, in many cases, those systems were poorly maintained, with visible runoff into streams.

They also observed high phosphate levels during the winter just inside the Kruger National Park and attributed this to a large commercial farming venture located immediately to the west of the KNP fence. At this farm, 20 centre pivot irrigation systems, each about 25 ha in size, were used for the cultivation of cash crops. These systems used liquid fertilisers. The farm was situated just to the north of the Mphongolo River and various small drainage lines and streams were noted carrying irrigation return flows from the cultivated fields to the river.

They also found evidence of mining impacts. Elevated Magnesium, EC and TDS concentrations were observed at Shangoni on the Shingwedzi River. These were probably caused by runoff from the abandoned Giants Reef mine, which lies approximately 3 km to the north-west, upstream of the site. A small stream just north of the mine dump collects acid mine drainage water and flows into the main stem of the Shingwedzi River.

Dams

There is a small dam in the upper reaches of the B90C quaternary, downstream of the Malamulele WWTW near the village of Boltman (BOLTMAN 2). At this sampling point, salts (Chloride and EC) are elevated and in an Acceptable/Tolerable category. Unionised ammonia is very high and in an Unacceptable category and therefore detrimental to aquatic organisms. This confirms the findings of Fouche and Vlok (2010). Nutrients are also in an Unacceptable category. This is probably the result of poor performance of the Malamulele WWTW.

At Silvervis Dam in the Kruger National Park (B9H002) (B90F quaternary) elevated salt (Chloride, DMS and EC) concentrations and pH values are observed. The median Chloride and Dissolved Mineral Salt concentrations are in an Ideal category, but elevated concentrations are observed from time to time that takes the dam into Tolerable categories. This sampling point is at EWR Site R-VI-13.

At Kanniedood Dam, further downstream in the Kruger National Park (B9H003) (B90H quaternary), water quality is mostly in Acceptable or Tolerable categories. The salts, namely Chloride, Dissolved Mineral Salts, and Electrical Conductivity, are classified in Acceptable or Tolerable categories while pH is also in an Acceptable/Tolerable category. Nutrients are low and in an Ideal category. This site is located about 10km downstream of EWR sites R-IV-27 and R-IV-28, and about 14km upstream of EWR site R-I-37.

Table 7-13: Present day "fitness for use" categories for selected water quality variables at river water quality sampling points in the Shingwedzi River catchment (B9)

			Chloride (mg/l)			DMS (mg/l)			EC (mS/m)			NH3(25)-Union (mg/L)			NO3+NO2-N (mg/L)			PO4-P (mg/L)			SAR			SO4 (mg/L)			pH (pH units)	
Point	Quat	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile	N	Median	95%tile
BOLTMAN 2	B90C	23	64.000	85.000	0			44	70.150	88.000	10	0.054	0.467	13	1.600	14.000	24	0.845	5.900	13	1.842	2.304	30	18.255	50.000	44	7.650	8.200
MALAMULEL	B90C	12	58.800	79.000	0			19	75.000	96.000	8	0.019	0.134	9	0.600	16.000	14	0.200	4.200	9	1.810	1.990	14	10.540	44.000	18	7.600	8.200
B9H002 AT	B90F	13	14.379	170.500	7	202.332	780.206	13	21.100	113.900	13	0.001	0.017	13	0.005	0.439	13	0.049	0.299	11	0.972	2.795	13	3.000	19.733	13	7.870	8.713
B9H003 SH	B90H	9	24.138	152.018	3	706.295	724.302	9	38.400	103.200	9	0.003	0.015	9	0.063	0.655	9	0.016	0.284	6	1.600	1.968	9	4.400	8.992	9	8.013	8.699

Note: 95%tile = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

6.5 Wetlands

6.5.1 General Overview

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. The distribution of different wetland types (HGMs – hydro-geomorphic units, Level 4 classification from Ollis *et al.*, 2013) are shown in Figure 6-21. This includes two RAMSAR sites, the Nylsvley floodplain and the Makuleke wetland associated with the Luvuvhu and Limpopo rivers. A more detailed breakdown of wetland distribution and extent within each of the secondary catchments is shown in Table 6-14. It is clear the Lephalala (A5) and Nzhelele (A8) catchments contain the lowest extent of wetlands (Ha), while the Mogalakwena (A6) contains the highest. Furthermore, it is notable that depression and seep wetlands are less extensively represented (about 3000 to 3500 Ha) while valley bottom (both channelled and unchanneled) and riverine wetlands are similarly more extensive (about 16800 Ha), and floodplain wetlands are the most extensive wetland type (19600 Ha). At the quaternary catchment scale, catchment A61D stands out with the highest wetland coverage of 18613 Ha, which represents 24.2% of the total wetland coverage in the study area (Table 6-15). This quaternary catchment is associated with the Nylsvley floodplain system. The quaternary with the next highest wetland coverage is A91K, with 5934 Ha (representing 7.7% of total) and is associated with the Makuleke wetlands of the Luvuvhu and Limpopo rivers. It is notable that both these quaternaries contain the Ramsar sites. In addition, riverine wetlands that do not have a single dominant QC, i.e. traverse QC's represent 21.8% of wetland area.

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, the details of which are shown in Table 6-16 and the distribution of springs, thermal springs, oxbows and waterfalls. The distribution of thermal springs, springs and oxbows in the study area is shown in Figure 6-22 and the details pertaining to thermal springs in Table 6-17. There is also a notable hot spring mire (peatlands) called Malahlapanga in Kruger National Park which was assessed by Grundling *et al.* (2017). The Malahlapanga peatland is about 9 Ha and contains several thermal springs and spring mires and four small peat domes (cupolas). This study also assessed several other peatland wetlands (not within this study area) but importantly found that peatlands in South Africa are mostly groundwater-dependent ecosystems with isotope analysis and water flow measurement results supporting the fact that groundwater is the main driver.

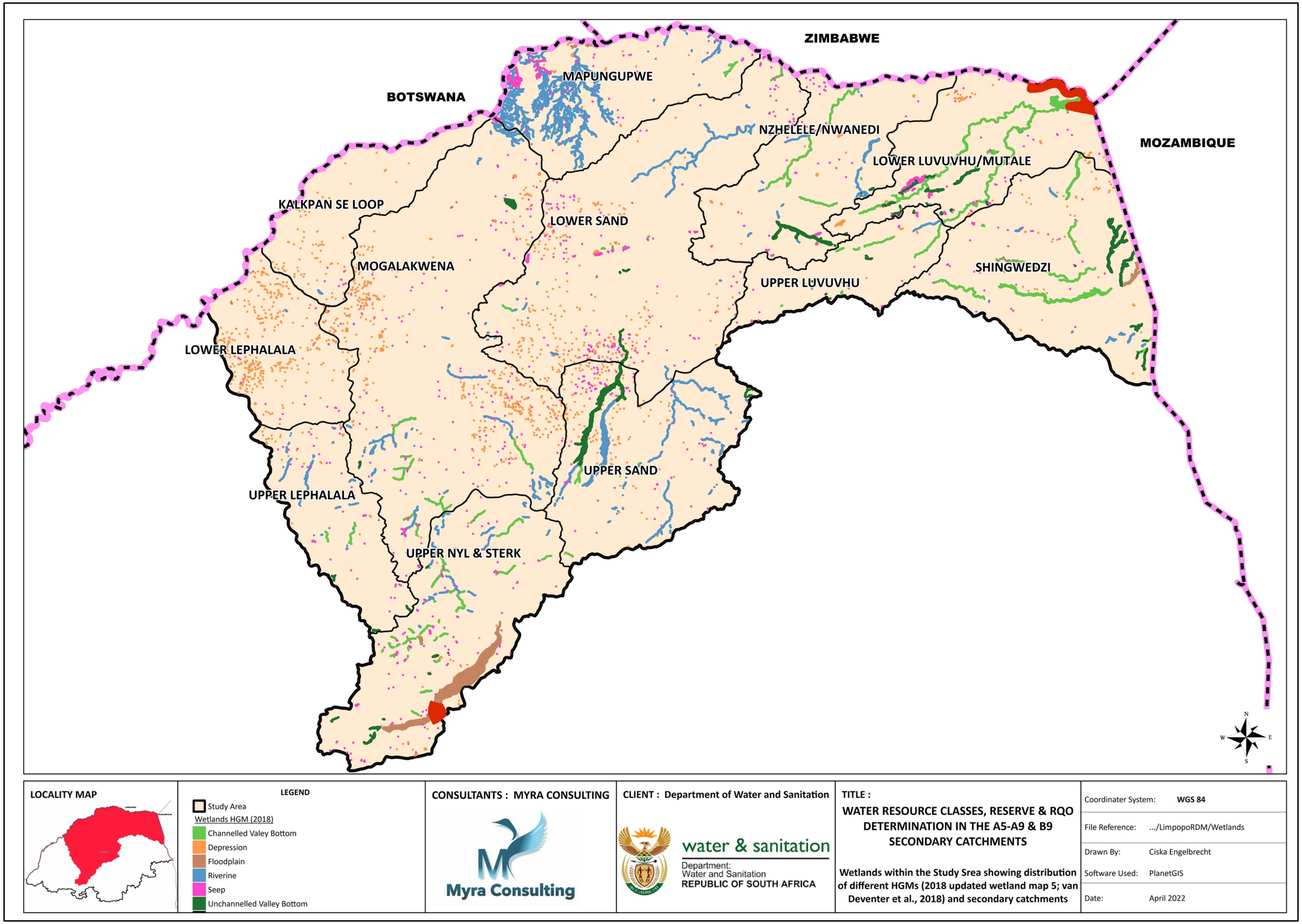


Figure 6-21. Wetlands within the study area showing distribution of different HGMs (2018 updated wetland map 5; van Deventer *et al.*, 2018) and secondary catchments.

Table 6-14. HGM wetland area (Ha) within each secondary catchment (analysis from NWM5, 2018 data).

Secondary Catchment	Main River	Channeled Valley Bottom	Unchanneled Valley Bottom	Depression	Floodplain	Riverine	Seep	Total (Ha)	Total (% of Wetlands in the Study Area
Boundary						16784		16784	21.8
A5	Lephalala	115	196	585	9		36	941	1.2
A6	Mogalakwena	1797	1979	1177	19003		771	24727	32.1
A7	Sand	418	6911	724			421	8474	11.0
A8	Nzhelele	971	2323	202			142	3639	4.7
A9	Luvuvhu	8610	1834	737	33		1933	13146	17.1
B9	Shingwedzi	4955	3589	82	586		20	9233	12.0
Total		16866	16832	3508	19630	16784	3323	76944	100.0

Table 6-15. Wetland area (Ha) per quaternary catchment, and expressed as a % of total wetland coverage.

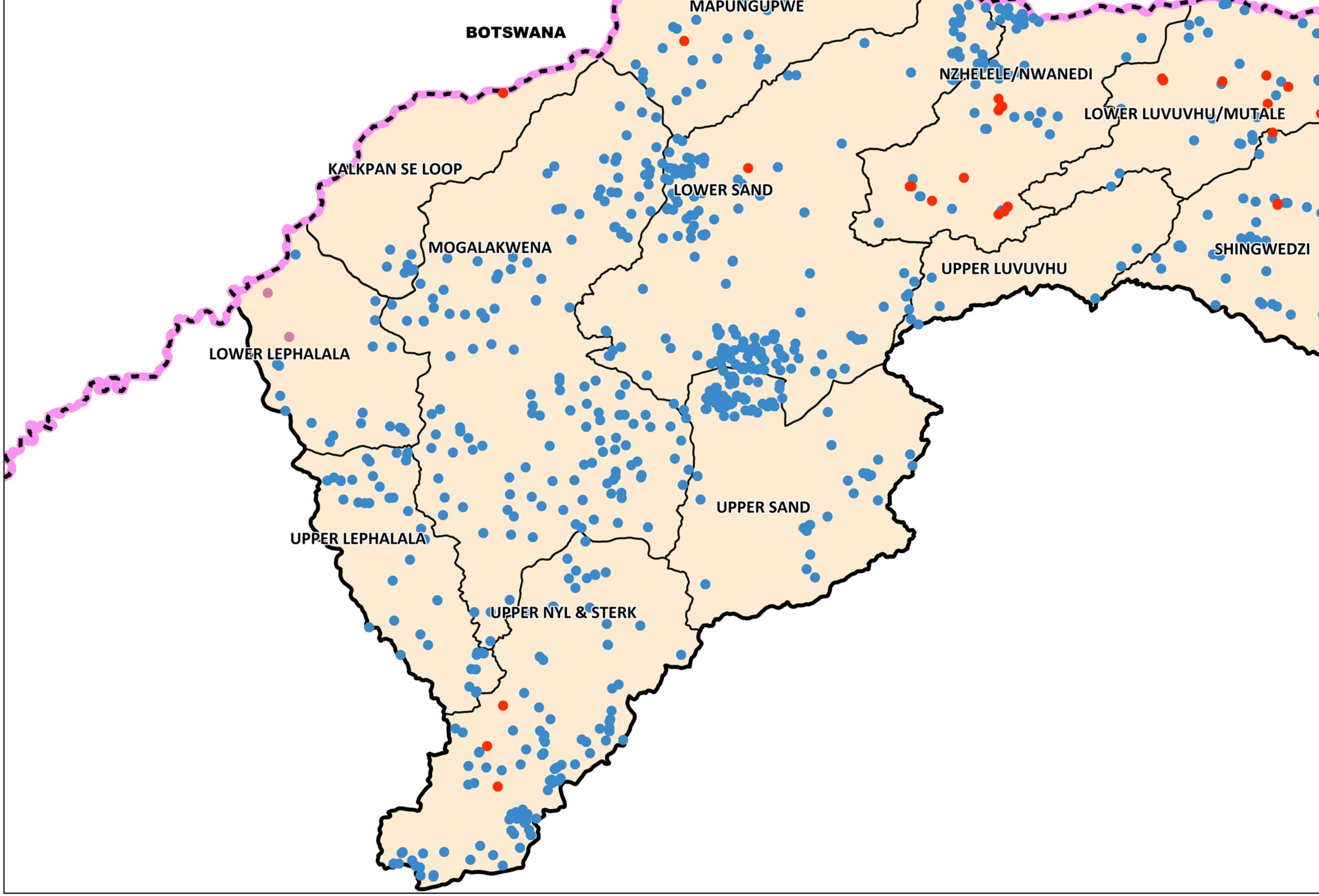
QC	Ha	%	QC	Ha	%	QC	Ha	%
A50A	145	0.2	A62J	38	0.0	A80H	50	0.1
A50B	25	0.0	A63A	457	0.6	A80J	24	0.0
A50C	131	0.2	A63B	12	0.0	A91A	0	0.0
A50D	57	0.1	A63C	6	0.0	A91B	18	0.0
A50E	25	0.0	A63D	1146	1.5	A91C	59	0.1
A50F	20	0.0	A63E	819	1.1	A91D	56	0.1
A50G	23	0.0	A71A	39	0.1	A91E	62	0.1
A50H	471	0.6	A71B	15	0.0	A91F	0	0.0
A50J	45	0.1	A71C	130	0.2	A91G	210	0.3
A61A	474	0.6	A71D	10	0.0	A91H	701	0.9
A61B	52	0.1	A71E	7026	9.1	A91J	225	0.3
A61C	535	0.7	A71F	34	0.0	A91K	5934	7.7
A61D	18613	24.2	A71G	107	0.1	A92A	531	0.7
A61E	65	0.1	A71H	21	0.0	A92B	5158	6.7
A61F	94	0.1	A71K	68	0.1	A92C	0	0.0
A61G	159	0.2	A71L	125	0.2	A92D	193	0.3
A61H	647	0.8	A72A	308	0.4	B90A	743	1.0
A61J	498	0.6	A72B	97	0.1	B90B	56	0.1
A62A	170	0.2	A71J	494	0.6	B90C	493	0.6
A62B	296	0.4	A80A	2395	3.1	B90D	185	0.2
A62C	40	0.1	A80B	26	0.0	B90E	2320	3.0
A62D	190	0.2	A80C	170	0.2	B90F	262	0.3

QC	Ha	%	QC	Ha	%	QC	Ha	%
A62E	155	0.2	A80D	7	0.0	B90G	3219	4.2
A62F	35	0.0	A80E	13	0.0	B90H	1956	2.5
A62G	23	0.0	A80F	34	0.0	Riverine (more than 1 QC)	16784	21.8
A62H	202	0.3	A80G	921	1.2			
Total (Ha)								76943.8

Table 6-16. Detail of named wetlands from the National Spatial Biodiversity Assessment (Driver *et al.*, 2005).

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 water falls	Unknown	unknown
RU 3	Upper Lephalala	Lephalala	riverine	permanent rivers and streams, including water falls	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 water falls	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	No legal protection	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



LOCALITY MAP

LEGEND

IUA Areas
Study Area
International Boundaries

SAIIAE
Oxbows
Springs
Thermal Springs

CONSULTANTS : MYRA CONSULTING

CLIENT : Department of Water and Sanitation

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

TITLE :

WATER RESOURCE CLASSES, RESERVE & R
DETERMINATION IN THE A5-A9 & B9
SECONDARY CATCHMENTS

The Spatial distribution of Spring, Oxbows an
Thermal Springs in the study area (data from t

Table 6-17. Details of thermal spring in the study area (data from the National Spatial Biodiversity Assessment, Driver et al., 2005).

Wetland RU	IUA	Thermal Spring Name	Year	Latitude	Longitude	Quaternary Catchment
RU 1	UPPER NYL & STERK	Vischgat	1949	-24.5667	28.6	A61C
RU 2	UPPER NYL & STERK	Die Oog	1949	-24.3333	28.616667	A61H
RU 2	UPPER NYL & STERK	Warmbad	1949	-24.45	28.566667	A61H
RU 6	KALKPAN SE LOOP	Tugela	1949	-22.5667	28.616667	A63C
RU 8	MAPUNGUBWE	Evang	1949	-22.4167	29.183333	A63E
RU 8	MAPUNGUBWE	Evangelina	1949	-22.4167	29.183333	A63E
RU 11	LOWER SAND	Buffelshoek	1949	-22.7833	29.383333	A72B
RU 13	NZHELELE/NWANEDI	Eiland Spa	1980	-22.8361	29.894444	A80E
RU 13	NZHELELE/NWANEDI	Maseque	1980	-22.8361	29.888889	A80E
RU 13	NZHELELE/NWANEDI	Minwamadi	1980	-22.8111	30.058333	A80B
RU 13	NZHELELE/NWANEDI	Moreson	2008	-22.9084	30.18408	A80A
RU 13	NZHELELE/NWANEDI	Mphephu	1949	-22.9167	30.166667	A80A
RU 13	NZHELELE/NWANEDI	Mphephu	1980	-22.8778	29.958333	A80E
RU 13	NZHELELE/NWANEDI	Mphephu spring	2004	-22.8942	30.1949	A80A
RU 13	NZHELELE/NWANEDI	Paddisland	1980	-22.8111	30.058333	A80B
RU 13	NZHELELE/NWANEDI	Siloam	2008	-22.8942	30.1949	A80A
RU 13	NZHELELE/NWANEDI	Tshipise	2008	-22.6088	30.17257	A80G
RU 13	NZHELELE/NWANEDI	Tshipisi	1980	-22.6056	30.177778	A80G
RU 13	NZHELELE/NWANEDI	Tshipisi	1949	-22.6167	30.166667	A80G
RU 13	NZHELELE/NWANEDI	Vischgat	1949	-22.5833	30.166667	A80G
RU 13	NZHELELE/NWANEDI	Windhoek	1980	-22.8361	29.894444	A80E
RU 15	LOWER LUVUVHU/MUTALE	Klopperfontein	2008	-22.6263	31.17502	A91J
RU 15	LOWER LUVUVHU/MUTALE	Magovani Hoof	2008	-22.5979	31.00877	A91J
RU 15	LOWER LUVUVHU/MUTALE	Natal Spa	1949	-22.5333	30.866667	A92D
RU 15	LOWER LUVUVHU/MUTALE	Sagole	1980	-22.525	30.677778	A92C
RU 15	LOWER LUVUVHU/MUTALE	Sagole	2008	-22.5304	30.68137	A92C
RU 15	LOWER LUVUVHU/MUTALE	Tshalungwa	2008	-22.5488	31.073	A91J
RU 15	LOWER LUVUVHU/MUTALE	Tshipala A	2008	-22.5165	31.00465	A91J
RU 16	SHINGWEDZI	Mafayini	2008	-23.0082	31.2341	B90D
RU 16	SHINGWEDZI	Malahlapanga	2008	-22.8893	31.0395	B90B
RU 16	SHINGWEDZI	Malahlapanga B	2008	-22.8857	31.04045	B90B
RU 16	SHINGWEDZI	Maritumbe	2008	-22.6809	31.02408	B90A
RU 16	SHINGWEDZI	Matiyavila act	2008	-23.0127	31.23768	B90D

The PES-ES-EI data (DWS, 2014) that are available for the study area show a mixture of ecological categories within the study area (Figure 6-23) with natural and near natural systems generally associated with National Parks (Kruger and Mapungubwe) or other conservation areas, while the unsustainable and worst ecological categories are associated with dams, agriculture (centre pivots), mining or intense human settlements. The PES data outlined in Figure 6-23 represent the combined PES however, so are not directly related to wetlands within the sub-quaternary they represent. Within the PES calculation the riparian and wetlands habitats are rated on a scale of 0 to 4 (where 0 is natural, akin to a category A, and 4 is poor/compromised, akin to a category E) for riparian / wetland zone modification and for riparian/wetland continuity modification. The summary results for this study area are shown in Table 6-18 at secondary catchment scale and Figure 6-24 for the whole study area. From these data it appears that most riparian zones / wetlands are near natural (B) or moderately modified (C) and that continuity within and between systems is less impacted than internal ecological condition.

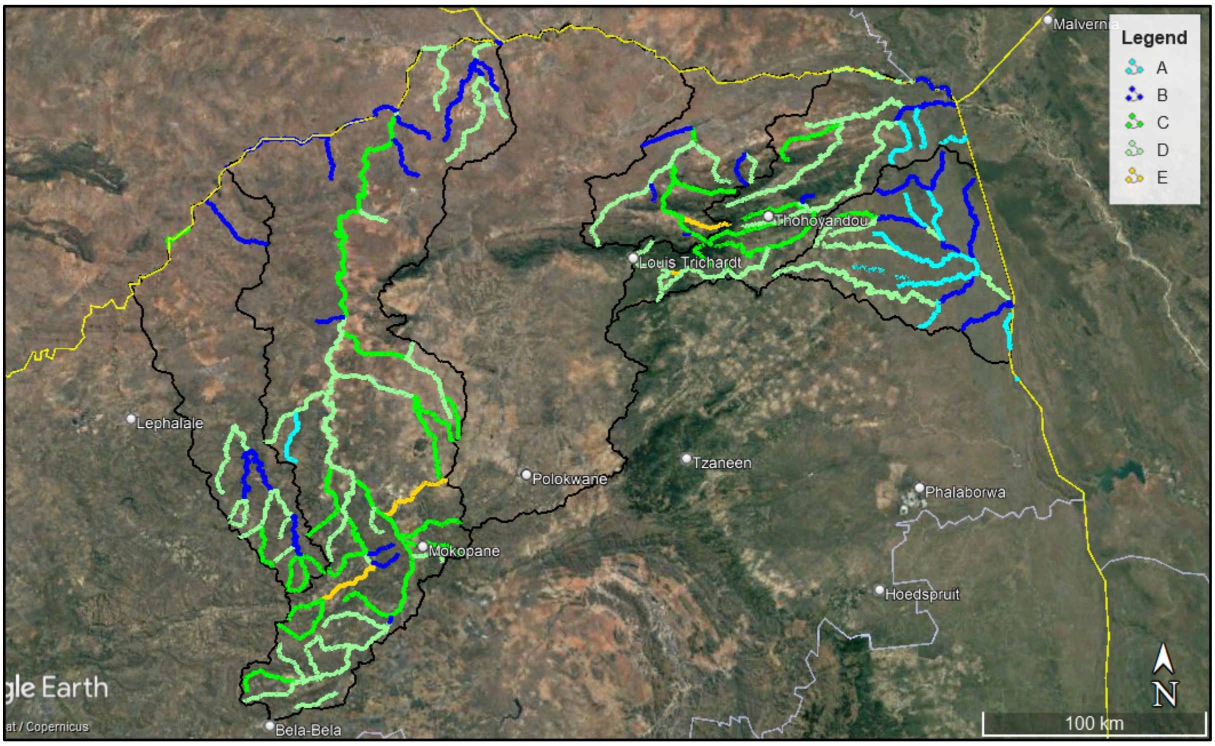


Figure 6-23. Available PES data (from DWS, 2014) for some of the secondary catchments. Legend indicates PES category.

Table 6-18. Summary of PES-EI-ES riparian/wetland ratings (DWS, 2014). Ratings are 0 to 4, where 0 is natural (akin to category A) and 4 is poor (akin to category E).

Secondary Catchment	Ratings						Total
	0	1	2	3	4	Nd	
Riparian / Wetland zone continuity modification							
A5	2	9	9	5			25
A6	2	31	32	11	2	1	79
A7	3	25	21	2			51
A8		11	3	4	1	1	20
A9	12	16	22	14	2		66
B9	13	14	1				28
Total	**32**	**106**	**88**	**36**	**5**	**2**	**269**

Secondary Catchment	Ratings						Total
	0	1	2	3	4	Nd	
Riparian / Wetland zone modification							
A5		8	16	1			25
A6		21	44	12	1	1	79
A7	1	23	23	4			51
A8		4	11	2	2	1	20
A9	8	14	34	10			66
B9	6	16	6				28
Total	**15**	**86**	**134**	**29**	**3**	**2**	**269**

Where: Nd= not defined.

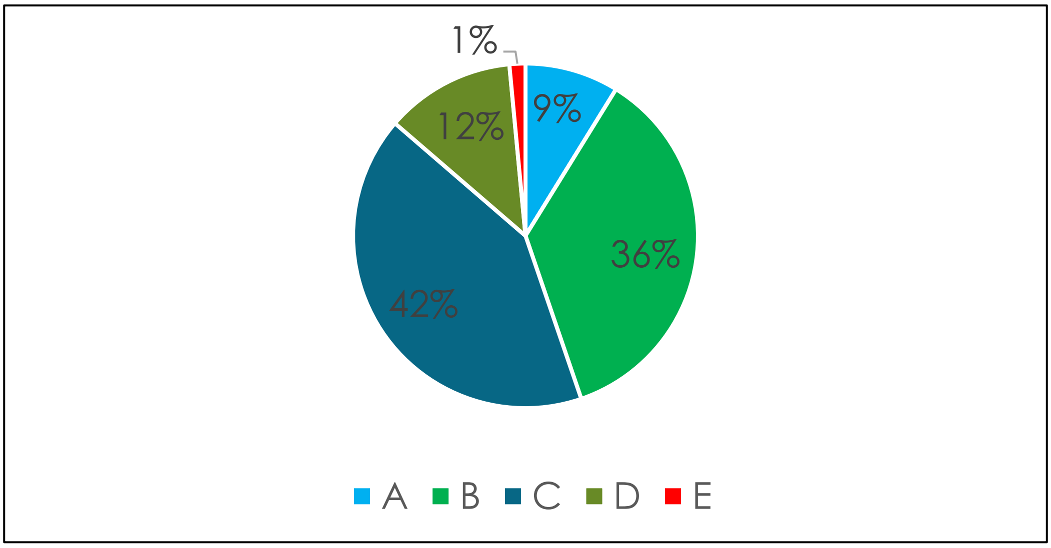


Figure 6-24. Summary of combined riparian/wetland metrics expressed as a category (akin to PES).

<u>Threatened or sensitive species</u>

A number of threatened or sensitive riparian / wetland plant species occur in the study area (Data from SANBI (POSA), 2016):

- Vulnerable:
    - Crinum moorei (Upper Luvuvhu / Mutale IUA)
- Rare:
    - Isoetes schweinfurthii (Shingwedzi IUA)
- Near Threatened:
    - Ectadium virgatum (Nzhelele / Nwanedi IUA)
- Sensitive, Stable:
    - Oryza longistaminata (Upper Nyl & Sterk IUA)

- Sensitive, Declining:
    - Balanites maughamii subsp. Maughamii (Upper Sand, Lower Sand, Nzhelele / Nwanedi IUAs), Crinum bulbispermum (Lower Sand IUA), Crinum macowanii (Upper Nyl & Sterk, Uppers Sand, Nzhelele / Nwanedi, Upper Luvuvhu / Mutale, Lower Luvuvhu, Shingwedzi IUAs), Cyathea capensis var. capensis (Nzhelele / Nwanedi, Upper Luvuvhu / Mutale IUAs), Gunnera perpensa (Upper Nyl & Sterk, Upper Lephalala, Mogalakwena, Upper Sand, Lower Sand, Nzhelele / Nwanedi, Upper Luvuvhu / Mutale IUAs), Ilex mitis var. mitis (Upper Nyl & Sterk, Upper Lephalala, Upper Sand, Lower Sand, Nzhelele / Nwanedi, Upper Luvuvhu / Mutale IUAs).

Ramsar Wetlands within the Study Area

The Convention on Wetlands of International Importance was adopted in the Iranian city of Ramsar in 1971 and is generally known as the Ramsar Convention. It is an intergovernmental treaty that provides a recognised framework for national action and international cooperation in the conservation and wise use of wetlands and the natural resources associated with them (Ramsar 2010). One of the fundamental concepts of the Ramsar convention is Wise Use, which is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". Ramsar sites are therefore designated as high priority wetlands in this study in which two Ramsar sites are present, the Nylsvley floodplain and the Makuleke wetlands. The following are descriptions of each Ramsar site, extracted from the Ramsar fact-sheets (Ramsar, 2010):

Nylsvley Nature Reserve

Ramsar site no. 952

Date: 07/07/1998

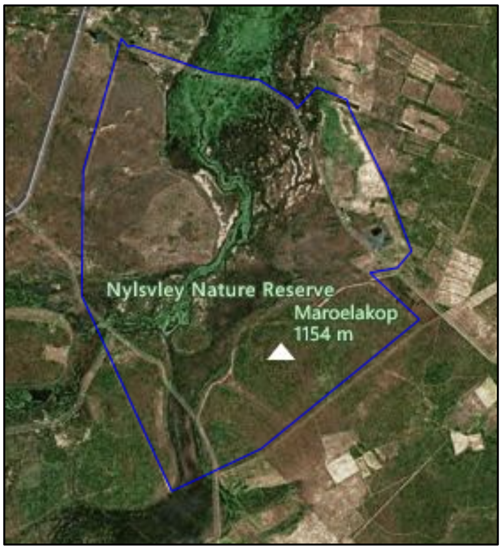
Location: Limpopo Province, South Africa

Size: 3,970 ha

Coordinates: 24º39'S 028º42'E

Status/Type: Nature Reserve.

Ramsar information sheet available here.



Description: The nature Reserve has riverine floodplains, flooded river basins, and seasonally flooded grassland, with the dominant wetland type being a seasonal river associated with a grassland floodplain. The wetland has the endangered roan antelope *Hippotragus equis*, and the area serves as a breeding ground for eight South African red-listed waterbirds and is the only site in South Africa which is a recorded locality for wild rice, *Oryza longistaminata*. The area is open to tourists, who usually come for birdwatching, and has high research value.

Makuleke Wetlands

Ramsar site no. 1687

Date: 22/05/2007

Location: Limpopo, South Africa

Size: 7,757 ha

Coordinates: 22°23'S 031°11'E

Status/Type: National Park

Ramsar information sheet available here.

Description: An excellent example of a floodplain vlei type, most of which lies within the Kruger National Park, bordered by Zimbabwe and Mozambique to the north and east. Prominent features include riverine forests, riparian floodplain forests, floodplain grasslands, river channels and flood pans. Flood pans are depressions in the floodplains which are intermittently filled from floods and rains - they are of great importance in this ecosystem as they hold water right into the dry season, thus acting as a refuge point for wildlife and waterbirds during both winter and summer months, and there are 31 of them found on these floodplains, where groups of Hippopotamus (*Hippopotamus amphibious*) are found. The floodplains attenuate floods, resulting in reduced flood damage in downstream areas of Mozambique, are important for groundwater recharge, and maintain riparian and floodplain vegetation. In the Makuleke Region of the National Park there is an attempt to harmonize biodiversity protection with the interests of rural dwellers through cooperation between the Community Property Association of Makuleke community, South African National Parks Board, and many government departments. The proclamation of the Great Limpopo Transfrontier Park (GLTP) in 2002 through an international treaty between South Africa, Mozambique, and Zimbabwe aims at jointly managing the bordering National Parks and conservation areas, and the Ramsar site will benefit from that protection status.

6.5.2 Secondary Catchments

Lephalala Catchment (A5)

The Lephalala catchment has 941 Ha of wetlands, which is 1.2% of all the wetlands in the study area. The majority of these (62%) are depressional wetlands (Figure 6-25) mostly in the northern half of the catchment, some of which were noted as important wetland clusters in the NFEPA data. The NFEPA coverage of 2011 shows floodplain wetlands in this part of the catchment, now not present on the new wetlands map. Channelled and unchanneled valley bottom wetlands comprise 12% and 21%

respectively of wetlands in the catchment. The National Spatial Biodiversity Assessment (Driver *et al.*, 2005) noted the Lephalala wetlands (Table 6-16), two oxbows and several springs (Figure 6-22).

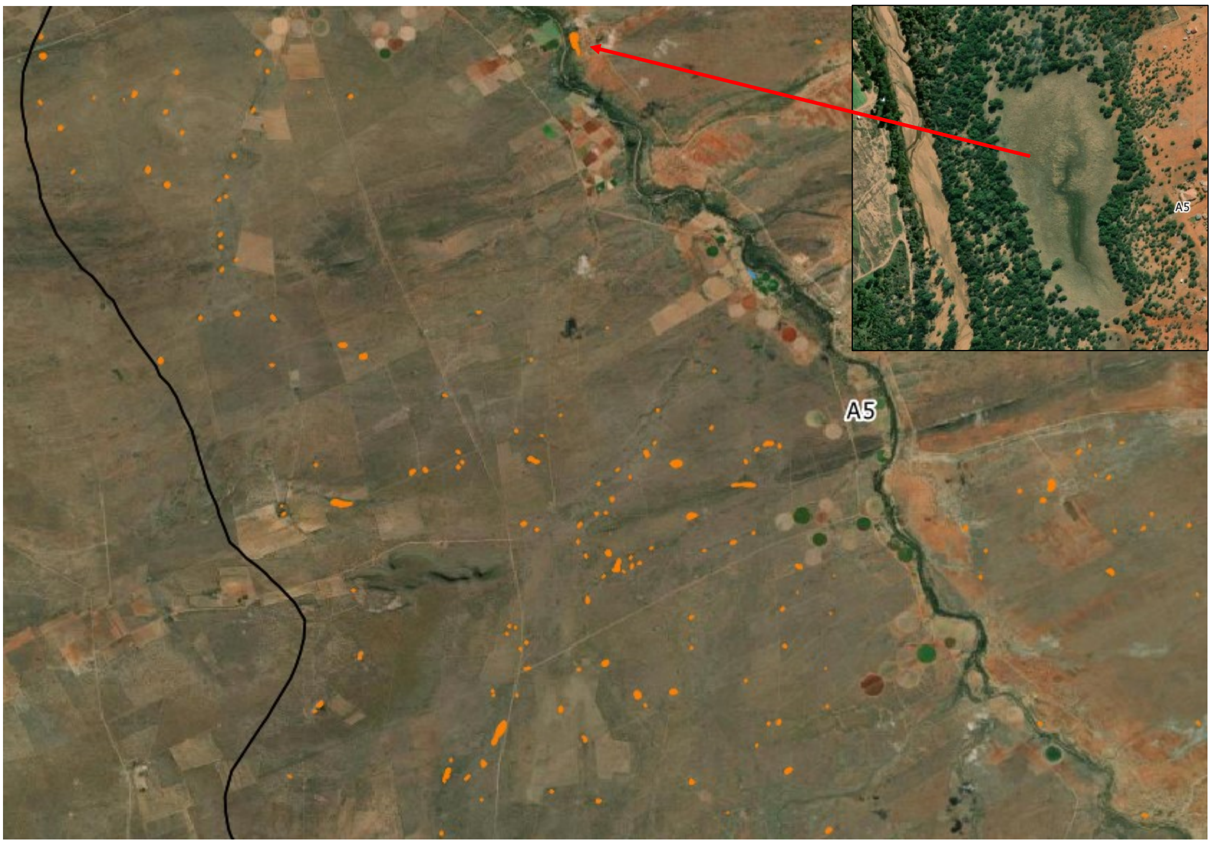


Figure 6-25. Google Earth © image of depressional wetlands in the Lephalala catchment (orange polygons). The inset shows a depressional wetland identified as an oxbow by the National Spatial Biodiversity Assessment (Driver et al., 2005).

<u>Mogalakwena Catchment (A6)</u>

The Mogalakwena catchment has 24727 Ha of wetlands, which is 32.1% of all the wetlands in the study area, more than any other sub-catchment. The majority of these (77%) are floodplain wetlands, dominated by the Nyl floodplains associated with the Nylsvley Ramsar site (Figure 6-26). Channelled valley bottom (7% of wetlands in the sub-catchment) and unchannelled (8%) wetlands dominate the central region of the sub-catchment. The NFEPA data from 2011 indicate additional floodplain wetlands along the Mogalakwena River in the central to northern part of the sub-catchment. The National Spatial Biodiversity Assessment (Driver et al., 2005) noted the Nyl floodplain, Malapatsi wetlands and the Maloutswa floodplain (Table 6-16), five thermal springs (Vischgat, Warmbad, Die Oog, Tugela and Evang) and many other springs (Figure 6-22).

Figure 6-26. Nylsvley floodplain in Nylsvley Nature Reserve showing a clear floodplain-savanna ecotone, with Wild Rice and aquatic vegetation.

Sand River Catchment (A7)

The Sand River catchment has 8474 Ha of wetlands, which is 11% of all the wetlands in the study area. These are dominated by unchanneled valley bottom wetlands (82% of wetlands in the sub-catchment), the bulk of which occur along the Hout River in quaternary A71E (Figure 6-27), which is largely modified, including the riparian and wetland condition and continuity (DWS, 2014). Depressional wetlands, mostly in the central region of the sub-catchment comprise 9% of all wetlands. The National Spatial Biodiversity Assessment (Driver *et al.*, 2005) noted the Soutpan and Zoutpan pans (Table 6-16), one thermal springs (Buffelshoek) and several other springs (Figure 6-22).

Figure 6-27. Google Earth © image of unchanneled valley bottom wetlands in the Hout River.

<u>Nzhelele and Nwanedi Catchments (A8)</u>

The Nzhelele and Nwanedi catchments have 3639 Ha of wetlands, which is 4.7% of all the wetlands in the study area, the majority of which are unchanneled valley bottom wetlands (82%). The largest of these occur in the upper reaches of the Nzhelele River which is heavily impacted by human settlements (Figure 6-28) and consequently has a poor ecological status (PES is C or E in PES-EI-ES data). The main impacts are denudation of vegetation and subsequent bank erosion (Figure 6-29). The National Spatial Biodiversity Assessment (Driver *et al.*, 2005) noted the Melrose Farm wetlands (Table 6-16), eleven thermal springs (including Vischgat, Tshipisi group, Maseque, Windhoek, Mphephu, Paddisland, Moreson, Siloam, Eiland Spa and Minwamadi) and several other springs (Figure 6-22).

Figure 6-28. Google Earth © image of unchanneled valley bottom wetlands in the upper Nzhelele.

Figure 6-29. Image from street view in Google Earth © of the unchanneled valley bottom wetlands in the upper Nzhelele.

<u>Luvuvhu and Mutale Catchments (A9)</u>

The Luvuvhu and Mutale catchments have 13146 Ha of wetlands, which is 17.1% of all the wetlands in the study area. The majority of these are channelled valley bottom wetlands (65%) but seep (15%) and unchanneled valley bottom wetlands (14%) also feature. On a quaternary catchment scale, A91K and A92B feature the bulk of the wetlands. The Makuleke Ramsar wetland which occurs in KNP along the Luvuvhu River in A91K (Figure 6-30), while extensive seep and valley bottom wetlands occur in quaternary catchment A92B (Figure 6-31). The National Spatial Biodiversity Assessment (Driver *et al.*, 2005) noted the Banyini Pan, Makwadzi Pan, Spokonyolo Pan, Limpopo-Levubu wetlands, Fundudzi, the Mutale wetlands, Mathlaguza and Ximuweni (Table 6-16), six thermal springs (Sagole, Natal Spa, Tshipala A, Magovani Hoof and Klopperfontein) and several other springs (Figure 6-22).

Figure 6-30. Makuleke concession area, KNP showing Fever tree floodplain in the background (old photograph taken before the 2013 floods which removed extensive area of Fever trees).

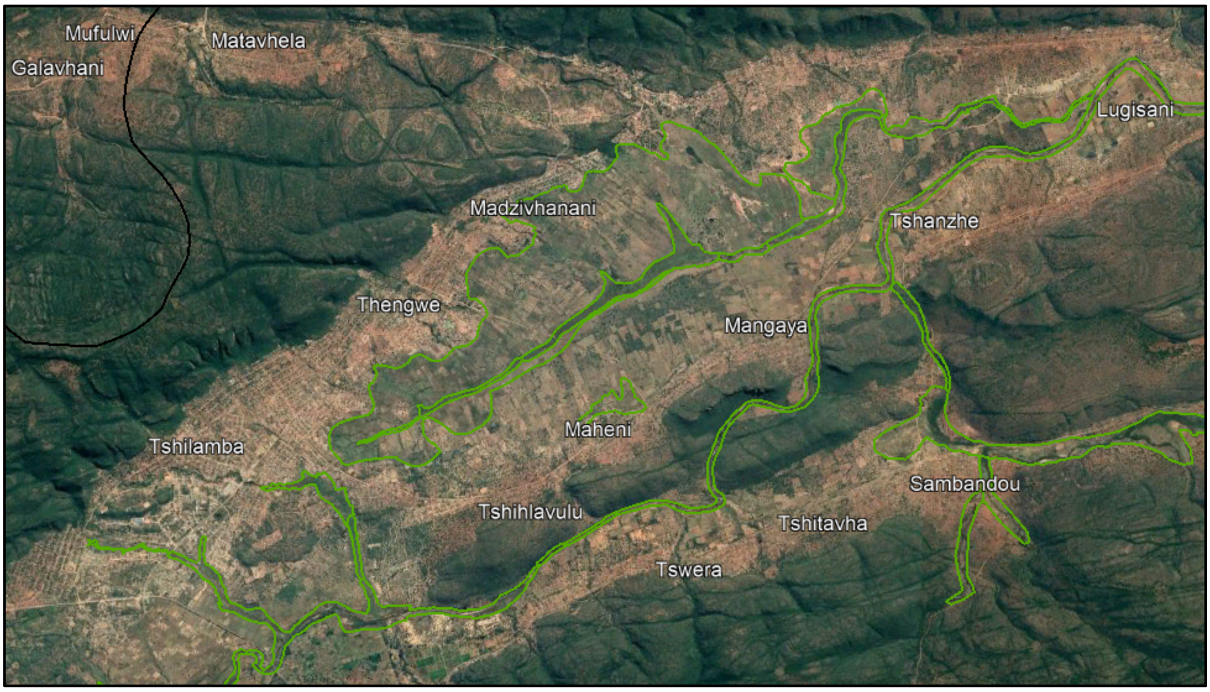


Figure 6-31. Google Earth © image of seep and valley bottom wetlands in the A92B.

Shingwedzi Catchment (B9)

The Shingwedzi catchment has 9233 Ha of wetlands, which is 12% of all the wetlands in the study area. The majority of these are channelled (54%) and unchanneled (39%) valley bottom wetlands, many of which are in a good ecological condition since much of the catchment occurs in conservation areas such as KNP and surrounding conservation properties. The National Spatial Biodiversity Assessment (Driver *et al.*, 2005) noted the Masokosa, Klawer, Mintomeni, Nwambiya, Magwitsi and Xirhamberhombe Pans (Table 6-16), five thermal springs (Maritumbe, Malahlapanga, Malahlapanga B, Mafayini and Matiyavila act) and several other springs (Figure 6-22).

6.5.3 Quinary Catchments

To complete the description of wetland status quo in the study area, existing wetland data from the PES-EI-ES assessment (DWS, 2014), the NFEPA data (Nel *et al.*, 2011) and the national biodiversity assessment (van Deventer *et al.*, 2018) were summarised at the quinary catchment scale (Table 6-19). The wetland PES category calculated in Table 6-19 (Wet PES) is a surrogate measure (surr) based on the average of the riparian / wetland zone continuity modification and the riparian / wetland zone modification metrics, and as such only moderately represents wetlands within the respective quinary catchment.

Table 6-19. Summary of existing wetland-related data at the quinary scale.

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A50A-00354	Lephalala	1	1	B								
A50A-00357	Snyspruit	3	2	C/D	D/E/F	UVB	CR	Not protected	143.4			
A50A-00370	Rietbokvleispruit	3	2	C/D								
A50A-00374	Lephalala	3	2	C/D	D/E/F	UVB	CR	Not protected	73.6	Y		
A50B-00262	Lephalala	1	1	B	D/E/F	CVB	CR	Not protected	106.7	Y		
A50B-00298	Lephalala	0	1	A/B	D/E/F	SEEP	CR	Not protected	0.0			
A50B-00303		2	2	C								
A50B-00344	Lephalala	1	1	B								
A50B-00345		2	2	C						Y		
A50C-00273	Melk	1	2	B/C	D/E/F	CVB	CR	Not protected	95.0			
A50C-00302		2	2	C	D/E/F	SEEP	CR	Not protected	0.0			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A50C-00310	Melk	3	3	D	D/E/F	UVB	CR	Not protected	50.6	Y		
A50D-00229	Lephalala	0	1	A/B	No assess	RIVER	N/A	N/A	55.3			
A50D-00237	Bloklandspruit	1	1	B	D/E/F	CVB	CR	Not protected	34.8			
A50D-00278	Goud	2	2	C	D/E/F	SEEP	CR	Not protected	27.1	Y		
A50D-00281	Bloklandspruit	1	2	B/C	D/E/F	CVB	CR	Not protected	34.8			
A50E-00196	Lephalala	2	2	C	A/B	DEPR	LC	Poorly protected	32.3			
A50E-00210	Goud	1	2	B/C	No assess	RIVER	N/A	N/A	115.4	Y		
A50H-00110/Lephalala	Lephalala	3	2	C/D	A/B	DEPR	LC	Poorly protected	552.9	Y	Y	
A50H-00110/Limpopo	Limpopo	2	2	C								
A50H-00090	Limpopo	2	2	C	A/B	DEPR	LC	Poorly protected	153.5	Y	Y	
A50J-00061		2	1	B/C	A/B	DEPR	LC	Poorly protected	32.3	Y		
A50J-00061/Limpopo	Limpopo	1	2	B/C								
A50J-00073/Kalkpan se Loop	Kalkpan se Loop	1	1	B	No assess	RIVER	N/A	N/A	77.1	Y		
A50J-00073/Limpopo	Limpopo	2	2	C								
A61A-00520	Little Nyl	3	2	C/D	D/E/F	UVB	CR	Not protected	377.8	Y	Y	

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A61A-00561	Great Nyl	2	2	C	D/E/F	UVB	CR	Not protected	288.0	Y	Y	
A61B-00489	Olifantspruit	1	2	B/C	D/E/F	FLOOD	CR	Not protected	18501.5	Y	Y	
A61B-00503	Middelfonteinspruit	1	2	B/C	D/E/F	FLOOD	CR	Not protected	18467.6	Y		Y
A61B-00541	Nyl	2	1	B/C	D/E/F	FLOOD	CR	Not protected	18470.0	Y	Y	Y
A61B-00552	Nyl	1	2	B/C	D/E/F	FLOOD	CR	Not protected	18654.5	Y		
A61C-00484	Badseloop	2	2	C	D/E/F	FLOOD	CR	Not protected	36992.0	Y	Y	Y
A61C-00501	Nyl	1	1	B	D/E/F	FLOOD	CR	Not protected	37374.7	Y	Y	Y
A61C-00574		3	2	C/D	D/E/F	SEEP	CR	Not protected	16.6			
A61D-00442	Tobiasspruit	2	1	B/C	D/E/F	FLOOD	CR	Not protected	18590.0	Y	Y	Y
A61D-00464	Nyl	1	1	B	D/E/F	FLOOD	CR	Not protected	73871.4	Y	Y	Y
A61E-00386	Nyl	2	2	C	D/E/F	FLOOD	CR	Not protected	18465.2	Y		Y
A61E-00427	Andriesspruit	2	2	C	D/E/F	FLOOD	CR	Not protected	18521.1	Y		Y
A61E-00465	Nyl	1	1	B	D/E/F	FLOOD	CR	Not protected	36924.6	Y	Y	Y
A61F-00276	Rooisloot	2	3	C/D	D/E/F	CVB	CR	Not protected	101.8	Y		
A61F-00319	Dorps	3	3	D	A/B	SEEP	CR	Moderately protected	1.2	Y		

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A61F-00333	Mogalakwena	3	3	D	D/E/F	CVB	CR	Not protected	66.3	Y		
A61F-00353	Mogalakwena	4	2	D	D/E/F	SEEP	CR	Not protected	0.2			
A61F-00371		2	2	C								
A61G-00248	Mogalakwena	2	3	C/D	D/E/F	CVB	CR	Not protected	254.6			
A61G-00266	Groot-Sandsloot	4	4	E	D/E/F	CVB	CR	Not protected	158.8			
A61G-00274	Mogalakwena	2	3	C/D	No assess	RIVER	N/A	N/A	32.2			
A61G-00294		1	2	B/C								
A61G-00297	Mogalakwena	2	2	C	D/E/F	SEEP	CR	Not protected	0.0			
A61H-00395	Sterk	3	3	D	D/E/F	CVB	CR	Not protected	655.8	Y		
A61H-00418	Sterk	2	2	C	D/E/F	CVB	CR	Not protected	278.3	Y		
A61H-00441		2	2	C	D/E/F	CVB	CR	Not protected	79.1	Y		
A61J-00267	Sterk	2	2	C	D/E/F	CVB	CR	Not protected	455.2			
A61J-00299	Sterk	2	2	C	D/E/F	CVB	CR	Not protected	347.0			
A61J-00306	Klein-Sterk	2	2	C	No assess	CVB	CR	Not protected	117.2	Y		
A61J-00349		1	1	B	No assess	RIVER	N/A	N/A	76.0			
A61J-00359	Mmadikiri	3	2	C/D	No assess	RIVER	CR	Not protected	198.9			
A61J-00369	Sterk	2	2	C	No assess	RIVER	N/A	N/A	64.2			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A61J-00375		1	1	B	D/E/F	CVB	CR	Not protected	127.7	Y		
A61J-00376	Sterk	2	2	C	D/E/F	CVB	CR	Not protected	179.2			
A62A-00253	Mokamole	2	2	C	No assess	RIVER	CR	Not protected	302.2	Y		
A62B-00188	Mogalakwena	2	2	C	D/E/F	CVB	CR	Not protected	238.0			
A62B-00223	Mogalakwena	2	2	C	D/E/F	CVB	CR	Not protected	300.0			
A62D-00179	Klein Mogolakwena	2	2	C	D/E/F	CVB	CR	Not protected	570.0			
A62D-00198	Klein Mogolakwena	2	1	B/C	No assess	RIVER	N/A	N/A	354.3			
A62D-00202	Mothlakole	1	1	B	No assess	RIVER	N/A	N/A	164.4			
A62E-00184	Matlala	2	2	C	No assess	RIVER	N/A	N/A	111.9			
A62E-00190	Seokeng	3	3	D	No assess	RIVER	N/A	N/A	99.9			
A62E-00191	Matlala	3	3	D	No assess	RIVER	N/A	N/A	745.9			
A62F-00185					No assess	RIVER	N/A	N/A	125.2	Y		
A62G-00167	Matlalane	2	3	C/D	D/E/F	DEPR	LC	Poorly protected	21.7			
A62G-00177	Mogalakwena	1	2	B/C	D/E/F	CVB	CR	Not protected	138.8			
A62H-00148	Seepabana	3	3	D	No assess	RIVER	N/A	N/A	162.5			
A62H-00155		2	2	C	A/B	DEPR	LC	Poorly protected	14.1			
A62H-00158	Natse	2	3	C/D	A/B	DEPR	LC	Poorly protected	165.0	Y		

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A62H-00192	Tshipu	3	3	D	A/B	DEPR	LC	Poorly protected	2.3			
A62H-00195		2	2	C	A/B	DEPR	LC	Poorly protected	3.8			
A62J-00140		1	2	B/C	D/E/F	SEEP	CR	Not protected	0.0			
A62J-00142	Mogalakwena	2	2	C	A/B	DEPR	LC	Poorly protected	38.9			
A62J-00143	Mogalakwena	2	2	C	D/E/F	SEEP	CR	Not protected	0.0			
A63A-00071	Mogalakwena	1	2	B/C	A/B	DEPR	LC	Poorly protected	480.4	Y		
A63B-00046	Mogalakwena	2	2	C	No assess	RIVER	N/A	N/A	10.3			
A63B-00077	Leokeng	2	2	C	D/E/F	SEEP	CR	Not protected	0.0			
A63C-00033		1	1	B	A/B	DEPR	LC	Poorly protected	6.3			
A63C-00033/Limpopo	Limpopo	1	2	B/C								
A63D-00034	Mogalakwena	1	2	B/C	D/E/F	SEEP	EN	Poorly protected	82.7			
A63D-00036	Mogalakwena	1	2	B/C	No assess	RIVER	N/A	N/A	4.5			
A63D-00037	Sonope	1	1	B	No assess	RIVER	N/A	N/A	525.7			
A63D-00044	Sethonoge	1	1	B	A/B	UVB	CR	Not protected	1314.2	Y		
A63E-00010	Madibohloko	1	1	B	No assess	RIVER	N/A	N/A	5001.1	Y		
A63E-00011/Limpopo	Limpopo	1	2	B/C								

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A63E-00011/Stinkwater	Stinkwater	1	1	B	No assess	RIVER	N/A	N/A	1307.2	Y		
A63E-00016	Setoka	1	1	B	No assess	RIVER	N/A	N/A	4047.3			
A63E-00018	Kolope	0	1	A/B	No assess	RIVER	N/A	N/A	4033.3			
A63E-00020	Setonki	1	1	B	No assess	RIVER	N/A	N/A	5108.1			
A63E-00021	Kolope	0	1	A/B	No assess	RIVER	N/A	N/A	4009.2			
A63E-00024	Matotwane	1	1	B	No assess	RIVER	N/A	N/A	4009.8			
A63E-00025	Kolope	1	1	B	No assess	RIVER	N/A	N/A	4004.9			
A63E-00005	Limpopo	1	1	B	C	DEPR	VU	Well protected	35.8	Y		
A63E-00007/Kolope	Kolope	1	2	B/C	C	FLOOD	CR	Not protected	473.7	Y		
A63E-00007/Limpopo	Limpopo	1	2	B/C								
A63E-00007/Maloutswa	Maloutswa	3	2	C/D	C	FLOOD	CR	Not protected	473.7	Y		
A63E-00008	Kolope	1	2	B/C	No assess	RIVER	N/A	N/A	4409.9	Y		
A63E-00009	Limpopo	1	2	B/C	No assess	RIVER	N/A	N/A	46.6			
A71A-00211	Sand	2	2	C	No assess	RIVER	N/A	N/A	78.3			
A71A-00239	Bloed	2	2	C	No assess	RIVER	N/A	N/A	20.1			
A71A-00249	Sand	2	2	C	No assess	RIVER	N/A	N/A	92.5			
A71B-00214	Diep	1	2	B/C								
A71B-00221	Turfloop	2	3	C/D	No assess	RIVER	N/A	N/A	13.4			
A71B-00222	Diep	2	2	C	No assess	RIVER	N/A	N/A	263.3			
A71C-00156	Dwars	2	2	C	No assess	RIVER	N/A	N/A	509.8			
A71C-00172	Sand	1	2	B/C	No assess	RIVER	N/A	N/A	277.9			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A71C-00181	Kopersspruit	2	1	B/C	No assess	RIVER	N/A	N/A	717.5			
A71C-00183	Sand	2	2	C	No assess	RIVER	N/A	N/A	308.4			
A71D-00118	Sand	1	2	B/C	No assess	RIVER	N/A	N/A	573.5			
A71E-00169	Hout	3	3	D	D/E/F	UVB	CR	Not protected	14009.9	Y		
A71F-00170	Brakspruit	1	2	B/C	D/E/F	UVB	CR	Not protected	6764.0			
A71F-00174		2	2	C	D/E/F	UVB	CR	Not protected	6768.7			
A71F-00176	Strydomsloop	2	3	C/D	D/E/F	UVB	CR	Not protected	11280.9			
A71G-00107	Hout	2	2	C	A/B	UVB	CR	Not protected	37.2			
A71G-00129	Mogwatsane	1	2	B/C	A/B	DEPR	LC	Poorly protected	92.5			
A71G-00131	Hout	1	2	B/C	D/E/F	UVB	CR	Not protected	20306.4			
A71H-00088	Sand	1	2	B/C	A/B	SEEP	CR	Not protected	32.8			
A71J-00055	Sand	1	2	B/C	No assess	RIVER	N/A	N/A	947.1			
A71J-00074	Sand	2	2	C	A/B	SEEP	EN	Poorly protected	26.4			
A71J-00076		1	1	B								
A71J-00084	Moleletsane	1	1	B	D/E/F	DEPR	LC	Poorly protected	466.4	Y		
A71K-00019/SAND	Sand	1	1	B	D/E/F	CVB	CR	Poorly protected	70.1	Y		
A71K-00019/LIMPOPO	Limpopo	1	1	B								

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A71K-00029		1	2	B/C	No assess	RIVER	N/A	N/A	12.3			
A71K-00031	Sand	1	1	B	No assess	RIVER	N/A	N/A	605.3			
A71L-00012		1	1	B	No assess	RIVER	N/A	N/A	9.7			
A71L-00013	Kongoloop	0	1	A/B	A/B	DEPR	VU	Well protected	8.3			
A71L-00014		0	1	A/B	No assess	RIVER	N/A	N/A	8009.1	Y		
A71L-00015	Soutsloot	1	0	A/B	A/B	SEEP	EN	Poorly protected	9.2			
A71L-00017	Kongoloop	0	1	A/B	D/E/F	SEEP	EN	Poorly protected	0.0			
A71L-00002		1	1	B						Y		
A71L-00002/LIMPOPO	Limpopo	2	1	B/C								
A71L-00022	Soutsloot	1	1	B	D/E/F	CVB	CR	Poorly protected	63.0			
A71L-00023		1	1	B	D/E/F	CVB	CR	Poorly protected	63.0			
A71L-00003		1	1	B	No assess	RIVER	N/A	N/A	6.1	Y		
A71L-00003/LIMPOPO	Limpopo	1	1	B								
A71L-00004		1	1	B	C	DEPR	VU	Well protected	53.5	Y		
A71L-00004/LIMPOPO	Limpopo	2	1	B/C								
A71L-00005/KONGOLOOP	Kongoloop	2	1	B/C	C	DEPR	VU	Well protected	35.8	Y		
A71L-00005/LIMPOPO	Limpopo	2	1	B/C								

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A71L-00006		1	1	B	No assess	RIVER	N/A	N/A	113.3	Y		
A71L-00006/LIMPOPO	Limpopo	2	1	B/C								
A72A-00116	Boshela	3	3	D	No assess	RIVER	CR	Not protected	78.2			
A72A-00123	Brak	2	2	C	No assess	RIVER	N/A	N/A	16.6	Y		
A72A-00133	Ga-Mamasonya	2	2	C	D/E/F	DEPR	LC	Poorly protected	24.5			
A72A-00134	Brak	2	2	C	No assess	RIVER	N/A	Moderately protected	95.6			
A72B-00038	Brak	1	2	B/C	No assess	RIVER	N/A	N/A	1545.6			
A72B-00052		1	1	B	No assess	RIVER	N/A	N/A	126.1			
A72B-00057	Brak	2	2	C	D/E/F	SEEP	CR	Not protected	438.6	Y		
A80A-00100	Tshiluvhadi	3	3	D								
A80A-00102	Phangani	1	1	B								
A80A-00089	Nzhelele	4	4	E	D/E/F	UVB	CR	Not protected	2395.3			
A80A-00095	Mutshedzi	3	3	D	D/E/F	UVB	CR	Not protected	2271.8			
A80B-00069	Nzhelele	3	4	D/E	D/E/F	UVB	CR	Moderately protected	4584.9			
A80C-00068	Mufungudi	3	2	C/D	D/E/F	CVB	CR	Not protected	169.5			
A80D-00075	Mutamba	1	2	B/C	D/E/F	RIVER	N/A	N/A	36.5			
A80F-00063	Mutamba	1	2	B/C	D/E/F	CVB	CR	Not protected	824.3			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A80F-00065	Nzhelele	2	2	C	D/E/F	CVB	CR	Not protected	784.0			
A80F-00070		1	1	B								
A80G-00026/Limpopo	Limpopo	1	2	B/C								
A80G-00026/Nzhelele	Nzhelele	1	2	B/C	D/E/F	CVB	CR	Not protected	910.2	Y		
A80G-00043		1	1	B	D/E/F	CVB	CR	Not protected	832.2			
A80G-00048	Nzhelele	1	2	B/C	D/E/F	CVB	CR	Not protected	832.4			
A80G-00053	Nzhelele	1	2	B/C	D/E/F	CVB	CR	Not protected	1596.2			
A80G-00054	Tshishiru	1	2	B/C	D/E/F	CVB	CR	Not protected	784.0			
A80H-00060	Luphephe	2	2	C	No assess	RIVER	N/A	N/A	1203.2			
A80H-00064	Nwanedi	1	1	B	No assess	RIVER	N/A	N/A	1345.1			
A80J-00028/Limpopo	Limpopo	1	1	B								
A80J-00028/Nwanedi	Nwanedi	2	2	C	No assess	RIVER	N/A	N/A	603.2			
A91A-00105	Luvuvhu	2	2	C	D/E/F	SEEP	CR	Not protected	0.0			
A91B-00119	Luvuvhu	4	3	D/E								
A91B-00120	Doringspruit	1	2	B/C	A/B	SEEP	CR	Not protected	17.6			
A91C-00115	Luvuvhu	2	2	C	D/E/F	FLOOD	CR	Poorly protected	120.7			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A91C-00122	Mudzwiriti	2	2	C	A/B	CVB	CR	Not protected	6.3			
A91D-00108	Latonyanda	3	3	D	D/E/F	FLOOD	CR	Poorly protected	88.1			
A91E-00103	Dzindi	3	3	D	D/E/F	UVB	CR	Poorly protected	62.0			
A91F-00111	Luvuvhu	2	2	C	D/E/F	FLOOD	CR	Poorly protected	32.6			
A91F-00093	Luvuvhu	3	3	D	D/E/F	CVB	CR	Not protected	2818.8			
A91G-00078	Mukhase	1	1	B								
A91G-00079	Mbwedi	2	2	C	No assess	RIVER	N/A	Moderately protected	151.0			
A91G-00083		2	2	C								
A91G-00086	Mutshindudi	2	2	C	D/E/F	CVB	CR	Not protected	2993.1			
A91G-00087	Mukhase	2	2	C								
A91G-00091	Mutshindudi	2	2	C	No assess	RIVER	N/A	Moderately protected	108.4			
A91G-00092	Mutshindudi	2	2	C	No assess	RIVER	N/A	N/A	87.1			
A91G-00094	Tshinane	3	2	C/D						Y		
A91G-00098	Mutshindudi	3	2	C/D	D/E/F	CVB	CR	Not protected	124.9			
A91H-00045	Luvuvhu	1	2	B/C	D/E/F	CVB	CR	Not protected	9368.6			
A91J-00040	Luvuvhu	0	1	A/B	D/E/F	CVB	CR	Not protected	2818.8			
A91J-00050	Matsaringwe	0	0	A	D/E/F	CVB	CR	Not protected	2834.4			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
A91K-00032	Limpopo	1	1	B	C	CVB	CR	Poorly protected	5868.8	Y		
A91K-00035	Luvuvhu	0	1	A/B	C	CVB	CR	Poorly protected	8137.4	Y		
A91K-00039	Luvuvhu	1	1	B	D/E/F	CVB	CR	Not protected	5637.7	Y		
A91K-00042	Mashikiri	0	0	A	D/E/F	CVB	CR	Not protected	2818.8	Y		
A91K-00056	Saselandonga	0	0	A	D/E/F	DEPR	VU	Well protected	46.6	Y		
A91K-00058		0	0	A								
A92B-00051	Mutale	1	2	B/C	D/E/F	CVB	CR	Not protected	11346.4	Y		
A92C-00041	Tshipise	3	2	C/D	D/E/F	CVB	CR	Not protected	2818.8			
A92C-00047	Mutale	2	1	B/C	D/E/F	CVB	CR	Not protected	2818.8			
A92C-00049	Mbodi	3	3	D	D/E/F	CVB	CR	Not protected	2818.8			
A92D-00027	Limpopo	1	1	B	D/E/F	DEPR	VU	Well protected	194.4	Y		
A92D-00030	Mutale	1	2	B/C	D/E/F	CVB	CR	Not protected	8472.5			
B90A-00062		1	1	B	D/E/F	CVB	CR	Poorly protected	724.0	Y		
B90A-00066	Shisha	1	1	B	No assess	RIVER	N/A	N/A	80.0	Y		
B90B-00080		0	0	A								
B90B-00096	Mphongolo	1	2	B/C								
B90B-00097		1	2	B/C								

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
B90B-00099		2	2	C	D/E/F	SEEP	EN	Poorly protected	0.0			
B90B-00081	Mphongolo	0	0	A	No assess	RIVER	N/A	N/A	73.0	Y		
B90B-00082	Mphongolo	1	2	B/C	D/E/F	CVB	CR	Poorly protected	51.5			
B90B-00101	Mphongolo	1	1	B	D/E/F	CVB	CR	Poorly protected	175.5			
B90C-00104	Shihloti	0	0	A	D/E/F	CVB	CR	Poorly protected	492.8			
B90C-00106	Phugwane	1	2	B/C	D/E/F	CVB	CR	Poorly protected	492.8			
B90D-00067	Shisha	0	1	A/B	D/E/F	CVB	CR	Poorly protected	192.3	Y		
B90D-00109	Phugwane	0	0	A	D/E/F	CVB	CR	Poorly protected	990.1			
B90D-00085	Mphongolo	0	1	A/B	D/E/F	CVB	CR	Poorly protected	178.3			
B90D-00112	Mphongolo	0	1	A/B	D/E/F	UVB	CR	Poorly protected	2324.3			
B90E-00072	Nkulumbeni	1	1	B	D/E/F	UVB	CR	Poorly protected	3203.6			
B90F-00114	Shingwedzi	1	2	B/C	D/E/F	CVB	CR	Poorly protected	263.2			
B90G-00121	Bububu	1	1	B	C	CVB	CR	Poorly protected	3218.5			
B90G-00136	Nshenhene	0	0	A	C	CVB	CR	Poorly protected	3215.0			
B90G-00144	Tshange	0	1	A/B	No assess	RIVER	N/A	N/A	9.3			
B90G-00125	Bububu	0	1	A/B	C	CVB	CR	Poorly protected	3216.7			

PES-EI-ES					NWM 2018					NFEPA 2011		
SQ	River Named in SQ	RIP/ WET ZONE CONT MOD	RIP/ WET ZONE MOD	Wet PES (surr)	Dom WETCON	Dom HGM	Dom Threat Status	Dom Protection Level	Extent within SQ (Ha)	Wet FEPA	Wet Cluster	Ramsar
B90G-00130	Shingwedzi	1	1	B	C	CVB	CR	Poorly protected	3215.0			
B90G-00124	Shingwedzi	0	0	A								
B90H-00147	Dzombo	1	1	B	No assess	RIVER	N/A	N/A	391.7			
B90H-00152	Kumba	0	1	A/B	C	UVB	CR	Poorly protected	322.2			
B90H-00113	Mphongolo	0	1	A/B	C	UVB	CR	Poorly protected	884.0			
B90H-00117	Shingwedzi	1	1	B	C	UVB	CR	Poorly protected	1480.3	Y		
B90H-00145	Shingwedzi	1	1	B								

Where: N/A = not assessed / not applicable; HGMs as follows: RIVER = riverine wetlands, UVB = unchanelled valley bottoms, CVB = chanelled valley bottoms, SEEP = seepage wetlands, DEPR = depressional wetlands, FLOOD = floodplain wetlands.

7 SOCIO-ECONOMICS AND ECOSYSTEM SERVICES

7.1 Introduction

This section of the report provides a description of the status quo in terms of (1) economic activities, outputs and employment and (2) the characteristics and current socio-economic situation of people living within the secondary catchments A5-A9 of the Limpopo WMA and secondary catchment B9 in the Olifants WMA (hereafter referred to as the study area). The status quo assessment provides a baseline against which to measure the potential impacts associated with changes in water yields and environmental flows and how this will affect economic output and social well-being under a range of classification scenarios. As well as providing the overall context against which to evaluate change, the descriptions provided in this section highlight these linkages to water and focus on the aspects of economy and livelihoods that are likely to change under altered availability and allocation of water resources.

The allocation of the ecological Reserve is central to the environmental, economic and social outcomes of a region (Figure 7-1). Economic activities that depend on the licenced use of water include urban supply, irrigation agriculture, plantation forestry and industry. Economic activities whose outputs are linked to the quality of aquatic ecosystems include nature-based tourism, for example. In addition, the functioning of aquatic ecosystems also plays a role in overall economic productivity through ecosystem services that lead to cost savings, such as flood attenuation, sediment retention and water quality amelioration. These cost savings manifest in both the private and public sector. Similarly, social wellbeing within the study area is determined by both water supply and instream flows, namely the abstraction and supply of water for domestic purposes, the supply of abstracted or instream water to economic activities which provide employment opportunities, and the supply of instream flows which lead to the provision of instream water, natural resources and opportunities for recreation and spiritual fulfilment.

Ecosystem services are therefore an integral factor influencing the economic and social status of the different parts of the study area (see Box 7-1). The roles of water and aquatic ecosystem services in determining the economic prosperity and the social wellbeing of people living in the study area are summarised in Figure 7-1.

The Classification of water resources will define their intended condition and the amount and quality of water required to maintain that condition. This in turn will determine the amount of water available for use. The Classification of water resources will be decided at the IUA scale on the basis of an analysis of a range of alternative scenarios in which the classes of each IUA are varied in different combinations. This report lays out the methods and assumptions used in estimating the changes in economic output and societal wellbeing as a result of changes in water use and ecosystem services under the different water allocation scenarios.

The economic impacts are considered in terms of changes in the two main macro-economic indicators of GDP and employment, as well as changes in cost savings due to changes in specific types of ecosystem services. This requires estimating the relationships between water use and economic outputs as a result of production in water user sectors, stream flow reducing sectors and sectors relying on ecosystem services. The social impacts are considered in terms of a composite index of societal wellbeing that takes impacts on household income, health and happiness into account.

This chapter begins with providing thematic overviews of the economic activities and socio-economic variables with a description of how they vary across the study area and the delineated IUAs. A description of the aquatic ecosystem services and the benefits that they provide are then presented. It then summarises the information by IUA for later comparison in the scenario analyses.

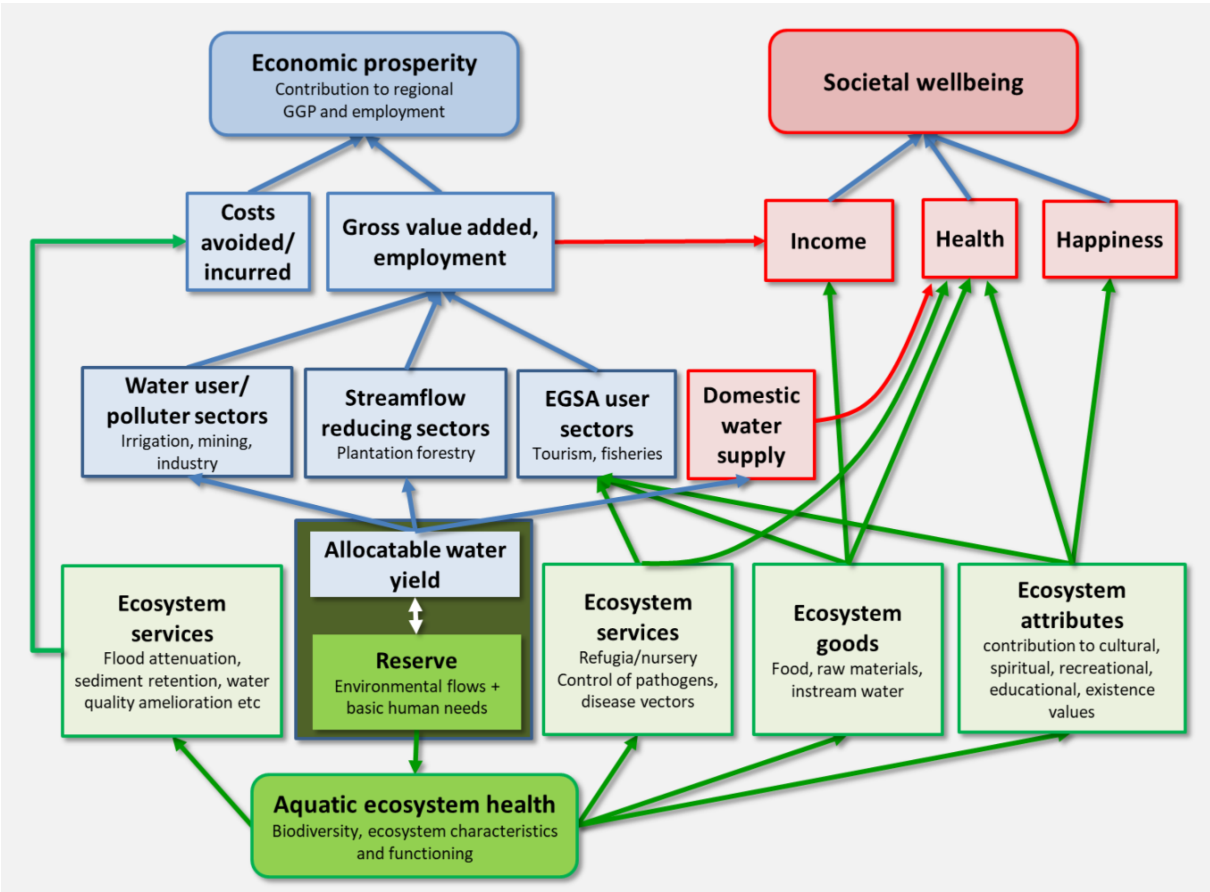
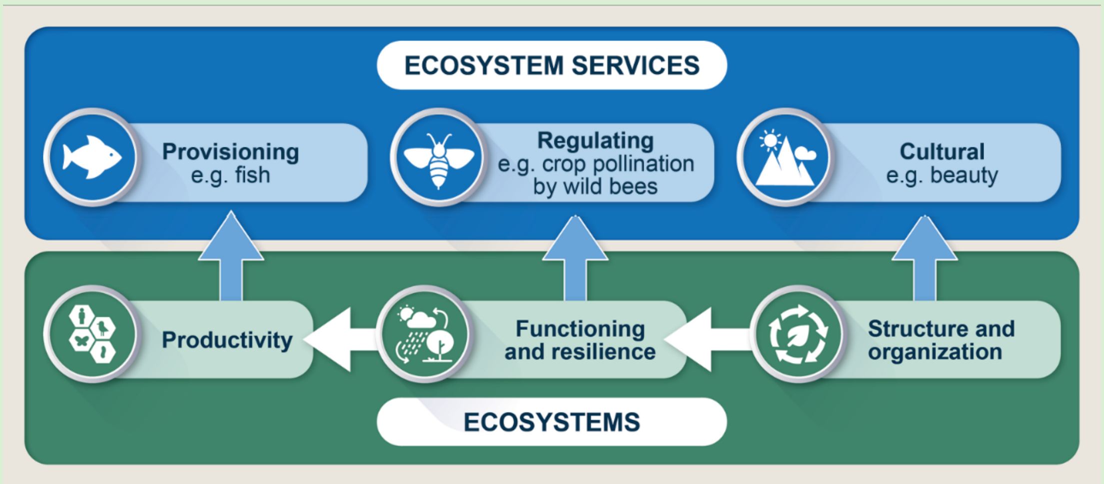


Figure 7-1. Linkages arising from the trade-off between water abstracted for use and water retained for the ecological Reserve. EGSA stands for ecosystem goods, services and attributes. Source: DWS, 2017.

Box 7-1. Biodiversity, ecosystem services and their valuation. Source: DWS, 2017; Turpie, 2018; Turpie *et al.*, 2021.

Ecosystem services are broadly defined as "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2003, 2005). These benefits depend on the nature of the ecosystems, and their biodiversity. An ecosystem is a community of living organisms in conjunction with non-living components of their environment, interacting as a system. The biotic and abiotic components are linked together through nutrient and energy flows. Ecosystems can be defined in space, and range in size, e.g., from wetlands to a large rainforest.

Ecosystem services were originally conceptualised in terms of "goods" (such as fish), "services" (such as pollination of crops by wild bees) and "attributes" (such as beauty and rarity), which determine how they are used or appreciated for purposes such as recreation, religious ceremonies, or sense of place (Barbier, 1994). The attributes of ecosystems and their capacity to supply goods and services are strongly linked to ecosystem condition. The concepts of ecosystem goods, services and attributes are now more commonly referred to as provisioning, regulating and cultural services, respectively. Supporting services, a term coined by the MEA (2003), are services that are necessary for the production of all other ecosystem services, and include biomass production, soil formation, nutrient cycling, water cycling, and provisioning of habitat. These are now considered to be underlying processes that enable the supply of provisioning, regulating and cultural services.



Source: J.K. Turpie, unpublished.

Ecosystem services are fundamentally linked to biodiversity, which is the variability among living organisms and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems. The biological diversity found within an ecosystem is critically important to its functioning and value. In particular, an ecosystem's composition determines its productivity and resilience. Diversity within functional groups also helps to maintain ecosystem structure and functioning, such as its trophic balance (the ratios of predators to prey, etc.). Therefore, biodiversity plays the same role in ecosystems as diversity in a financial portfolio, in that it reduces variability (uncertainty) in yield. This is known as the "portfolio effect". In this way, biodiversity acts as "insurance" against climate change and other shocks. Biodiversity is the foundation of the vast array of ecosystem services that critically contribute to human well-being. Thus, decisions humans make that influence biodiversity affect the well-being of themselves and others.

Provisioning services are the harvestable resources supplied by aquatic ecosystems, such as wild foods, raw materials, and wetland inputs to agricultural and livestock production. Resource availability is linked to both ecosystem characteristics and property rights, while demand is influenced by the socio-economic circumstances of households and the prices of alternatives. Rural households in South Africa depend on subsistence agriculture and harvest a wide variety of wild plant and animal resources for nutrition, health, energy, and raw materials, particularly where there are limited economic opportunities (DWA, 2010). Importantly, the use of provisioning services reduces the opportunities to obtain cultural and regulating services. The uses of these services often have to be limited or modified in order to secure regulating and/or cultural ecosystem services.

Regulating services are the functions that ecosystems and their biota perform that benefit people in surrounding or downstream areas or even distant areas. These services include carbon sequestration—the active removal of carbon from the atmosphere by vegetation growth—reducing the potential impacts of climate change, or the passive benefit of retaining the carbon stored in the landscape by avoiding deforestation or degradation and hence avoiding causing further climate change damages both locally and in the rest of the world. Other greenhouse gases are also regulated in situ if the natural habitats are healthy e.g., leaching of ammonia and other substances is controlled.

Three types of regulating services are strongly linked to the way in which catchment hydrology is mediated by vegetative cover and ecosystem condition. These are the regulation of water flows, the control of sediments, and the removal of excess nutrients that affect water quality (Ekka *et al.*, 2020).

Vegetated landscapes, and wetlands in particular, regulate flows and help to slow down floodwaters during storm events, reducing potential damage (Nedkov & Burkhard, 2012). Wetlands provide temporary storage for high flows and slow their movement through the catchment. In addition, wetlands can also trap eroded sediments that are transported from upstream (Conte *et al.*, 2011). When flows enter wetlands, they are slowed down, and part of the sediment load settles out. This enriches the productivity of the wetland and also the agricultural potential of floodplains. In addition, where catchment sediment loads are elevated by erosion, the settling out of sediments in wetlands reduces the damage caused downstream. The ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity and is thus closely related to its flow regulation capacity. This protects downstream areas from sedimentation, which can include impacts on water storage capacity, hydropower generation, and navigability of rivers. Furthermore, some of the nutrients in nutrient-enriched runoff can be removed when it passes through natural vegetation and wetlands in the landscape, mitigating downstream eutrophication, toxic algal blooms, deoxygenation, and fish kills that affect human health, water treatment costs, and fisheries (Conte *et al.*, 2011). All of these services help to save on grey infrastructure costs.

Cultural services are the ecosystem attributes (e.g., beauty, species diversity) that give rise to the "use values" gained through any type of activity ranging from river-based adventure tourism to birdwatching, religious or cultural ceremonies or just passive observation, or the "non-use values" gained from knowing that they exist and can be enjoyed by future generations. These values can be observed through local use, domestic and international tourism, and the premiums paid for properties that are close to natural amenities, or they can be investigated through stated-preference surveys, in which society's willingness to pay to secure the biodiversity in question is estimated.

Values and valuation of ecosystem services

The values produced by ecosystem services are categorised into different types. The Total Economic Value of an environmental asset or an ecosystem comprises Direct Use, Indirect Use, Option and Non-Use values (Figure **7-2**).

Direct use values may be generated through the consumptive or non-consumptive use of resources. These values are more likely to be straightforward to estimate because there are often well-functioning markets. In the case of aquatic ecosystems in South Africa, most, if not all, of this use is recreational, and includes both consumptive (fishing) and non-consumptive (e.g., boating, bird watching) activities. Indirect use values are values generated by outputs from aquatic ecosystems that form inputs into production by other sectors of the economy, or that contribute to net economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functioning such as water purification. Non-use values include the value of having the option to use the resources (e.g., genetic) of aquatic ecosystems in the future (option value), and the value of knowing that their biodiversity is protected (existence value). Although far less tangible than the above values, non-use values are reflected in society's willingness to pay to conserve these resources, sometimes expressed in the form of donations.

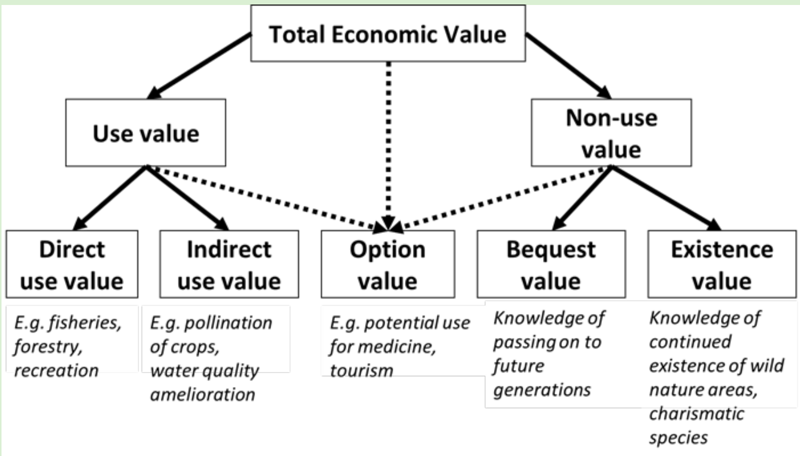


Figure 7-2. The components of Total Economic Value. Source: Turpie, 2018

The various different approaches, developed for the valuation of ecosystem services over the last few decades are typically classified into (a) market-based approaches, (b) functions, or estimating cost savings. The latter can be the avoided damages that would occur in the absence of the service, or what it would cost to replace the service using an engineering solution. Revealed preference approaches involve the analysis of expenditures that people make either to protect against a bad environment or to take advantage of a good environment. Commonly used methods include the averting behaviour method, travel cost method, and hedonic pricing method. Stated preference approaches involve asking people directly how they value environmental changes. Methods include contingent valuation and choice experiments. Table 7-1 shows which approaches and methods might be used in eliciting which value sets. Typically, the more intangible a value or type of value is, the fewer approaches and methods there are available for deriving and estimating values.

Table 7-1. Valuation approaches and the types of value that they are used to measure. Source: Turpie (2018).

Approach	Method	Direct use values	Indirect use values	Option & non-use values
Market value approaches	Observed market prices	X	X	
	Production functions	X	X	
	Damage/replacement cost		X	
Revealed preference approaches	Travel cost	X		
	Hedonic pricing	X		
	Averting behaviour		X	
Stated preference approaches	Contingent valuation	X		X
	Conjoint/choice experiments	X		X

The way in which values of ecosystem services are expressed also varies. Different measures of value are relevant to different decision-makers. Individuals and firms make decisions on the basis of their own financial and/or utility gains. Governments make decisions on the basis of overall welfare gains (including contribution to income and employment as measured in the national accounts). At a more local level, municipalities may make decisions based on the generation of revenues, e.g., from property rates. It is important to understand value from both an individual/firm perspective and a government or social planner perspective, since the former constitute the market forces of change, and the latter are required to make decisions that are in the overall interest of society.

7.2 Approach

For the status quo description and assessment, the socio-economic characteristics, aquatic ecosystem services and economic outputs of the study area were described using spatial data wherever possible. This includes:

- An overview of land use, population, and the use of water in the study area.
- Descriptions of the main water user groups and their economic outputs, where possible.
- A preliminary description of the value of aquatic ecosystems in terms of the ecosystem services they provide.
- Delineation of IUAs and descriptions of their economic activities and population characteristics.

Information on population, income, livelihoods and living conditions was derived from StatsSA Census data for 1996, 2001 and 2011. Where census data had been disaggregated into mesozones by StepSA (2016, 2018), these were used to obtain summaries at the level of the IUA. This dataset also includes information on demographic, education, poverty, and other socio-economic attributes over time. For other census data, summaries were produced based on data at the slightly larger sub-place (SP) level. The latest (2020) land-use-land cover maps were used in conjunction with information on water users in the study area, to create a spatial description of water use. Given the extent of the spatial mismatch between water resources and water uses in many parts of the study area, this step was extended to describe the water user groups as well as the IUAs in some detail. Estimates of gross value added (GVA) and employment per sector per IUA were made for 2016 (StepSA, 2018). These were based on the spatial disaggregation of GVA and employment data by mesozone for 2016 from the CSIR StepSA website7. These figures were based on original data provided by Quantec at the Local Municipality level and disseminated to Mesozone level using the dasymetric map method[8].

A preliminary assessment of the ecosystem services provided by aquatic ecosystems in the study area was undertaken based on available literature. The approach taken to value each ecosystem service is provided in the relevant section. Box 7-1 provides a description of aquatic ecosystem services and the benefits they provide, and a summary of the valuation approaches used to measure them.

7.3 Description of the status quo

7.3.1 Population of the study area

7.3.1.1 Population

A total of 3.3 million people lived within the secondary catchments A5-A9 of the Limpopo WMA and secondary catchment B9 in the Olifants WMA in 2016 (Figure 7-3). While the total population has increased by some 720 000 people since 1996 (a 28% increase), the population growth has slowed over the years, with a 10% increase between 1996 and 2011, an 8% increase between 2001 and 2011, and a 7% increase between 2011 and 2016.

Population growth has been the highest in the Mapungubwe, and Upper Sand IUAs with the population increasing by 87% and 51%, between 1996 and 2016, respectively. The IUAs situated in the west of the study area (IUAs 1-5) recorded a much lower population growth across the same period, with an

7 http://stepsa.org/socio_econ.html

8 A dasymetric map is a method of thematic mapping in which a choropleth map is refined by incorporating additional geographic information. In a dasymetric map, boundaries are modified to conform to known areas of homogeneity and are not restricted to administrative or statistical boundaries.

average increase of only 8%. In fact, the population of the Lower Mogalakwena and Kalkpan se Loop IUAs decreased over the same period by -7% and -20%, respectively (Figure 7-4).

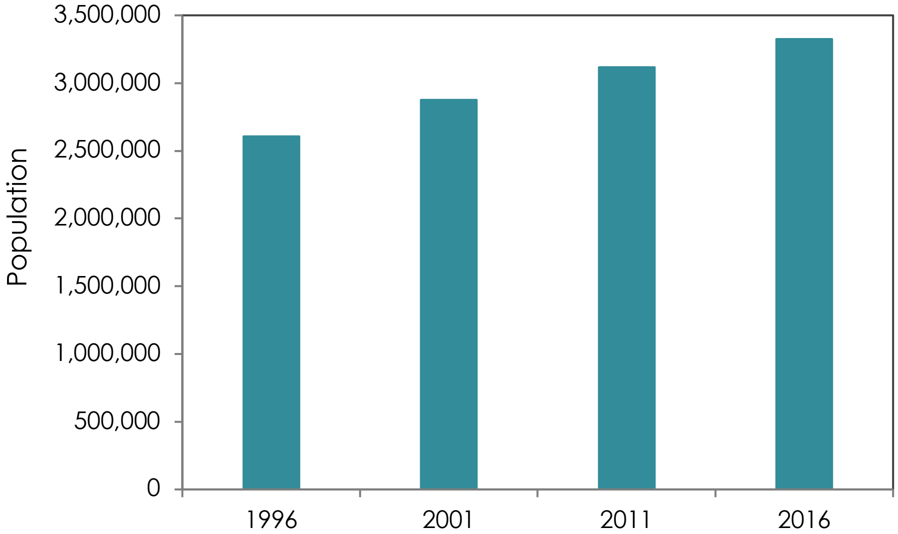


Figure 7-3. Population statistics for the study area 1996, 2001, 2011 and 2016. Source: StepSA, 2018.

In 2016, the most populated IUAs were the Upper Sand followed by the Upper Luvuvhu (Figure 7-4). Together these two zones accounted for 45% of the total population in the study area. There were just under 880 000 households in the study area, with an average household size of 3.8 in 2016 (Table 7-2). The Lower Lephalala IUA has an average household size of 4.3, the highest in the study area, and the Kalkpan se Loop IUA has the lowest household size of 2.6 (Table 7-2).

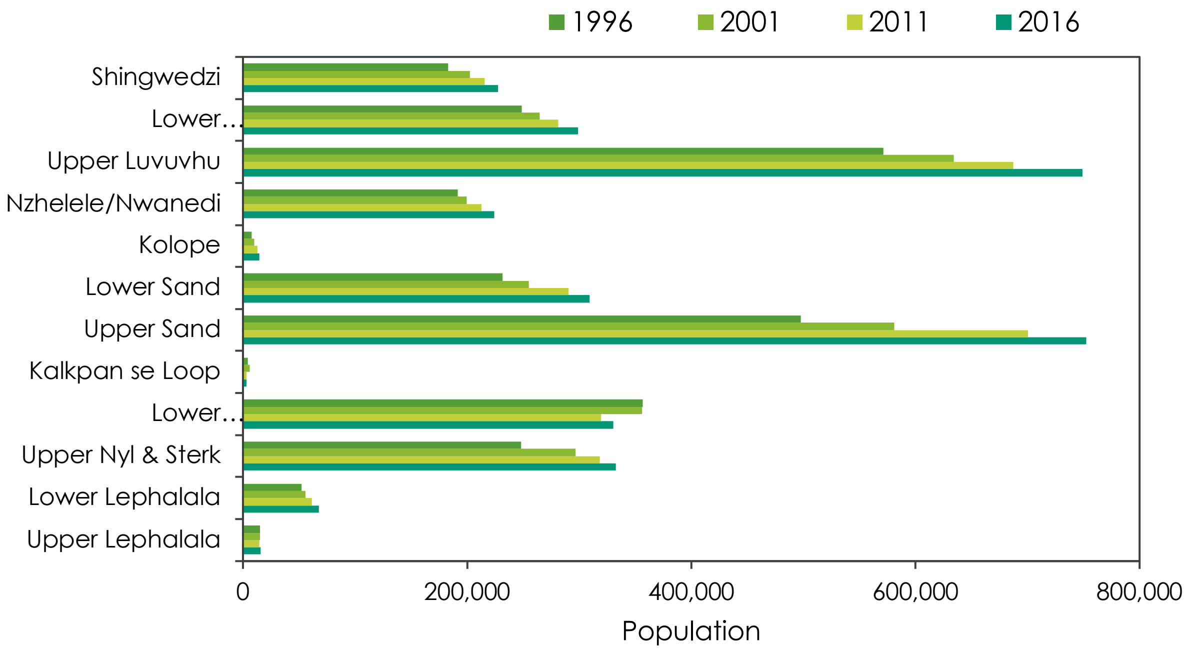


Figure 7-4. Population in each IUA in 1996, 2001, 2011 and 2016. Source: StepSA, 2018.

Table 7-2. Total population, number of households and average household size in each IUA in 2016. Source: StepSA, 2018.

IUA	IUA Name	Population	Households	Average household size
1	Upper Lephalala	15 899	3 785	4.2
2	Lower Lephalala	67 675	15 847	4.3
3	Upper Nyl & Sterk	332 663	87 608	3.8
4	Lower Mogalakwena	330 280	84 474	3.9
5	Kalkpan se Loop	3 421	1 292	2.6
6	Upper Sand	752 613	212 886	3.5
7	Lower Sand	309 562	82 919	3.7
8	Kolope	14 625	4 620	3.2
9	Nzhelele/Nwanedi	224 066	57 897	3.9
10	Upper Luvuvhu	748 968	191 099	3.9
11	Lower Luvuvhu/Mutale	298 930	77 022	3.9
12	Shingwedzi	227 561	57 749	3.9
	Total	3 326 262	877 198	3.8

Unsurprisingly, population density is highest around the main cities and large towns, such as Polokwane, Musina, Makhado, Modimole and Mokopane (Figure 7-5). The Upper Sand, Upper Luvuvhu, and Mogalakwena IUAs are particularly densely populated. Across the study area, a large proportion of the population live in dense rural areas, also known as homelands; Venda, Lebowa and Ganzankulu homelands. The majority of people who live in the study area are of the Pedi, Tsonga and Venda tribes. By 2016, 53% of the total population lived in big regional service centres, as opposed to 40% in 1996. The proportion of people living in dense rural settlements declined from 42% to 31% between 1996 and 2016. Of the 3.3 million people living in the study area, approximately 34% are below 14 years of age while 50% are between the ages of 20 and 64 years.

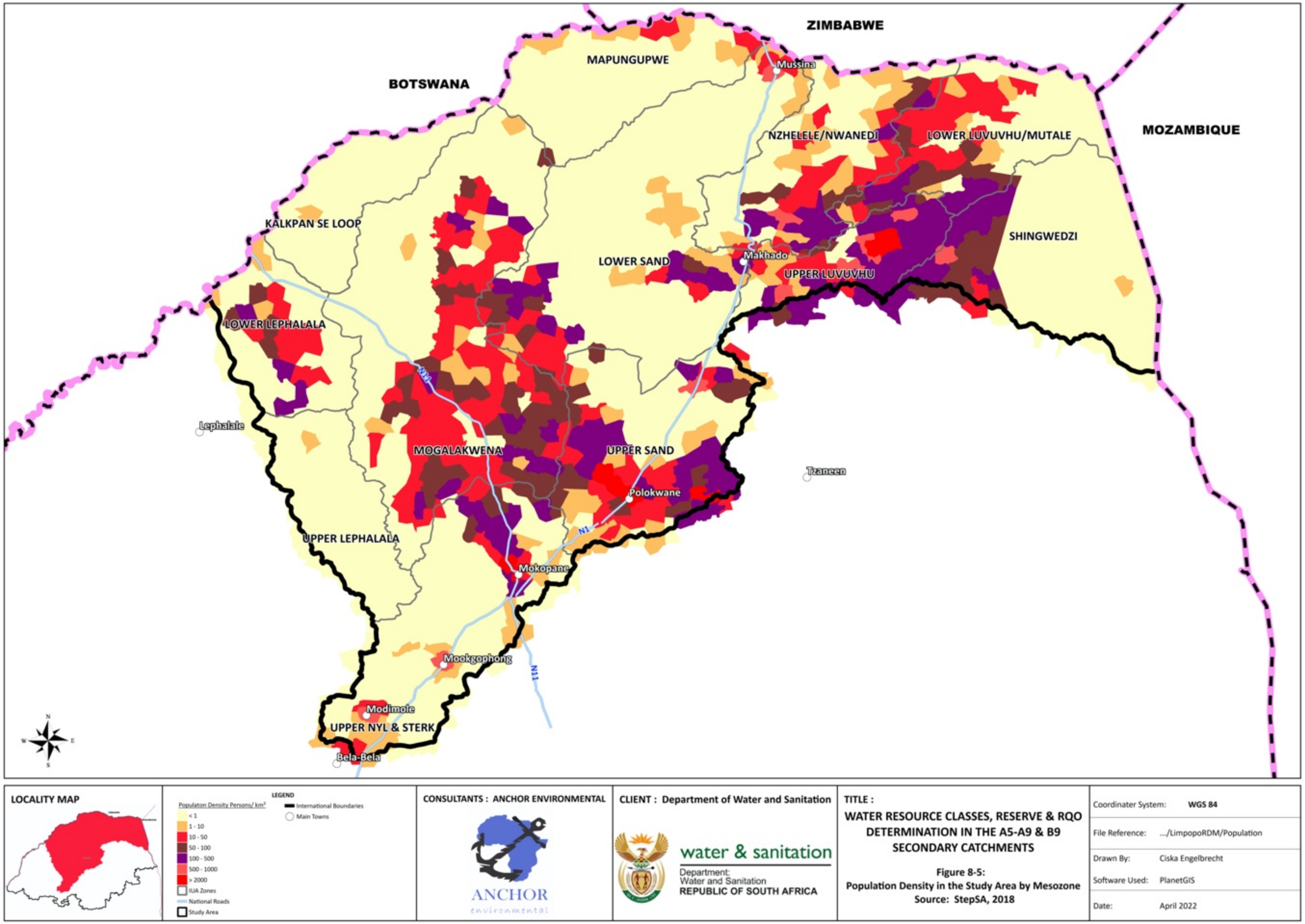


Figure 7-5. Population density in the study area, by mesozone. Source: StepSA, 2018.

7.3.1.2 Income, poverty and unemployment

The average annual household income for the study area was R70 996 in 2011 (Table 7-3). Households in the Shingwedzi, Lower Luvuvhu/Mutale, and Lower Mogalakwena IUAs had the lowest average household incomes, and households in Upper Sand, Upper Lephalala, and Upper Nyl and Sterk IUAs had the highest household incomes (Table 7-3). Of the 822 000 households in the study area, close to 100 000 (12%) of households had no income, and 175 000 households (21%) were considered poor[9], or living in poverty, in 2011. While there were 26 000 more households living in poverty in 2011 compared to 1996, overall, the percentage of poor households decreased from 29% to 21% (Figure 7-6).

Table 7-3. Number of households, average annual household income and percentage of households with no income in each socio-economic zone in 2011. Source: Census 2011.

IUA	Number of households	Ave. annual household income (R)	% Households with no income	% Poor households
Upper Lephalala	3 497	78 268	7%	15%
Lower Lephalala	14 398	60 709	10%	18%
Upper Nyl & Sterk	83 852	77 134	13%	19%
Lower Mogalakwena	81 710	50078	12%	22%
Kalkpan se Loop	1 266	71 219	7%	8%
Upper Sand	198 212	98 014	13%	20%
Lower Sand	77 864	70 279	12%	20%
Mapungubwe	4 114	66 612	5%	13%
Nzhelele/Nwanedi	54 966	54 562	11%	21%
Upper Luvuvhu	175 370	67 098	11%	21%
Lower Luvuvhu/Mutale	72 495	47 648	13%	26%
Shingwedzi	54 679	44 534	14%	27%
	822 421	70 996	12%	21%

[9] The proportion of poor households in the study area was based on household income and expenditure patterns in South Africa, developed by the Bureau of Market Research (BMR 2013). The 'poor' income category (R0 – R54 344 per household per annum) as defined by the BMR was used to establish the proportion of households living in poverty (StepsSA 2018). To calculate this for 1996, the CPI was used to inflate 1996 prices to establish the equivalent income category cut off for the census data in these years.

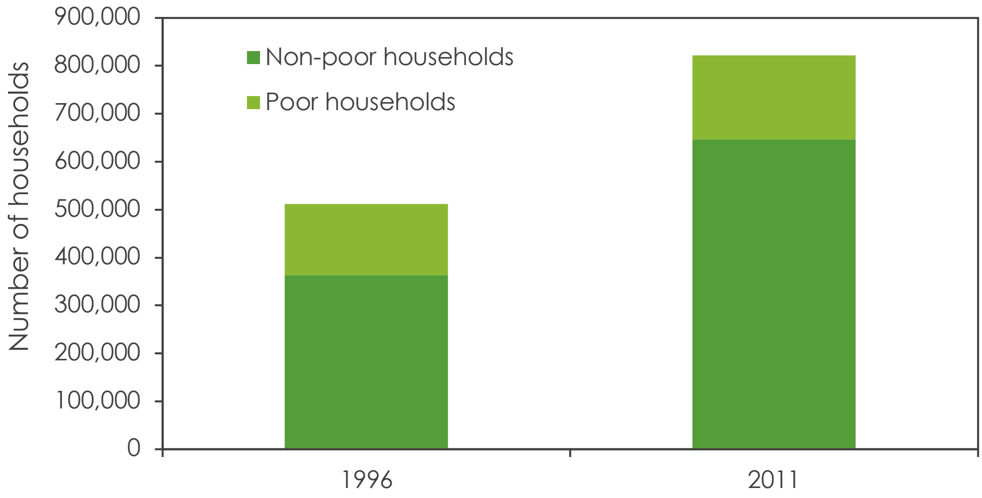


Figure 7-6. The number of poor and non-poor households in the study area in 1996 and 2011. Source: StepSA, 2018.

The Shingwedzi and Lower Luvuvhu/Mutale IUAs had the highest percentage of poor households in the study area in 2011 (Figure 7-7). All regions experienced an overall decrease in the percentage of poor households since 1996, but Upper Nyl & Sterk and Upper Sand had the lowest percentage change since 1996, with households living in poverty decreasing by just 4% in these IUAs. In only one IUA was the percentage of poor households lower than 10% and that was in Kalkpan se Loop IUA in 2011. The number of poor households tends to increase in and around urban settlements (Figure 7-8).

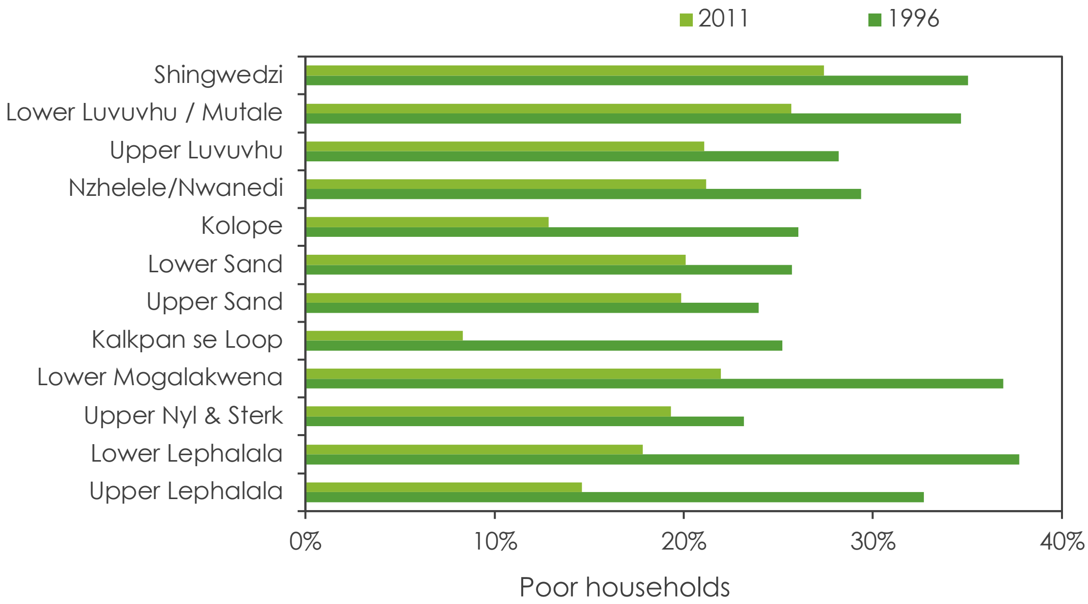


Figure 7-7. Percentage of poor households in each IUA in 1996 and 2011. Source: StepSA, 2018

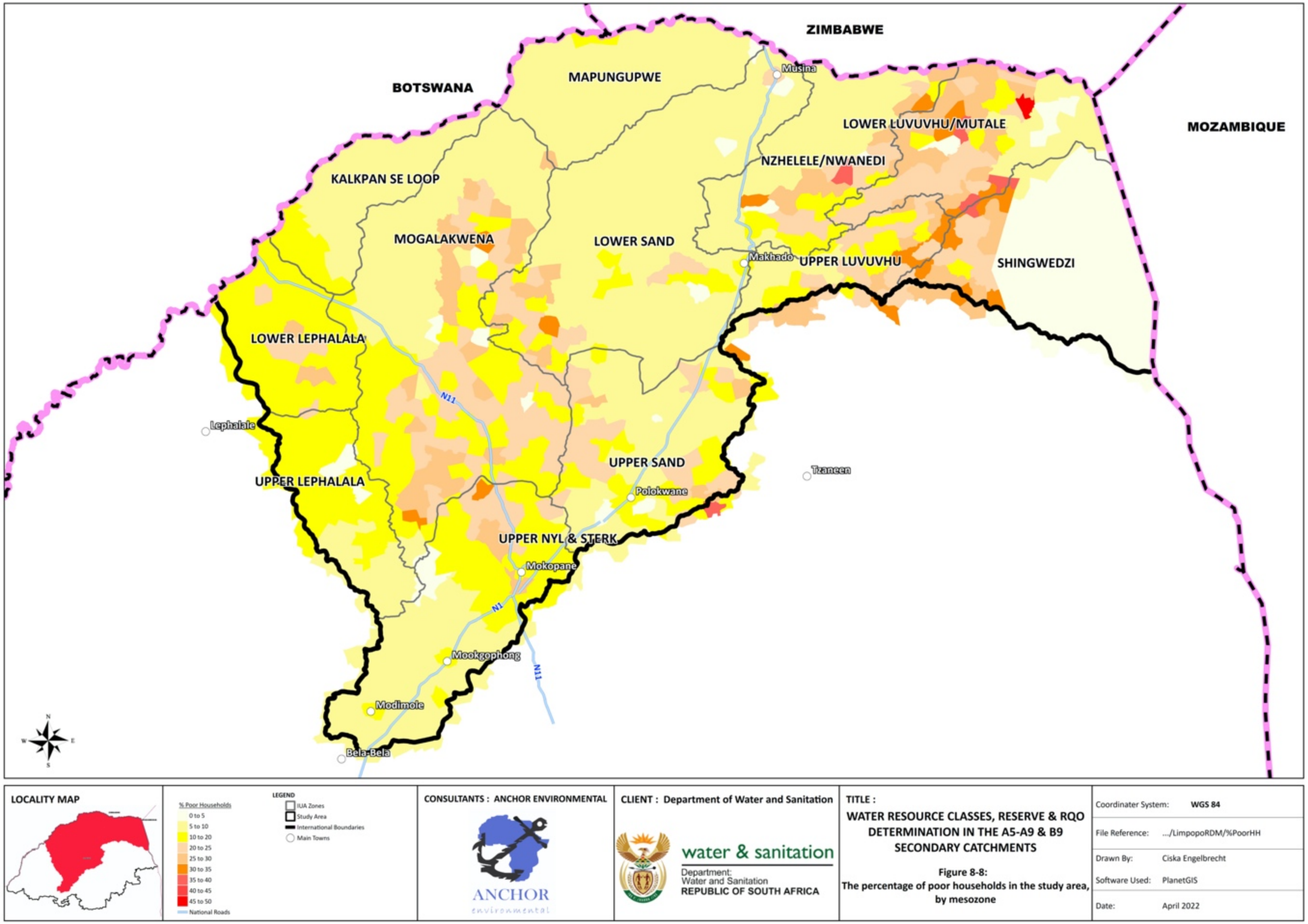


Figure 7-8. The number of poor households in the study area, by mesozone. Source: StepSA, 2018

Unemployment across the study area has decreased on average by 9% between 1996 and 2016 (Figure 7-9). Kalpan se Loop and Mapungubwe (Kolope) IUAs have both experienced increases in unemployment since 1996. Whilst the Lower Luvuvhu/Mutale and Shingwedzi IUAs have the highest percentage unemployment in 2016, at 41% and 40%, respectively, these figures have improved significantly since 1996 when almost 75% of the working population was unemployed (Figure 7-9). Unemployment was lowest in 2016 in Mapungubwe (Kolope), Lower Lephalala, and Upper Lephalala IUAs at 19%, 21% and 23%, respectively (Figure 7-9 and Figure 7-10).

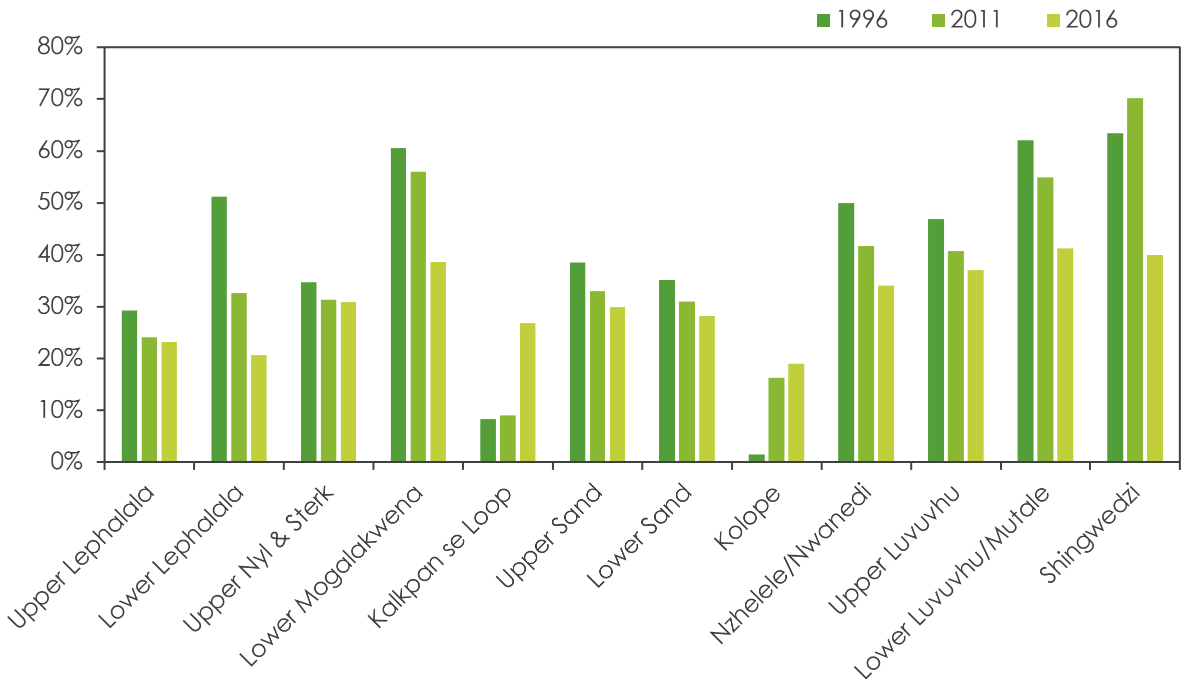


Figure 7-9. Percentage unemployment in each IUA in 1996, 2011 and 2016. Source: StepSA, 2018.

7.3.1.3 Access to electricity

In 2011, 83% of households in the study area were using electricity as their main source of energy for lighting. The use of other forms of lighting, such as candles, gas and paraffin are highest in the Mapungubwe (41%), Kalpan se Loop (38%) and Upper Lephalala IUAs (32%; Figure 7-11). The percentage of households in the study area using electricity as a main source of energy for cooking was only 49%, with 44% of households relying on wood and 6% using gas and paraffin (Figure 7-12). The use of wood for cooking was highest amongst households in the four most eastern IUAs in the study area, Lower Luvuvhu/Mutale (80%), Shingwedzi (79%), Nzhelele/Nwanedi (63%) and Upper Luvuvhu (57%; Figure 7-12).

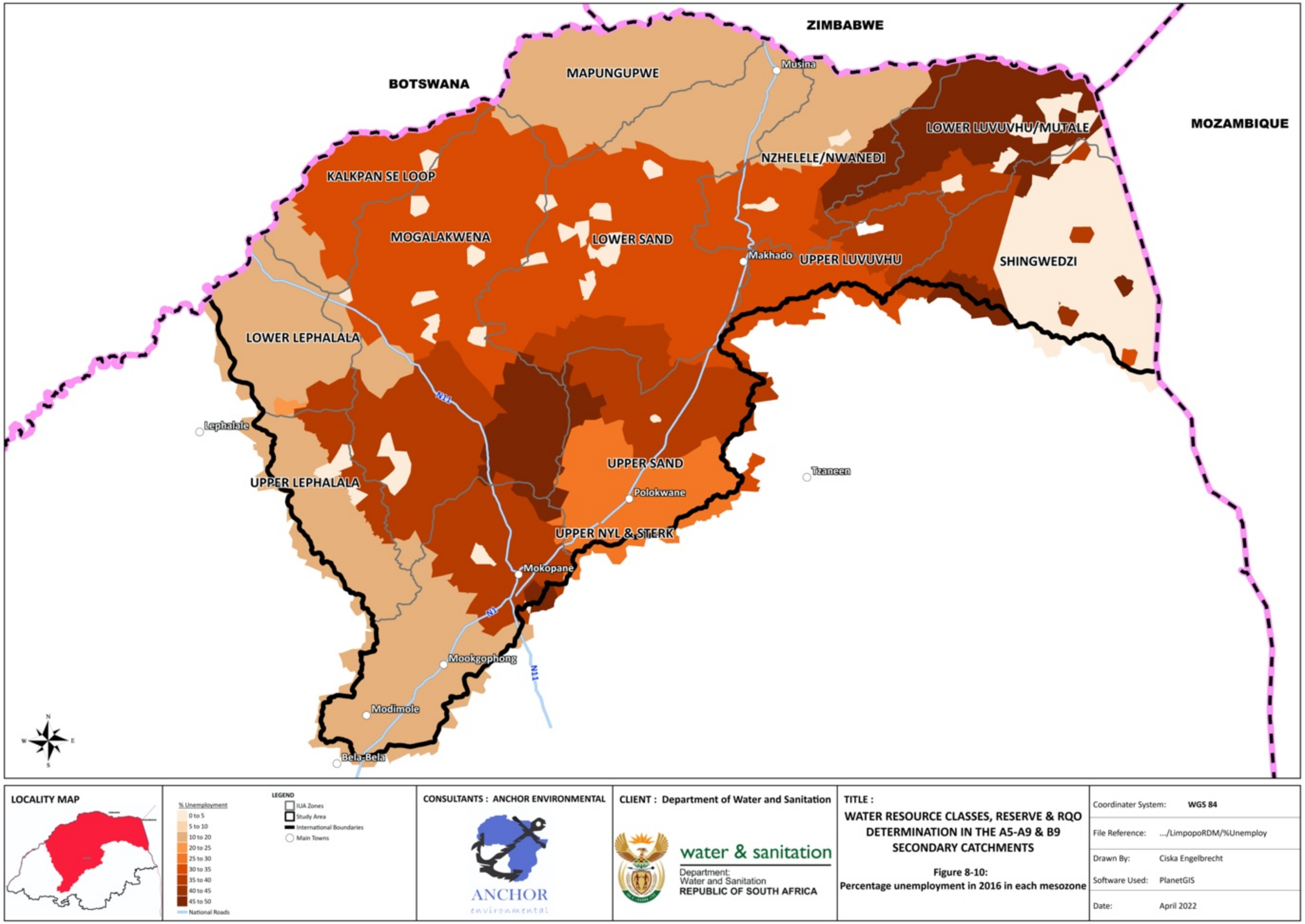


Figure 7-10. Percentage unemployment in 2016 in the study area, by mesozone. Source: StepSA, 2018.

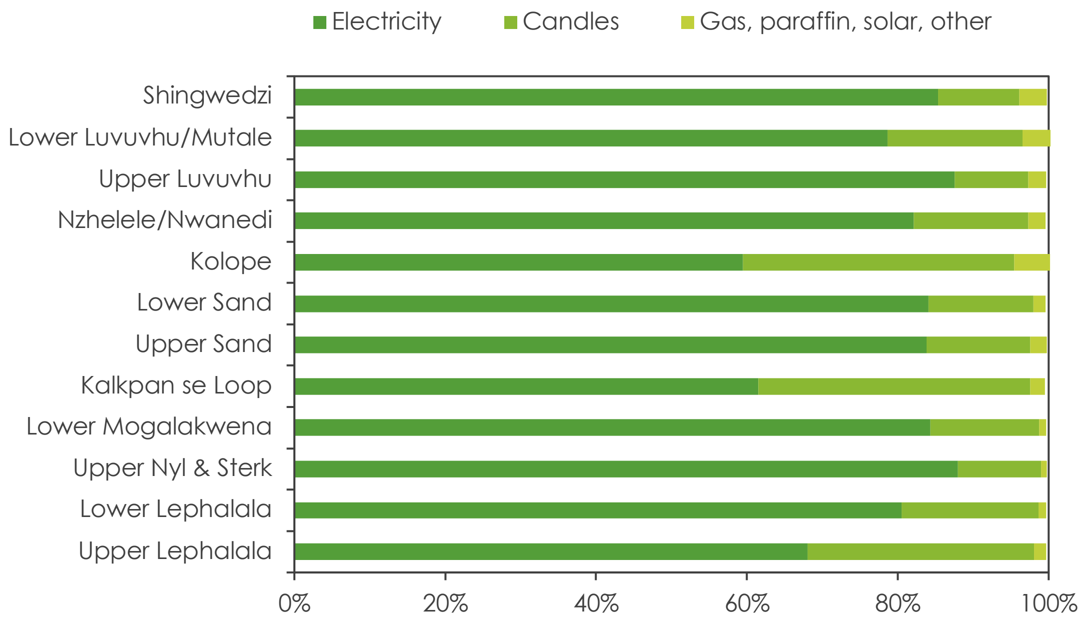


Figure 7-11. Percentage of households using electricity as a main source of lighting in 2011, compared to other sources. Source: Census 2011.

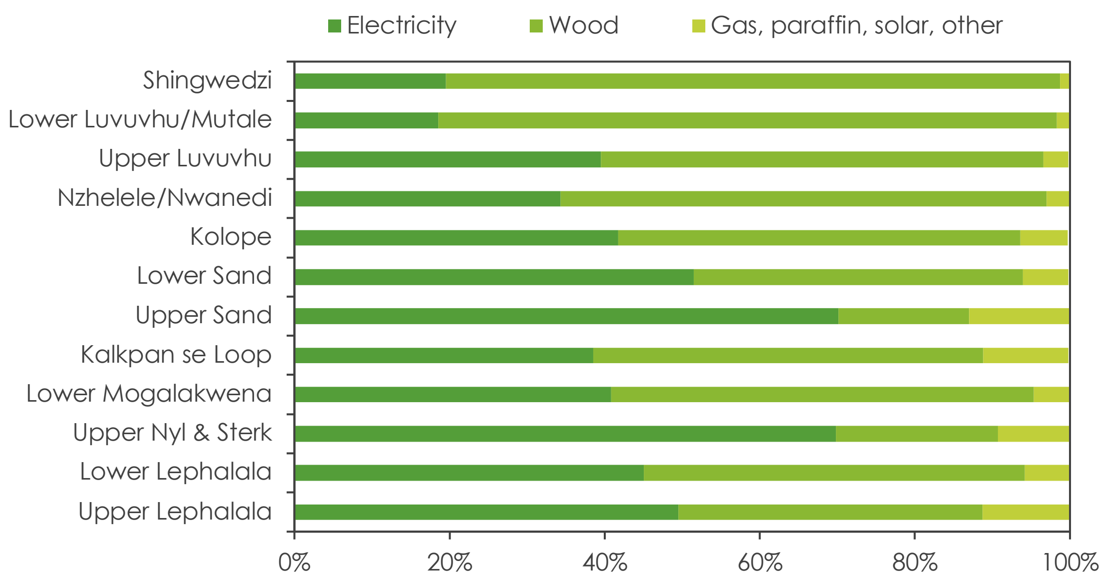


Figure 7-12. Percentage of households using electricity as a main source of cooking in 2011, compared to other sources. Source: Census 2011.

7.3.1.4 Water and sanitation

Access to water is variable across the study area (Figure 7-13). In 2011, 59% of households in the study area had good access to piped water (in their dwelling or yard), 32% had poor access (a communal stand), and 9% had no access to piped water. Households with no access to piped water is highest in the Nzhelele/Nwanedi IUA (17%) and Lower Luvuvhu/Mutale (17%). The majority of households in the Shingwedzi and Lower Luvuvhu/Mutale IUAs have poor access to piped water, relying on communal stands. Good access to piped water is highest in the Upper Lephalala (85%), Kalkpan se Loop (84%), Upper Sand (73%) and Upper Nyl & Sterk (72%) IUAs.

In the study area, close to 517 000 households (60%) received their water from a water scheme (i.e., water service provider) and 22% of households relied on boreholes for their water (Table 7-4). Less than 10% of households in the Upper Lephalala, Kalkpan se Loop and Mapungubwe (Kolope) IUAs receive their water from a water scheme. It was estimated that in 2011 a total of 30 886 households in the study area were reliant on rivers and streams as their main source of domestic water (Table 7-4). This equates to 4% of all households. The Lower Luvuvhu/Mutale, Mapungubwe (Kolope), and Nzhelele/Nwanedi IUAs had the highest percentage of households reliant on river water. This figure was lowest in the Upper Nyl & Sterk, Upper Sand and Shingwedzi IUAs where less than 1% of households collected water from rivers and streams. Whilst the second highest number of households reliant on river water was in the Upper Luvuvhu IUA at just over 5 413 households, this represented only 4% of all households in this area.

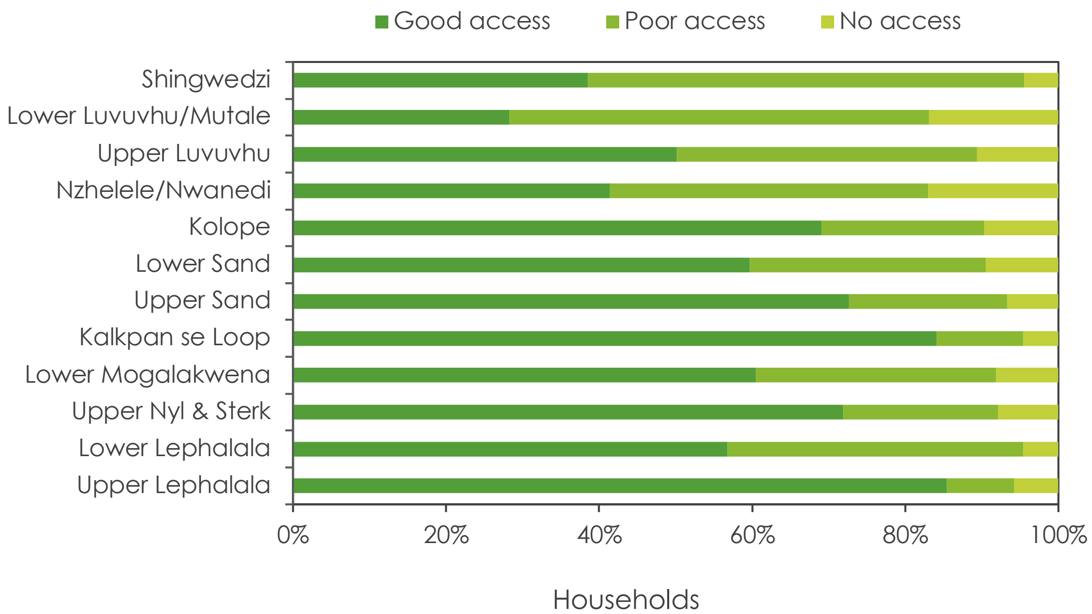


Figure 7-13. Percentage of households with good, poor or no access to piped water in 2011. Good access = piped water into the dwelling or on dwelling site, poor access = use of a communal stand. Source: Census 2011.

Table 7-4. Percentage of households in each IUA by type of water source. Source: Census 2011

IUA	Water-scheme	Borehole	Water tanker, water vendor	Dam, pool, stagnant water	River, stream	Spring, other
Upper Lephalala	8%	73%	10%	2%	4%	5%
Lower Lephalala	45%	40%	8%	2%	3%	4%
Upper Nyl & Sterk	65%	24%	6%	1%	0%	4%
Lower Mogalakwena	49%	32%	7%	4%	4%	7%
Kalkpan se Loop	7%	70%	14%	1%	5%	4%
Upper Sand	71%	16%	6%	3%	1%	6%
Lower Sand	56%	26%	9%	3%	3%	7%
Mapungubwe	8%	61%	9%	6%	12%	9%
Nzhelele/Nwanedi	41%	24%	8%	10%	8%	17%
Upper Luvuvhu	70%	10%	4%	4%	4%	12%
Lower Luvuvhu	59%	12%	3%	4%	14%	12%
Shingwedzi	82%	10%	4%	1%	1%	4%
	60%	22%	6%	4%	4%	8%

In 2011 just 24% of households in the study area had flush toilets, with almost half of all households using pit toilets (47%; Figure 7-14). The Upper Nyl & Sterk and the Upper Sand IUAs had the highest proportion of households using flush toilets, at 44% and 38%, respectively. In the Lower Mogalakwena IUA only 8% of households had a flush toilet, 64% used pit toilets, and 9% of households had no form of sanitation (Figure 7-14). In the Mapungubwe (Kolope) IUA households with no sanitation was as high as 23%. Ventilated improved pit (VIP) toilets, septic toilets and chemical toilets were the dominant sanitation type in the Lower Lephalala IUA (40%).

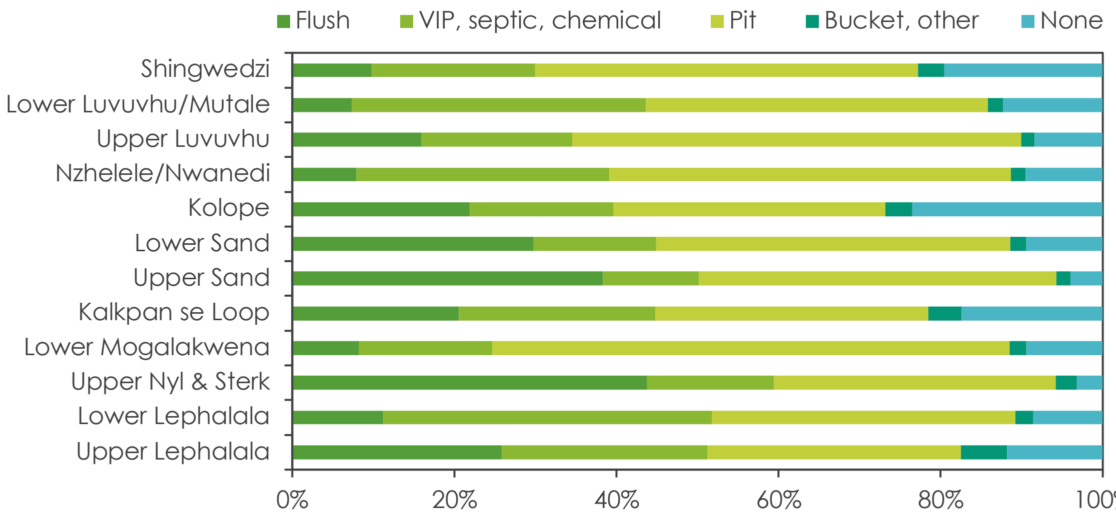


Figure 7-14. Percentage of households with access to a flush toilet and those using other types of toilets in 2011. Source: Census 2011. VIP = ventilated improved pit.

In 2011, just under a quarter of all of households (24%) in the study area had access to good refuse removal, which includes the weekly or monthly collection of refuse by local authority. Poor refuse removal includes no refuse disposal or the use of a communal or private dump. Good refuse removal was highest in the Upper Nyl & Sterk (44%), Upper Sand (40%), and Lower Sand (30%) IUAs (Figure 7-15). More than 90% of households in the Nzhelele/Nwanedi, Lower Luvuvhu/Mutale, Lower Lephalala and Lower Mogalakwena IUAs had poor refuse removal in 2011 (Figure 7-15).

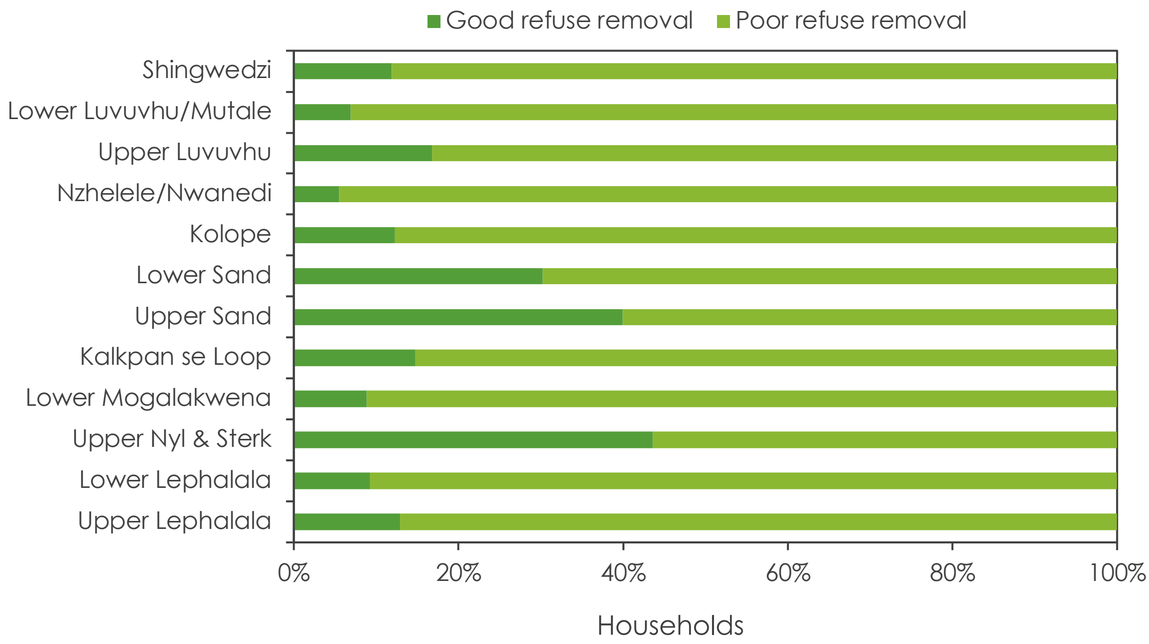


Figure 7-15. Percentage of households with good or poor refuse removal in 2011. Source: Census 2011.

7.3.2 Overall economic context

7.3.2.1 Economic activities and sectoral outputs

The study area falls entirely within the Limpopo Province of South Africa (Figure 7-16). The province is divided into five district municipalities and 22 local municipalities. In 2018, the Limpopo Province generated just over 7% of South Africa's gross domestic product (GDP) making it the nation's sixth largest provincial economy. The secondary catchments A5-A9 within the Limpopo WMA and secondary catchment B9 in the Olifants WMA cover much of the Waterberg District Municipality (DM) and Capricorn DM, and almost all of the Vhembe DM, as is depicted in Figure 7-16. A small part of the secondary catchment B9 in the Olifants WMA falls within the Mopani DM. The sectoral economic profiles of these four main District Municipalities that straddle the study area are presented in Table 7-5. Situated in the centre of the Limpopo Province and including the capital city of Polokwane, Capricorn DM had the highest total GVA in Limpopo in 2018.

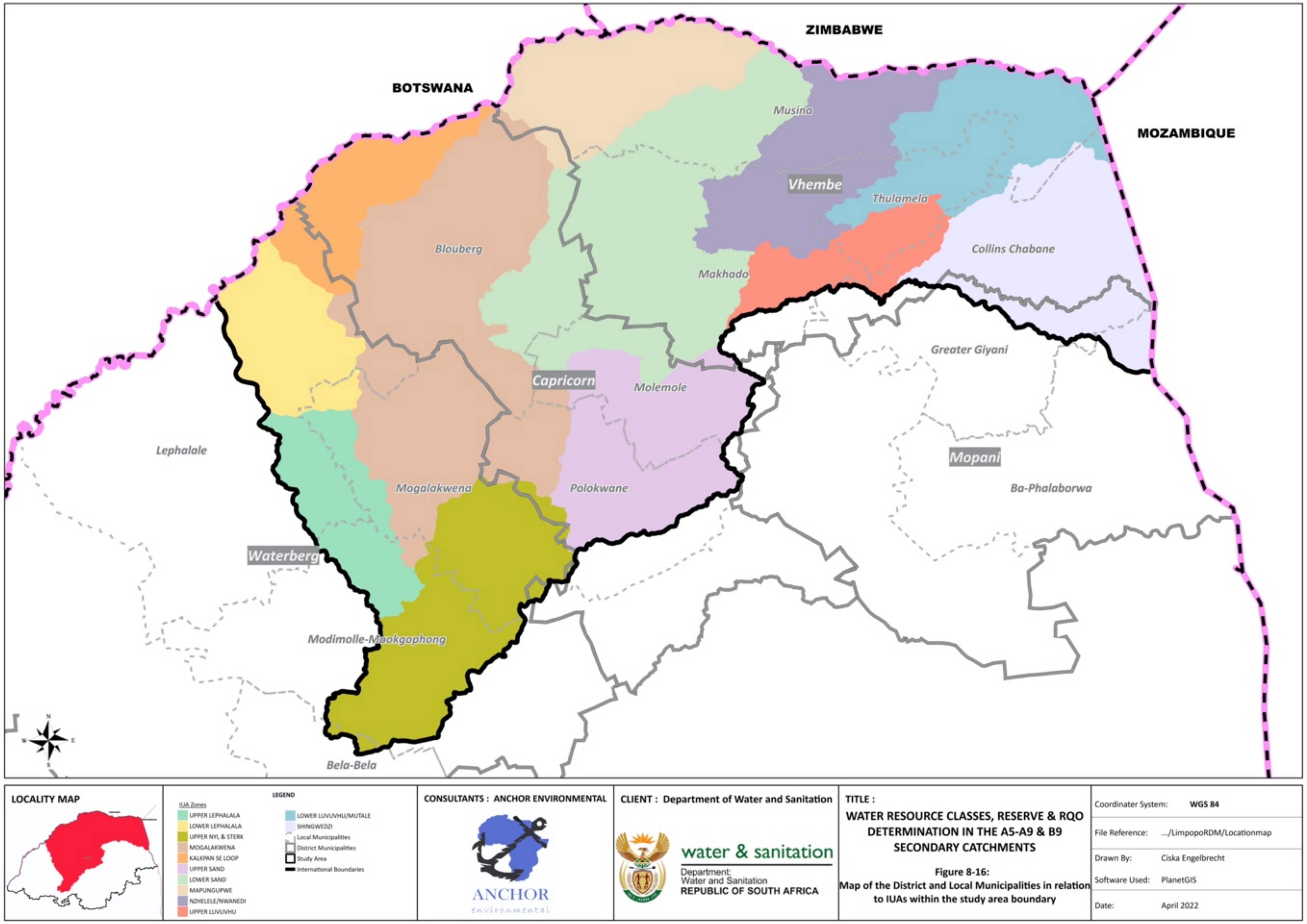


Figure 7-16. Map of the District and Local Municipalities in relation to IUAs within the study area boundary.

Table 7-5. Economic profiles of primary District Municipalities (GVA sectoral contributions, %) in the Study Area in 2018. Source: COGTA, 2020a, 2020b, 2020c, 2020d.

Broad economic sector	Waterberg	Capricorn	Vhembe	Mopani
Agriculture, Forestry & Fishing	3%	2%	3%	3%
Mining	56%	9%	10%	35%
Manufacturing	3%	3%	3%	2%
Electricity, Gas & Water	3%	3%	6%	8%
Construction	2%	3%	4%	2%
Trade, retail, catering & accommodation	9%	21%	17%	13%
Transportation & communication	4%	7%	6%	4%
Finance, real estate & business Services	8%	19%	18%	13%
Community and social services	12%	33%	33%	20%

The main drivers of the economy in the study area are mining and agriculture, and community services (i.e., government employment), trade, retail, wholesale, and financial services. While mining is the dominant sector across the Limpopo province, it is particularly important in the Waterberg and Mopani DMs where it is the highest contributor to GVA. The study area falls within one of the major mining areas of the region with platinum, iron ore, coal and diamonds being the main resources mined in the Waterberg region and copper, magnetite and phosphate the main minerals mined in the Mopani region (COGTA, 2020a, 2020b). Importantly, around 40% of national coal reserves are located in the Waterberg DM and it is also home to the Medupi power station. However, only part of these two district municipalities are within the boundary of the study area.

Mining is less important in Capricorn and Vhembe DMs, which are almost entirely in the study area, where community services, trade, retail, catering and accommodation services, and financial services are the dominant sectors. The bushveld landscape, rich biodiversity, culture and heritage attributes give this region a competitive advantage, making it an important tourist destination. With the northern Kruger National Park (from Olifants to Shingwedzi camps or Lepelle to Shingwedzi rivers), the Waterberg Biosphere Reserve, and numerous privately owned game reserves falling within the boundary of the study area, ecotourism is an important revenue and employment generator.

In the study area, most of the economic production is centred around the main urban centres, areas of mining activity, as well as from the areas where irrigation is practised to produce high value outputs. The agricultural sector is relatively diverse, encompassing an important fruit and vegetable industry, as well as substantial cereal and oil seed products. The most abundant and economically important agricultural crops are grains, cereals and oil seeds in the Waterberg region, vegetable crops including tomatoes, potatoes, cabbages and butternut grown mostly in the Waterberg and Capricorn DMs with some areas of Vhembe DM being important for tomatoes, as well as tree nuts such as macadamias and pecans (Stats SA, 2020). Sub-tropical fruit such as melons, paw-paw, bananas, mangoes, avocados and pineapples are produced in the eastern parts of the study area, and citrus, especially oranges and grapefruit in and around Musina (Stats SA, 2020). A large proportion of the sub-tropical fruits are exported. The trade sector is important and is supported by wholesale and service-orientated activities, and a growing tourism market. Mining and agriculture present opportunities for growth, along with tourism and logistics. The busy N1 highway passes through Limpopo from the south to the border town of Musina on the Zimbabwean border, and the N11 highway links Limpopo with Botswana to the west and Mpumalanga Province to the east.

The most important areas of economic activity in the study area as a whole have been identified as follows:

- Urban economies in the south-western (Polokwane, Mokopane, Modimole) and north-eastern (Mussina, Makhado) sections of the study area;
- Intensive mining in the south-western areas of the study area, mostly in the Upper Nyl & Sterk IUA, in the north-central areas in the Lower Sand and Mapungubwe IUAs, and in the eastern Lower Luvuvhu IUA;
- Commercial irrigation agriculture along the Limpopo, Sand, Luvuvhu, Lephalala and Nzhelele rivers;
- Commercial timber plantations in the Upper Luvuvhu IUA;
- Widespread dry-land cultivation economy in the western Upper Lephalala, Lower Lephalala, Upper Nyl & Sterk, and Mogalakwena IUAs; and
- Important ecotourism economy that covers large areas of the study area and is associated in particular with national and local protected areas and privately owned game reserves.

The total GVA for the study area was estimated to be R70.1 billion in 2016 (StepSA, 2018; Figure 7-17, Table 7-6). The highest GVA values are found in and around major towns, particularly in the Upper Sand, Upper Luvuvhu and Lower Sand IUAs (Figure 7-17). GVA is lowest in the Kalkpan se Loop and Mapungubwe IUAs.

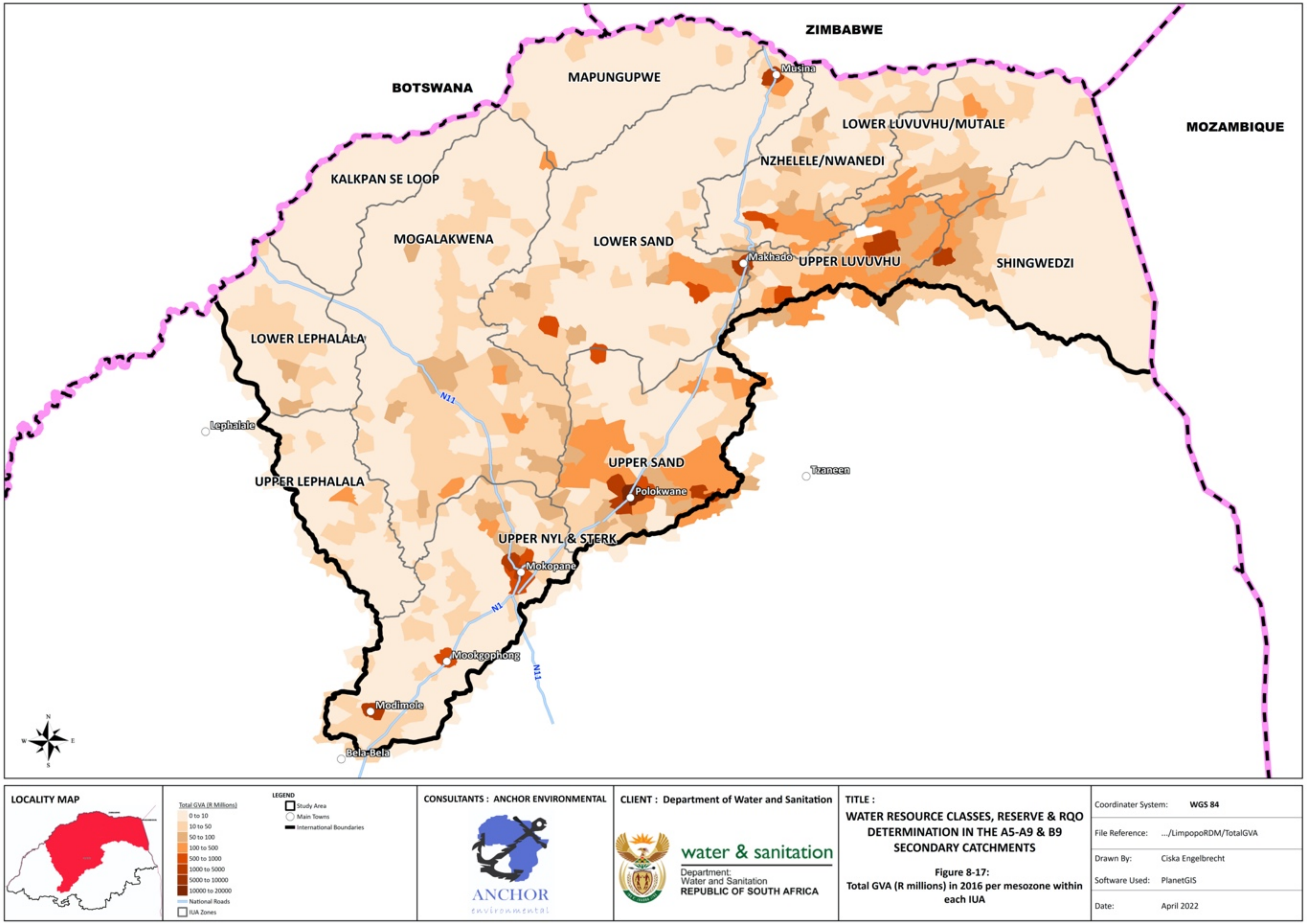


Figure 7-17. Total GVA (R millions) in 2016 per mesozone within each IUA. Source: StepSA 2018.

Overall, the community, social and government services sector contributed the most to GVA in 2016 at R32.4 billion followed by the trade, catering and accommodation sector (R21.1 billion), the financial services sector (R19.6 billion), the transport and communications sector (R6.3 billion), the agriculture, forestry and fisheries sector (R2.6 billion), manufacturing sector (R2.8 billion), the electricity, gas and water supply sector (R2.5 billion) and the mining sector (R1.9 billion; Table 7-6). Since 2011, the percentage share of GVA has decreased by less than 1% in the agriculture, forestry and fisheries sector, the mining sector, the manufacturing sector, the electricity, gas and water supply sector, and the trade, catering and accommodation sector (Table 7-6). GVA has increased for the transport and communications sector, financial services sector and the community, social and government services sector. The Upper Sand had the highest percentage contribution to total GVA of 38% (R34.3 billion) followed by the Upper Luvuvhu at 20% (R18.2 billion), and Lower Sand at 11.8% (R10.6 billion; Figure 7-17 and Figure 7-18). The Kalkpan se Loop, Mapungubwe, Lower Lephalala and Upper Lephalala IUAs contributed the least to overall GVA in the WMA at less than 1% (Figure 7-18).

Almost 40% of the total mining GVA was associated with outputs from the Upper Nyl & Sterk IUA. Mining was also important in the Upper Sand, Lower Sand and Lower Luvuvhu/Mutale IUAs. It was estimated that the agriculture, forestry and fisheries sector contributed R2.6 billion to total GVA in the study area in 2016 (Table 7-6, Figure 7-19). Outputs are highest in the Upper Luvuvhu, the Nzhelele/Nwanedi, and Upper Sand IUAs, and are lowest in the Kalkpan se Loop, Mapungubwe (Kolope) and Shingwedzi IUAs. Commercial timber plantations are important in the Upper Luvuvhu IUA. The community and government services sector and wholesale trade, catering and accommodation sector are important contributors to GVA in all socio-economic zones (Table 7-6).

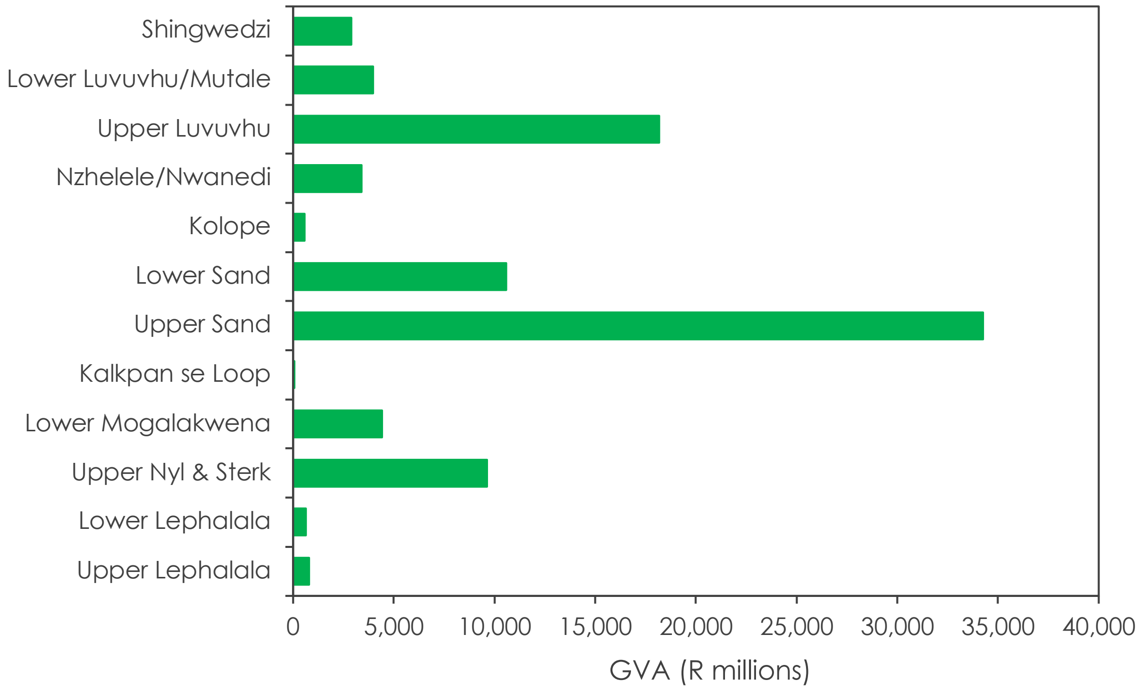


Figure 7-18. Total GVA (R millions) for each IUA in 2016. Source: StepSA 2018.

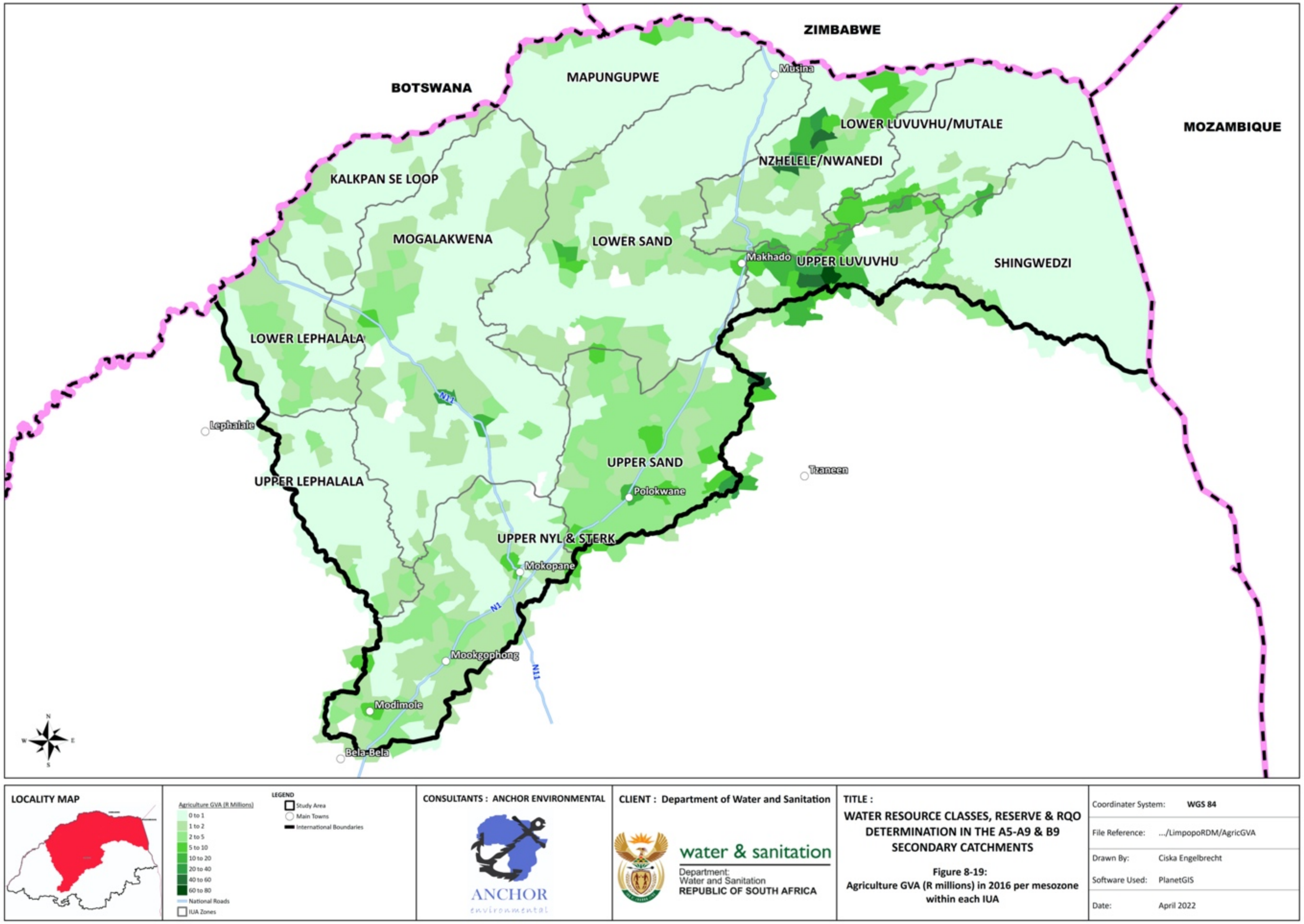


Figure 7-19. Agriculture GVA (R millions) in 2016 per mesozone within each IUA. Source: StepSA 2018.

Table 7-6. Total GVA (nominal 2016 prices) for each IUA in 2011 and 2016. Source: StepSA 2018.

IUA	Agriculture, Forestry & Fishing		Mining & Quarrying		Manufacturing		Electricity, Gas & Water		Trade, retail & accommodation		Transport & Communication		Financial services		Community services	
Total (R millions)	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**	**2011**	**2016**
Upper Lephalala	70.2	68.3	-	-	203.7	228.9	4.5	4.1	161.9	58.2	161.9	187.2	-	-	226.1	244.8
Lower Lephalala	107.2	106.4	-	-	-	-	0.4	0.3	7.3	34.8	7.3	8.3	-	-	432.7	471.1
Upper Nyl & Sterk	260.7	252.7	750.3	736.4	480.0	480.6	205.2	181.2	669.8	2 869.9	669.8	704.8	2 062.3	2 221.2	2 007.2	2 175.7
Lower Mogalakwena	291.8	283.7	47.2	46.1	66.2	61.5	173.0	150.2	182.7	551.5	182.7	188.3	3.1	3.3	2 892.9	3 128.5
Kalkpan se Loop	48.6	47.5	-	-	-	-	-	-	0.8	8.0	0.8	0.9	-	-	18.2	19.4
Upper Sand	453.1	450.1	268.3	281.2	1 193.2	1 252.6	1 014.0	909.6	2 481.7	8 175.6	2 481.7	2 824.8	9 515.3	10 280.8	8 946.4	10 095.8
Lower Sand	249.2	245.3	361.9	344.3	413.2	438.6	239.0	222.0	989.3	3 686.0	989.3	1 052.7	2 089.2	2 299.5	2 100.8	2 288.5
Mapungubwe	54.1	54.7	182.7	179.2	31.0	28.8	33.6	31.9	54.3	107.5	54.3	57.1	-	-	98.5	112.7
Nzhelele/Nwanedi	454.0	457.8	39.9	39.2	8.3	8.9	114.5	105.6	31.3	284.1	31.3	34.1	346.6	375.8	1 910.9	2 079.9
Upper Luvuvhu	474.9	470.6	2.9	2.7	265.1	247.4	799.7	706.1	906.6	4 883.6	906.6	947.8	3 669.8	3 978.9	6 439.7	6 922.2
Lower Luvuvhu/Mutale	153.9	150.4	294.9	272.3	13.5	13.0	164.7	151.4	58.7	196.9	58.7	61.2	177.7	213.6	2 696.5	2 918.0
Shingwedzi	56.1	56.4	-	-	68.2	60.7	35.6	30.9	249.4	276.9	249.4	260.3	241.2	261.5	1 828.2	1 949.2
Total	2 673.6	2 643.8	1 948.2	1 901.4	2 742.3	2 821.0	2 784.2	2 493.4	5 793.8	21 133.0	5 793.8	6 327.6	18 105.1	19 634.5	29 598.1	32 405.7

7.3.2.2 Employment by sector

In 2016, the community, social and government services sector employed the highest number of people in the study area (51%), followed by the wholesale trade, catering and accommodation sector (17%) and the financial services sector (11%; Figure 7-20). While the agriculture, forestry and fisheries sector only contributed 3% to total GVA in the study area, the sector employed 8% of the working population (Figure 7-20). This was similar for the mining, manufacturing and community and government services sector, all of which contributed more to employment relative to the sectors GVA contribution, i.e., the production value per individual is lower in these sectors compared to the wholesale trade, catering and accommodation sector, financial services sector and the transport and communications sector.

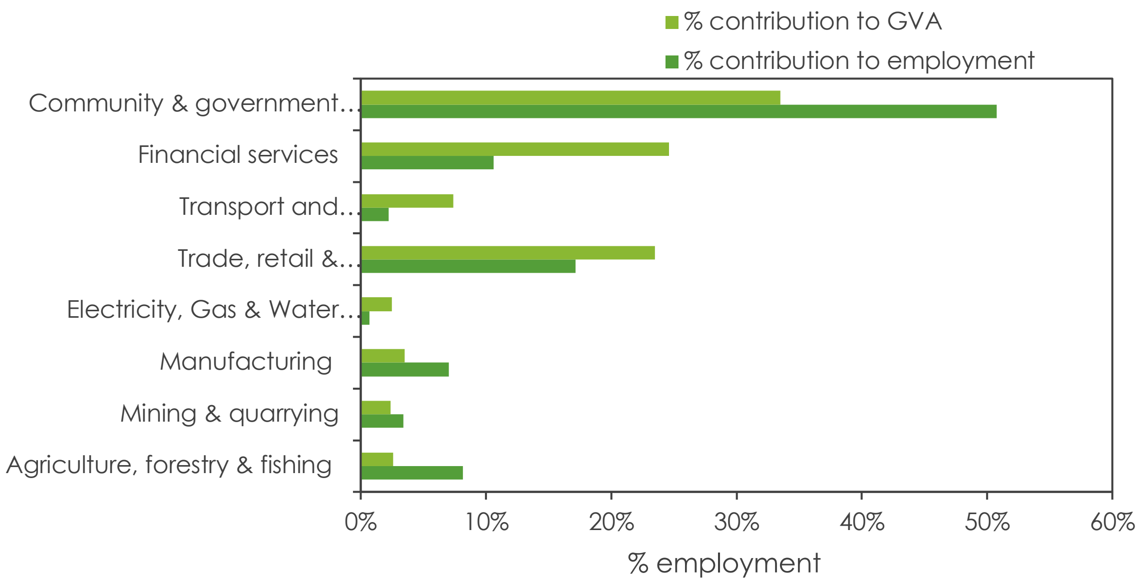


Figure 7-20. Sectoral contribution to employment and to total GVA in the study area in 2016. Source: StepSA 2018.

Percentage employment per sector for each IUA is shown in Table 7-7. Employment in the agriculture, forestry and fisheries sector is highest in the Upper Sand, Nzhelele/Nwanedi, Upper Luvuvhu, and Lower Lephalala IUAs. However, in the Upper Sand and Upper Luvuvhu this only accounts for 5% and 6% of employment, respectively. Employment in the associated manufacturing sector is also high in these IUAs, particularly in the Upper Sand. The mining sector is important for employment in the Upper Nyl & Sterk and Mapungubwe IUAs. While only about 300 people are employed in the agriculture, forestry and fisheries sector in the Kalkpan se Loop IUA, this represents just over 50% of employment in this IUA, with the remainder of the working population being mostly employed in the community, social and government services sector. This sector employs a significant number of people across all IUAs in the study area.

Table 7-7. Total number of individuals and percentage contribution to employment within each sector of the economy for each IUA in 2016. Source: StepSA 2018.

IUA	Agriculture, Forestry & Fishing		Mining & Quarrying		Manufacturing		Electricity, Gas & Water		Trade, retail & accommodation		Transport & Communication		Financial services		Community services	
	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%
Upper Lephalala	901	21%	-	0%	541	13%	14	0%	242	6%	325	8%	-	0%	2 292	53%
Lower Lephalala	6 534	31%	-	0%	-	0%	5	0%	638	3%	68	0%	-	0%	13 564	65%
Upper Nyl & Sterk	3 425	5%	10 819	15%	6 613	9%	848	1%	14 209	20%	1 818	3%	9 061	13%	23 240	33%
Lower Mogalakwena	4 684	11%	680	2%	363	1%	762	2%	4 054	9%	337	1%	11	0%	33 012	75%
Kalkpan se Loop	300	55%	-	0%	-	0%	-	0%	36	7%	2	0%	-	0%	203	38%
Upper Sand	9 966	5%	2 528	1%	17 219	9%	1 452	1%	31 728	16%	5 090	3%	32 184	17%	92 750	48%
Lower Sand	3 274	5%	3 220	5%	7 482	12%	270	0%	17 786	28%	2 893	5%	8 498	13%	19 881	31%
Mapungubwe	745	16%	2 151	45%	201	4%	48	1%	443	9%	129	3%	-	0%	1 086	23%
Nzhelele/Nwanedi	9 495	24%	615	2%	202	1%	163	0%	2 770	7%	193	0%	1 642	4%	24 684	62%
Upper Luvuvhu	7 396	6%	29	0%	8 206	7%	752	1%	31 100	26%	2 259	2%	12 906	11%	58 647	48%
Lower Luvuvhu/Mutale	3 735	9%	1 568	4%	762	2%	153	0%	3 268	8%	406	1%	2 090	5%	29 970	71%
Shingwedzi	1 435	4%	-	0%	3 150	9%	42	0%	2 901	9%	784	2%	1 134	3%	24 127	72%
Total	51 890		21 610		44 738		4 510		109 174		14 303		67 527		323 458	

7.3.3 Economic activities dependent on water

7.3.3.1 Overview of water use in the WMA

The most recent summary of water requirements is provided in the 2017 Reconciliation Strategy for the Limpopo Water Management Area and the Development of a Reconciliation strategy for the Luvuvhu and Letaba Water Supply System, both produced by DWS (DWS, 2015, 2017b; Table 7-8). The bulk of the water requirements in the study area is for irrigation agriculture, followed by domestic use, industry and mining, and livestock watering (Figure 7-21). Invasive alien plants (IAPs) and afforestation are not considered water users but rather they are stream flow reducers in that they cause a reduction in runoff. The domestic water requirements associated with the Mogalakwena, and Sand River catchments as presented in Table 7-8 include transfer volumes of 35.2 million m^3 from the neighbouring Olifants, Luvuvhu/Letaba and the Crocodile (West) and Marico WMAs, which augment supply to the towns of Mokopane, Polokwane and Makhado (formally Louis Trichardt). The following sections describe the irrigated agriculture, mining, and forestry sectors in more detail.

Table 7-8. Water Requirements at the 2010 development level (million m^3/a). Note that afforestation and IAPs are not water users but stream flow reducers (i.e., they cause a reduction in runoff).

River catchment	Irrigation	Domestic	Industrial & mining	Livestock	IAPs	Afforest-ation	Total
Lephalala	69.8	2.8	0.1	2.39	1.2	0	76.3
Mogalakwena	99.4	29.9	15.3	11.49	2.6	0	158.7
Sand	221.7	55.8	10.8	4.39	1.0	0.2	293.9
Nzhelele	29.1	9.0	0.5	0.75	2.1	2.0	43.5
Luvuvhu & Shingwedzi	99.4	43.8		1.8	20.0	165.1	1.8
Mutale	4.4	4.6		0.4	4.4	13.8	0.4

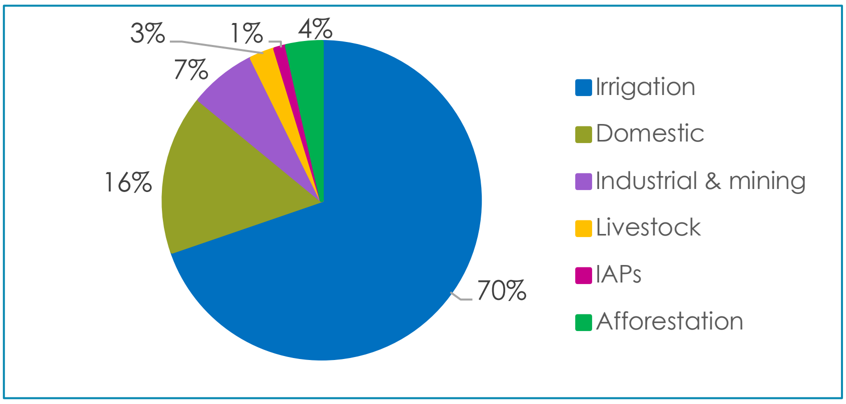


Figure 7-21. Proportion of the total water requirements by sector in 2010. Source: DWS, 2015, 2017a.

7.3.3.2 Agriculture

The extent of agricultural crop production in the study area was assessed based on information collated from the census of commercial agriculture (2017) conducted by Stats SA (Stats SA, 2020). Information about the area and production of different irrigated and dryland crops were available at the local municipality level and these were used to determine the overall agricultural outputs for the study area within each IUA. The extent of each crop type within each local municipality was spread to the IUAs that fall within that municipality with the crop area being adjusted based on the proportion of irrigated, dryland and orchard agricultural land present within that IUA as per the land cover data. While this approach assumes that every hectare is discrete in terms of crop type, it provided the most reasonable estimation of agricultural production across the study area with the data that were available.

There are a total of about 31 000 hectares of dryland crops and 45 000 hectares of irrigated crops within the study area (Table 7-9, Figure 7-22). Just more than 43% of the dryland crops are located in the Upper Nyl & Sterk IUA, and 74% of the irrigated crops are located within the adjacent Upper Sand, Lower Sand, Mapungubwe, Nzhelele/Nwanedi and Upper Luvuvhu IUAs (IUAs 6-10). Oil seeds represent 21%, grains 7%, and planted pasture 4% of dryland crops in the study area. Fallow land covered just under 330 000 ha within the study area, with 22% of this being located in the Lower Sand IUA and 19% within the Lower Mogalakwena IUA.

Table 7-9. Estimated total hectares of irrigated agricultural area and dryland agricultural area, excluding fallow area, in each IUA in 2017. Source: Stats SA, 2020.

IUA	Irrigated crops	Dryland crops
Upper Lephalala	714	1 831
Lower Lephalala	1 603	1 889
Upper Nyl & Sterk	1 985	13 665
Lower Mogalakwena	2 483	2 113
Kalkpan se Loop	1 011	47
Upper Sand	6 625	956
Lower Sand	9 915	2 809
Mapungubwe	6 802	2 133
Nzhelele/Nwanedi	5 497	2 267
Upper Luvuvhu	4 800	2 071
Lower Luvuvhu/Mutale	91	54
Shingwedzi	3 765	1 526
Total	45 291	31 361

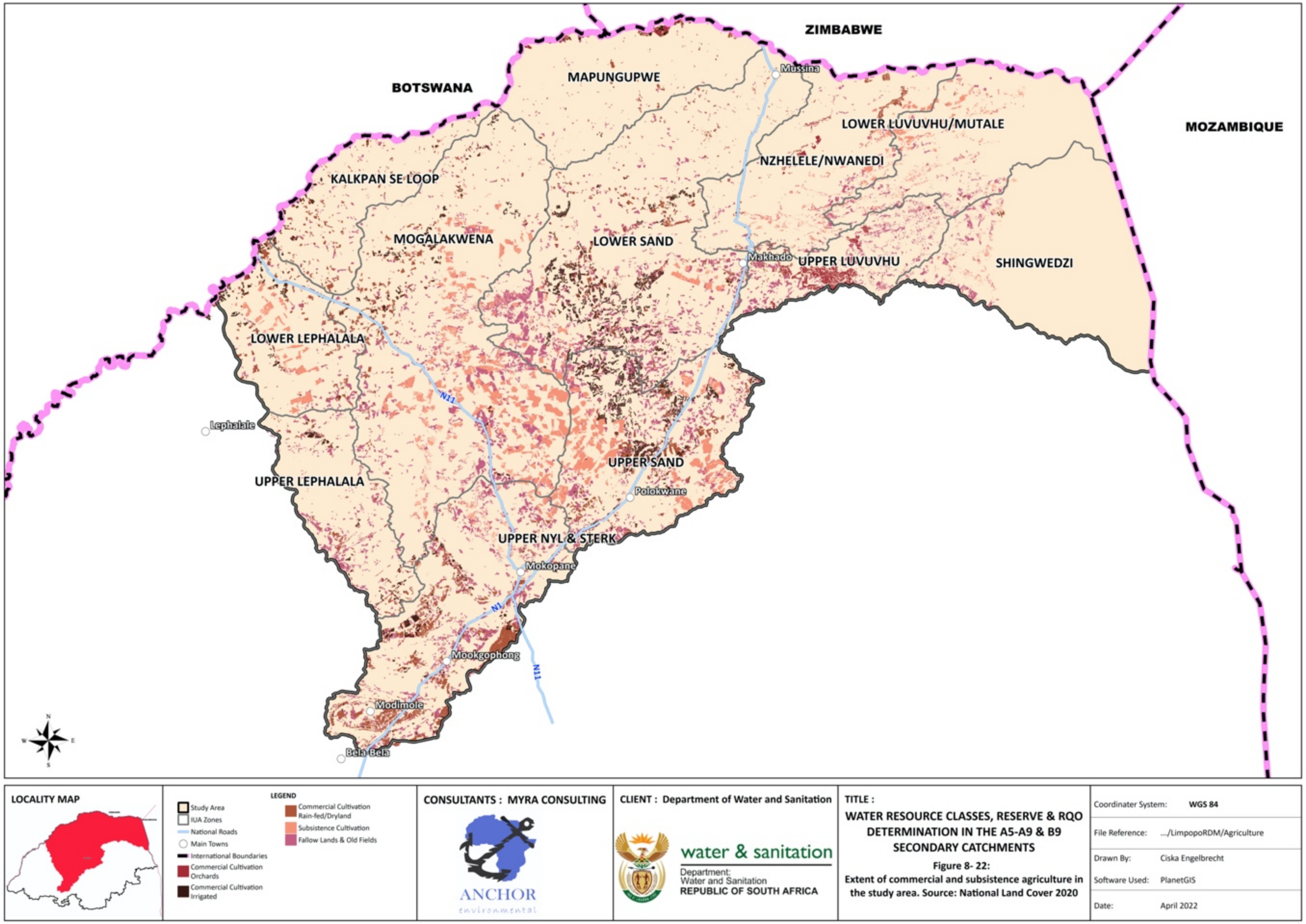


Figure 7-22. Extent of commercial and subsistence agriculture in the study area.

Vegetables (e.g., potatoes, tomatoes, butternut and onions) represent 33% of irrigated crops, citrus fruit (e.g., oranges, grapefruit, naarjies) 24%, subtropical fruit (e.g., avocados, bananas, mangoes) 13% and nuts (e.g., macadamia, pecan) 20% (Table 7-10). Irrigation agriculture plays a very important role not only in direct exports of fresh produce but in underpinning a number of agro-processing industries in the Limpopo Province, many of which are important export industries. These include canned fruit and dried fruit, canned and frozen vegetables, oil, packaged nuts, flour, and inputs into the livestock industry.

Economic outputs and employment associated with irrigated agriculture in the study area were estimated using information collated from the 2017 Commercial Agriculture Census, industry specific reports, and the 'Abstract of Agricultural Statistics' 2018 Report. Total production for each irrigated crop type was calculated by multiplying the average production per hectare by the total area of crop within the study area. This was then multiplied by the average price per tonne (in 2017 Rands) to determine average gross output per crop in 2017 Rands. Value-added multipliers were used from Pfunzo (2017) who developed a multiplier model for the Limpopo Province based on the Limpopo Social Accounting Matrix (SAM) developed by Conningarth Economists, updated to 2014 prices. Employment multipliers (also updated to 2014 prices) were used to estimate total employment for each agricultural activity based on the South African multipliers also developed by Conningarth Economists. These multipliers are disaggregated by agricultural crop types.

Table 7-10. Total area of irrigated crops in the study area, excluding fallow area in 2017. Source: Stats SA, 2020.

Irrigated crop	Hectares	%
Grains	1 587	4%
Oil seeds	231	1%
Planted pasture	912	2%
Other field crops	1 457	3%
Onions	1 443	3%
Potatoes	8 109	18%
Tomatoes	2 908	6%
Butternut	1 484	3%
Other vegetables	925	2%
Oranges	3 464	8%
Grapefruit	6 032	13%
Other citrus	1 328	3%
Avocado	1 616	4%
Bananas	1 110	2%
Other subtropical fruit	3 358	7%
Apples and peaches	156	0%
Table grapes	67	0%
Nuts	9 105	20%
Total	45 291	

The gross output for all irrigated crops was estimated to be R5.0 billion in 2017 (Table 7-11). Tomatoes and table grapes contributed the most to the overall output. Nuts (e.g., macadamia and pecans), table grapes and other field crops (e.g., legumes, tobacco) had the highest average price per tonne (Table 7-11). Value added from all irrigated crops was estimated to be to R3.9 billion in 2017.

It is estimated that just under 32 000 people are employed in irrigated farming in the study area (Table 7-11). Total employment includes direct, indirect and induced employment effects and includes all labourers employed within each activity, which are either skilled, semi-skilled or unskilled. Employment was highest in potato and tomato farming, the most economically productive crops within the study area, with 15 000 labourers employed. This was followed by citrus fruit farming and sub-tropical fruit farming.

Table 7-11. Total gross output, value added (R million, 2017) and total employment for the main irrigated crop types in the study area.

Irrigated crop	Ave. production per ha (tons/a)	Ave. price per tonne (R, 2017)	Gross output	Value added	Total employ-ment
Grains	4.6	2 526	22	15	109
Oil seeds	0.8	5 607	3	2	20
Planted pasture	15.4	1 952	68	44	461
Other field crops	1.4	14 500	6	4	43
Onions	28.4	3 231	211	163	1 214
Potatoes	38.0	3 445	1 307	1 011	7 523
Tomatoes	70.5	6 221	1 411	1 091	8 118
Butternut	23.9	3 506	122	94	702
Other vegetables	19.4	4 309	83	64	477
Oranges	24.7	3 651	253	179	1 773
Grapefruit	42.0	5 240	711	503	4 992
Other citrus	15.4	7 245	206	146	1 449
Avocado	10.8	10 578	168	152	1 178
Bananas	19.8	7 445	164	149	1 151
Other subtropical fruit	14.0	8 631	95	86	666
Apples and peaches	12.5	9 885	24	17	172
Table grapes	23.8	13 162	21	15	157
Nuts	0.9	22 000	214	164	1 446
			5 091	3 898	31 651

7.3.3.3 Forestry

About 1% of South Africa is under commercial forestry (Godsmark & Oberholzer, 2019). In 2017/18 there were a total of 49 126 ha of plantation forests in the Limpopo Province, representing 4% of the national total (Godsmark & Oberholzer, 2019). About 59% of the plantations in Limpopo are softwood (Pine) and the remaining 41% are hardwood plantations dominated by Eucalyptus. This yielded a roundwood production of 541 million m3 in 2018 (Godsmark & Oberholzer, 2019).

Based on land cover data, close to 33 200 hectares or 68% of commercial plantations in Limpopo are found within the study area (Figure 7-23). Most of this is in the Upper Luvuvhu (59%), Nzhelele/Nwanedi (15%) and Lower Luvuvhu/Mutale IUAs (11%; Figure 7-23).

Forestry production was estimated based on data collated from Forestry South Africa (Godsmark & Oberholzer, 2019). The value per m3 was calculated using the gross value of outputs and the total volume of roundwood sales for the Limpopo Province. Roundwood production of 11m3 per hectare was determined using provincial roundwood production estimates. The gross output per hectare per year was then calculated using these two estimates. The total gross output for the study area was estimated by multiplying the output per hectare by the total plantation area within the study area.

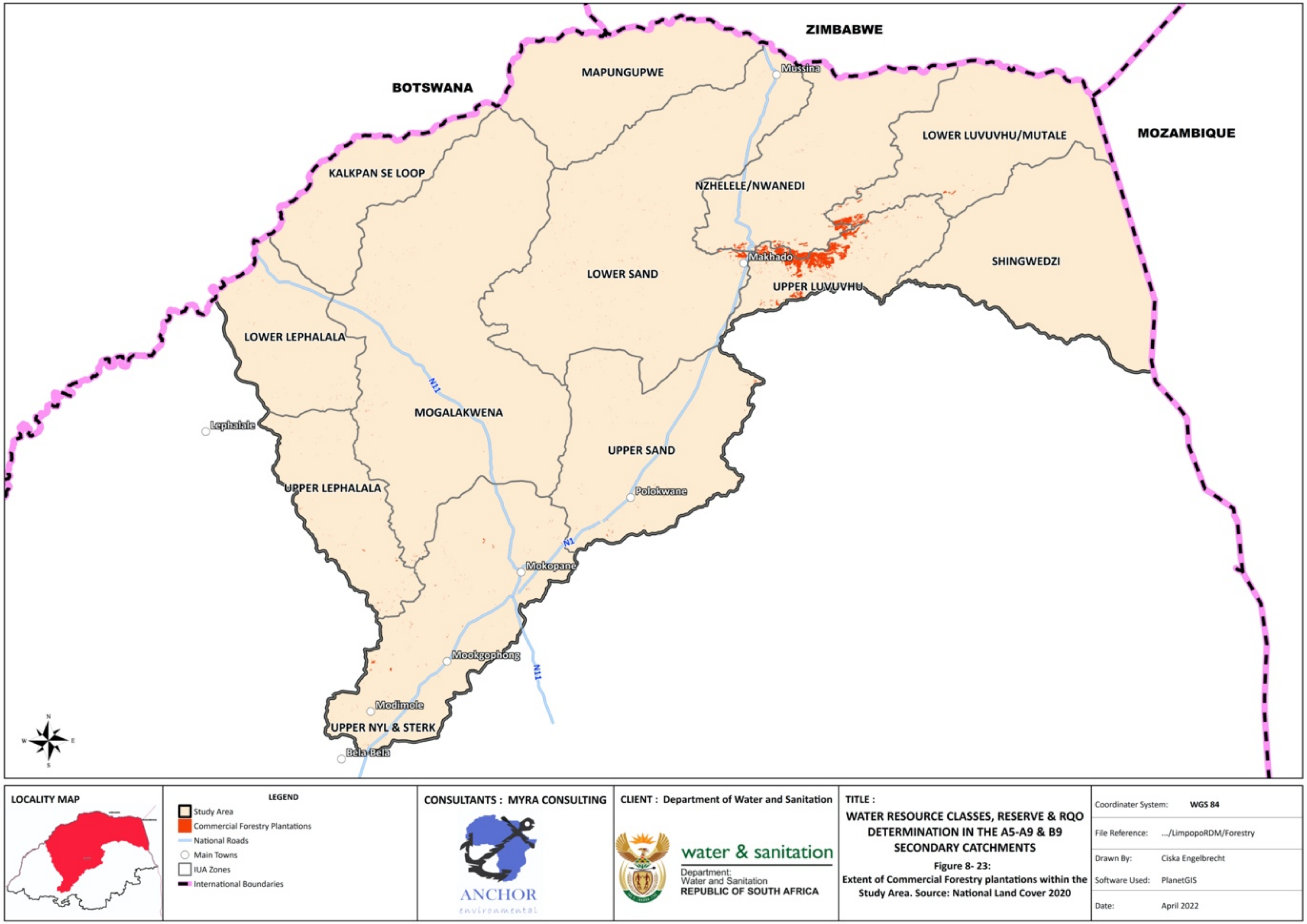


Figure 7-23. Extent of forestry plantations within the study area (Source: National Land Cover 2020).

Estimated plantation production statistics are summarised in Table 7-12. In 2017/18 the total output for plantation forestry in the study area was estimated to be R221 million, with the Upper Luvuvhu IUA contributing R130 million to this. The value added from plantation forestry was estimated to be R190 million. It was estimated that just under 1500 people were employed in the forestry sector in the study area in 2018 with just under 900 of these jobs being in the Upper Luvuvhu IUA.

Table 7-12. Total gross output, value added (R millions, 2017) and total employment for plantation forestry in the study area.

IUA	Gross output	Value added	Total employment
Lower Luvuvhu/Mutale	24	21	162
Nzhelele/Nwanedi	35	29	230
Upper Luvuvhu	154	112	879
All other IUAs	21	28	221
Total	222	190	1 492

7.3.3.4 Mining

The study area is rich in mineral resources and mining is an important economic activity. Due to the vast untapped mineral resources within the study area, it has been reported that mining operations are expanding (DWS, 2017b). This includes platinum group mining operations planned for the Mogalakwena municipal area, major industrial developments such as 'special economic zones' planned for the Musina municipal area in the north of the Sand catchment, and major coal mining developments between the towns of Musina and Makhado, also in the Sand catchment (DWS, 2017b). Some of the major mines and industries located within the study area include:

- Mogalakwena Platinum Mine in the Upper Nyl & Sterk IUA;
- Venitia Diamond Mine in the Mapungubwe IUA;
- Granite mining in the Mogalakwena IUA;
- Tshikondeni coal mine in the Lower Luvuvhu IUA; and
- Polokwane Silicon Smelter and AngloPlat smelter in the Upper Sand IUA.

Since 2008 the mining sector has on average contributed just less than 28% to the provincial GDP. This contribution has been highest in the Waterberg District Municipality (56%) where there are significant coal fields, and2934

the Mopani District Municipality (35%) which is dominated by copper and phosphates. The GVA of mining in the Vhembe and Capricorn District Municipalities, which fall almost entirely within the study area, is much lower at about 9% of the provincial total. In 2018 there were just less than 49 000 people employed in the mining industry in Limpopo of which approximately 10 000 of these are employed by mines in the Vhembe and Capricorn DMs.

Based on the latest National Land Cover (DEA 2020), mining and quarrying covers just over 7 600 hectares of land within the study area (Table 7-13). Most of this area is in the Upper Nyl and Sterk (44%), Kalope (23%) and Upper Sand (11%) IUAs. There is no mineral production data available at the provincial or DM level. Therefore, gross output, value added, and employment could not be estimated for the mining sector in the study area.

Table 7-13. Area (ha) of mining and quarrying in each IUA and % of total mining and quarrying in the study area. Source: Stats SA, 2020.

IUA	Mining & quarrying (ha)	% of total mining in study area
Upper Lephalala	24	0%
Lower Lephalala	109	1%
Upper Nyl & Sterk	3 321	44%
Lower Mogalakwena	485	6%
Kalkpan se Loop	26	0%
Upper Sand	863	11%
Lower Sand	334	4%
Mapungubwe	1 745	23%
Nzhelele/Nwanedi	296	4%
Upper Luvuvhu	66	1%
Lower Luvuvhu/Mutale	299	4%
Shingwedzi	41	1%
Total		

7.3.4 Aquatic ecosystem services and benefits

7.3.4.1 River water for domestic use

In many parts of the country, aquatic ecosystems play a significant role in supporting livelihoods. Census data provide the most comprehensive estimate of the degree to which households rely on rivers, wetlands or springs as their main domestic water source.

In the study area, it was estimated that in 2011 a total of just over 30 800 households were reliant on rivers and streams as their main source of domestic water (Table 7-14). This equates to 4% of all households in the study area. The Lower Luvuvhu/Mutale and Mapungubwe IUAs had the highest percentage of households reliant on river water. This figure was lowest in the Upper Nyl & Sterk, Upper Sand and Shingwedzi IUAs. Whilst the highest number of households reliant on river water was in the Lower Luvuvhu/Mutale IUA at about 7 500, this represented only 14% of all households in this IUA. The level of reliance appears to be particularly high in the former homeland areas.

Based on 2011 data, and the requirement of 25 litres per person per day for households depending on river flows as their source of domestic water, the Basic Human Needs requirement (as per the Water Act) is in the order of 3 000 m3 per day, which amounts to an annual allocation of just over 1 million m3 for the study area as a whole. It is assumed that numbers of households relying on rivers for basic human needs will diminish, rather than grow, over time.

Table 7-14. The number and percentage of households within each socio-economic zone that are collecting water from rivers and streams and the minimum daily flow required to meet these needs.

IUA	Number of households collecting river water	% Households collecting river water	Minimum daily flow required to meet Basic Human Needs m^3/day
Upper Lephalala	524	4%	55
Lower Lephalala	636	3%	68
Upper Nyl & Sterk	368	0%	35
Lower Mogalakwena	3 927	4%	384
Kalkpan se Loop	432	5%	29
Upper Sand	1 831	1%	162
Lower Sand	2 755	3%	257
Mapungubwe	2 093	12%	166
Nzhelele/Nwanedi	5 055	8%	489
Upper Luvuvhu	5 413	4%	530
Lower Luvuvhu/Mutale	7 560	14%	734
Shingwedzi	292	1%	29
	30 886	4%	2 937

Instream use of water was valued in terms of the market price of the next available substitute, i.e., water that is bought in containers from water vendors. In the Olifants, Inkomati and Usutu to Mhlatuze WMAs on average 24% of households purchased water in containers at an average reported price of R35 per m3 (adjusted to 2021 Rands; DWA, 2010). Using this price, the local market value of the instream water use in the study area is estimated to be approximately R37 million per year.

7.3.4.2 Wild aquatic resources

In the Limpopo Province households harvest wild plant and animal resources from rivers and wetlands for food, energy, medicine and raw materials (Table 7-15), particularly in areas where there are limited economic opportunities (Adekola *et al.*, 2008; Jogo & Hassan, 2010). This is mostly associated with people living in traditional households within former homeland areas where poverty levels tend to be highest. However, in South Africa, use of natural resources can also be important for poor households living in peri-urban areas (Lannas & Turpie, 2009). The harvesting of wild resources is mostly for subsistence purposes but for some households does provide cash income. In the Ga-Mampa wetland situated just south of the study area, sedges harvested from the wetland generated the highest cash income for households through the sale of baskets and mats (Adekola *et al.*, 2008). Households living around this wetland also harvested edible plants, reeds, fish and fuelwood from the wetland. Wild edible plants, and reeds and sedges were the dominant resources harvested by most households in the villages surrounding the wetland (Adekola *et al.*, 2008; Jogo & Hassan, 2010).

Table 7-15. Wild plant and animal resources typically harvested from aquatic ecosystems in South Africa.

	Purpose	Group
Wild plant resources	Nutrition and health	Wild plant foods and medicines
	Energy	Wood fuel
	Raw materials	Reeds
		Sedges
Wild animal resources	Nutrition	Aquatic birds and animals
		Fish

Former homeland areas (or tribal lands), characterised as mostly dense rural settlements, cover close to 30% of the study area (Table 7-16). It is in these areas that wetland resources are particularly important for supporting household livelihoods. The Lower Mogalakwena, Lower Luvuvhu/Mutale, Nzhelele/Nwanedi, Upper Sand and Upper Luvuvhu IUAs have the highest proportion of former homeland area. Just over one third of the natural wetland area, or 17 500 ha, can be found within these tribal lands, mostly within the Upper Sand, Lower Luvuvhu/Mutale and Lower Mogalakwena IUAs (Table 7-16). Similarly, just less than one third of main rivers that meander through the study area are situated within former homeland areas. Almost 500 km of river are found within the homelands of the Lower Mogalakwena IUA and 250 km in the homelands of the Upper Luvuvhu IUA. The Upper Lephalala, Kalkpan se Loop and Mapungubwe IUAs which all run along the eastern side of the study area on the Limpopo River have no former homeland area. These IUAs are sparsely populated and while rural households rely on aquatic ecosystems in these areas too, the demand and overall use of wild resources is expected to be relatively minor when compared to other areas in the study area.

Table 7-16. Area of former homelands and are of natural wetlands within homeland areas in each of the IUAs.

IUA	Former homeland area (ha)	Former homeland area (% of IUA)	Total area of natural wetland (ha)	Area of natural wetland in former homeland area (ha)
Upper Lephalala	0	0%	1 185	0
Lower Lephalala	64 989	24%	1 079	463
Upper Nyl & Sterk	58 383	11%	6 033	663
Lower Mogalakwena	511 406	48%	4 850	3 079
Kalkpan se Loop	0	0%	1 353	0
Upper Sand	158 919	32%	12 942	7 773
Lower Sand	124 723	14%	4 038	284
Mapungubwe	0	0%	4 755	0
Nzhelele/Nwanedi	186 212	44%	2 718	301
Upper Luvuvhu	133 562	64%	536	366
Lower Luvuvhu/Mutale	248 246	65%	7 402	4 494
Shingwedzi	106 814	20%	3 879	32
	1 593 253	28%	50 771	17 456

Very little of the harvesting of wild natural resources is monitored in South Africa. Therefore, the estimation of the value of wild aquatic resources was based on studies that have taken place in Limpopo and in other areas with similar characteristics. The household use of wild resources from rivers and wetlands was estimated for the Olifants, Inkomati and Usutu to Umhlatuze WMAs (see DWA, 2010). While fishing was found to be more valuable in rivers, the collection of plant raw materials, fuel wood, plant foods and hunting of birds and animals was more valuable in wetlands. In the Olifants WMA which borders the study area to the south, the value of the wild resources provided by wetlands was estimated to be approximately R1200 per hectare, and the value associated with rivers was estimated to be in the region of R3400 per km (DWA, 2010; in 2010 Rands). A study of the provisioning value of the Ga-Mampa wetland in Limpopo estimated that the per hectare value of the wetland for supplying wild resources was in the order of R2800 per ha, with plant foods being the most valuable resource harvested, followed by reeds and sedges (Adekola et al., 2008; in 2006 Rands).

Wild resources supplied by wetlands and rivers in the study area were estimated to be in the order of R45.6 million, with wetlands accounting for 77% of this value (Table 7-17). Wetland resources are particularly valuable in the Upper Sand, Lower Luvuvhu/Mutale, and Lower Mogalakwena IUAs. In the Lower Sand, Upper Luvuvhu, Shingwedzi and Nzhelele/Nwanedi IUAs wild resources from rivers are more valuable than from wetlands.

Table 7-17. The value of wild aquatic resources harvested from rivers and wetlands in the study area (R millions, 2021).

IUA	Wetland wild resources (R million)	River wild resources (R million)	Total (R million)	% of total
Upper Lephalala	-	-	-	0%
Lower Lephalala	0.9	0.3	1.3	3%
Upper Nyl & Sterk	1.3	0.5	1.9	4%
Lower Mogalakwena	6.2	2.8	9.0	20%
Kalkpan se Loop	-	-	-	0%
Upper Sand	15.6	1.1	16.7	37%
Lower Sand	0.6	0.7	1.2	3%
Mapungubwe	-	-	-	0%
Nzhelele/Nwanedi	0.6	1.2	1.8	4%
Upper Luvuvhu	0.7	1.5	2.2	5%
Lower Luvuvhu/Mutale	9.0	1.4	10.4	23%
Shingwedzi	0.1	1.0	1.1	2%
Total	35.1	10.4	45.6	

7.3.4.3 Wetland contribution to crop production

In addition to wild resources, wetlands also provide a store of freshwater that is used for cultivating crops and for watering and grazing livestock (Adekola et al., 2008; DWA, 2010). The local population use wetlands for cultivating crops as they have fertile soils and are able to store moisture during the dry season which enables farmers to produce crops throughout the year in areas where this is usually not possible. In using wetlands for crop production, households are able to mitigate the risk of crop losses during drought periods (Jogo & Hassan, 2010). However, agricultural activities undertaken in wetlands can cause extensive modifications, permanently altering the wetland environment, which has impacts not only within the wetland itself but also in downstream areas (DWA, 2010; Jogo & Hassan, 2010; Phethi & Gumbo, 2019). Importantly, the use of this service, by replacing wetland habitat, reduces the opportunities to obtain cultural and regulating services.

In the Olifants, Inkomati and Usutu to Umhlatuze WMAs it was found that while crops were being cultivated in some wetland areas, wetland and riverbanks did not make a significant contribution to overall agricultural income and that the average production per unit area in wetlands was not greater than reported production from upland areas (DWA, 2010). By 2006, more than half (66 ha) of the Ga-Mampa wetland just south of the study area had been converted to cropland (Adekola et al., 2008). At the time only 25% of households had permitted access to cultivate crops in the wetland (usually given by the headmen) with the main crop being maize, intercropped with vegetables and groundnut. The value of crop production was estimated to be just over R6000 per user household per year (Adekola et al., 2008).

Given that there is limited data on this service in the study area, no agricultural value was assigned to wetlands. Furthermore, this activity replaces wetland habitat reducing opportunities for other services, including the collection of wild resources and important regulating and cultural services.

7.3.4.4 Wetland contribution to livestock production

Similarly, wetlands are known to produce a safety net for small scale subsistence farmers in terms of fodder production during the end of the dry season or during periods of drought. In the study area, particularly in the homeland areas, poor rural households keep chickens, goats and cattle (Limpopo Provincial Government, 2015). In the Vhembe District Municipality within the Makhado, Mutale and Musina Local Municipalities, goats are particularly important and kept by most rural households. In 2015 there were an estimated 77 516 goats and 180 673 cattle in the Vhembe District Municipality (Limpopo Provincial Government, 2015). Cattle are also important in the Capricorn District Municipality.

In the Olifants WMA, 54% of households kept livestock, with an average of 1.6 cattle, 1.2 goats, and 4.3 chicken across these households (DWA, 2010). In the Ga-Mampa valley, it was estimated that about 70% of households owned at least one type of livestock and about 38% of these households used the wetland for forage and watering of their livestock. In the homeland area of Lebowa in the Olifants WMA it was estimated that the average contribution of wetlands and rivers to grazing or watering of livestock was just under R30 000 per ha of wetland area and just over R110 000 per km of river (DWA, 2010; 2010 Rands). However, this was particularly variable with some values in the WMA being as low as R220 per ha of wetland area.

Based on the overall average of R5 500 per ha of wetland within the Olifants WMA, and only considering the former homeland areas, the contribution of wetlands to livestock production in the study area was estimated to be R96 million. This was highest in the Upper Sand, Lower Luvuvhu/Mutale and Lower Mogalakwena IUAs, which accounted for R85 million of this value.

7.3.4.5 Tourism value of aquatic ecosystems

Tourism is an integral and significant part of the Limpopo economy. The study area includes some of South Africa’s and the Limpopo Province’s major attractions for overseas tourists. The study area is also an important domestic tourism area, particularly for people living in major urban centres of Johannesburg and Pretoria to the south. Encompassing all tourist activities related to nature, nature-based tourism is an important component of the overall tourism sector in the Limpopo Province. Activities include visits to national parks, nature, and game reserves, and outdoor activities such as hiking, hunting, fishing, nature walks and walking safaris, mountain-biking and birdwatching.

In the study area there are a number of important protected areas that are popular tourist destinations, including Kruger National Park, Mapungubwe National Park and UNESCO World Heritage Site, and the numerous state- and privately-owned game and nature reserves such as Nylsvley Nature Reserve and Polokwane Game Reserve (Figure 7-24). Most of the tourism activities are linked to natural environments, in which aquatic ecosystems are often a significant feature. Thus, choices regarding water allocation and RQOs may impact on the value of tourism in the study area, with knock-on effects within and beyond this area. The types of tourism and recreation that are potentially affected include recreational freshwater angling, through impacts on fish stocks; and general nature-based tourism, through impacts on landscapes, biodiversity, water levels for swimming, and suitability for human recreational contact.

Available information on some of these activities is described briefly below. However, information is patchy, and it is difficult to estimate the tourism value of any of these activities in the absence of reliable and comprehensive information on the numbers of tourists and their expenditure. Therefore, we have taken the approach of estimating the value of nature-based tourism in each of the IUAs from provincial and regional tourism statistics, using mapping techniques[10].

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[10] The spatial distribution of tourism value was mapped based on the density of geotagged photographs uploaded on the website flickr.com. These densities were obtained using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Recreation Model 3.5.0. Densities of geotagged photographs uploaded to platforms such as Flickr provide a means of mapping value to tourism attractions, rather than to the places where tourists spend their money (e.g., at their accommodations), so is more accurate in assigning the tourism value to the actual attractions that caused the expenditure. The model calculates the average annual photo-user-days (PUDs) for each grid cell (5 km x 5 km) across the period 2005-2017. The model used the latitude/longitude data from photographs as well as the photographer’s username and photo date to calculate PUDs. One PUD is one unique photographer who took at least one photo in a specific location on a single day.

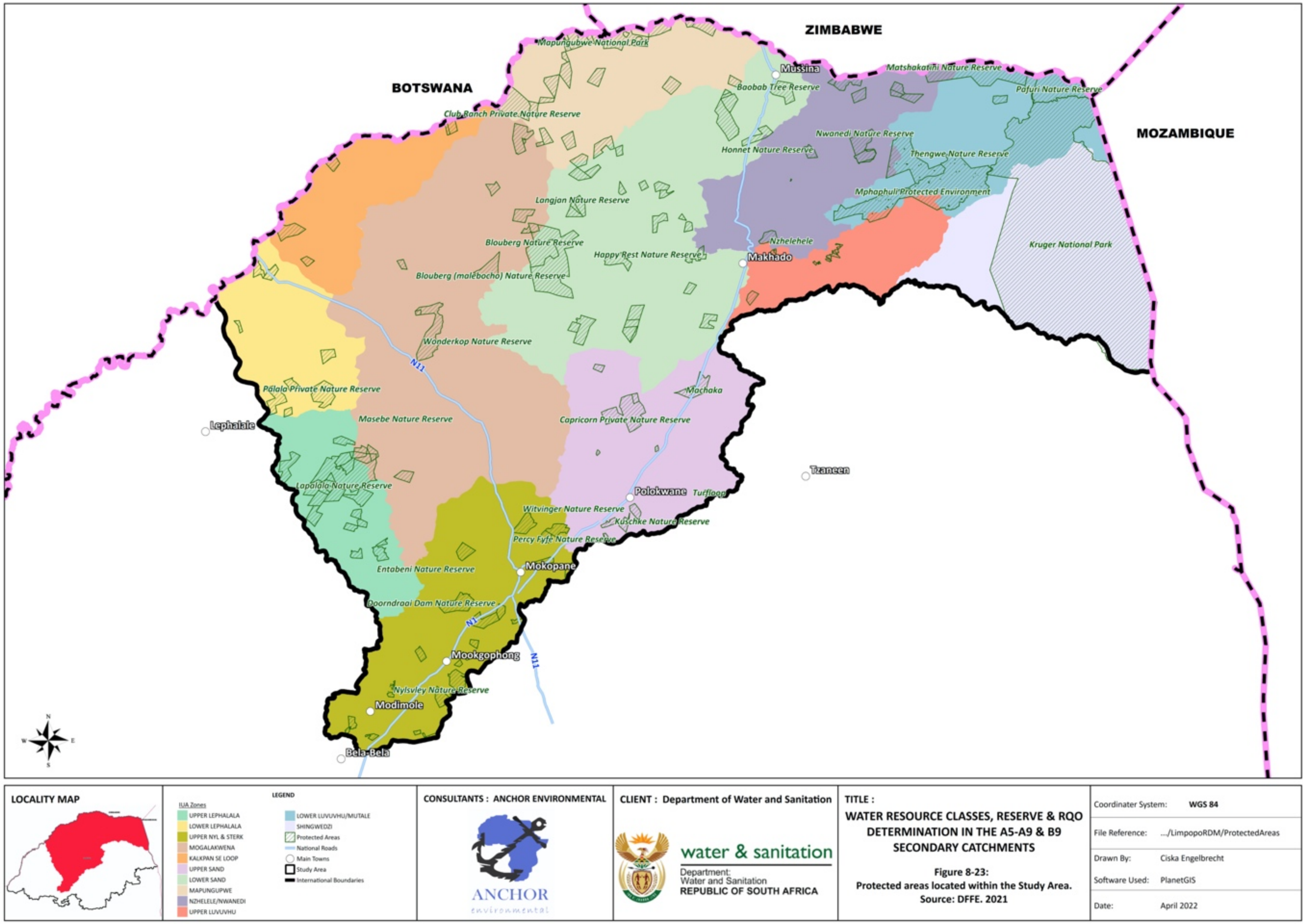

Figure 7-24. Protected areas located within the study area.

The Limpopo Province is known for its bushveld and wildlife reserves, diverse topography, vegetation and birdlife, cultural and natural heritage sites, ancient rock art and fossil-rich caves, scenic views, and rural villages. This diversity of attractions makes it a popular tourist destination for international and domestic tourists alike. The main nature-based tourist attractions in the study area that may be of relevance and importance to this study include:

- This northern section of the Kruger National Park includes the Makuleke concession, which is situated between the Luvuvhu and Limpopo Rivers. At the confluence of the Luvuvhu and Limpopo Rivers where South Africa, Zimbabwe and Mozambique meet is the famous Crooks Corner. There are many tourist lodges and camp sites along the perennial Luvuvhu River which has lush riverine and fever tree forests bordered by acacia strewn plains. The Pafuri walking safaris are an important attraction too.
- The Luvuvhu and Mutale rivers meander through the popular Makuya Nature Reserve which is characterised by stunning views over the Kruger National Park at places such as World View, the Luvuvhu Gorge and at the Singo Safari Lodge. Swimming in the Mutale River Falls is a popular attraction.
- The Greater Mapungubwe Transfrontier Conservation Area on the Limpopo River, and at the confluence of the Shashe River and Limpopo River where Zimbabwe, Botswana and South Africa meet.
- The Soutpansberg-Limpopo Birding Route is ideally situated along the Soutpansberg Mountains and the Limpopo River Valley. This little-known birding area has over 540 bird species and is becoming increasingly popular with birding tourists.
- Lake Fundudzi is a natural lake and is the sacred lake of the Venda people.
- Nwanedi Nature Reserve is a popular attraction, especially for domestic tourists. The reserve has two large dams and the scenic Tshihovhohovho Falls.
- Nylsvley wetland and floodplain is a designated RAMSAR wetland of international importance.

Holiday tourists represent about 10% of the tourists in Limpopo (Department of Tourism, 2016). These tourists have the highest daily spending and generate the most revenue. Those visiting friends and relatives (VFR) account for about 20% of the tourists to Limpopo. Tourists whose main purpose is either visiting friends or family or business tend to spend much less of their money on visiting attractions than holiday/leisure tourists. These types of tourists do, however, make up a large proportion of the total tourism spending and so these contributions are not insignificant.

The total attraction-based tourism value[11] in 2017 in the Limpopo Province was R2.6 billion. This value was spatially allocated in proportion to photo density (using the density of geotagged photos uploaded

[11] The proportion of tourism expenditure attributed to visiting attractions, as opposed to activities such as visiting family and friends, attending conferences or religious events, or receiving medical treatment, was estimated for each category of tourists

to Flickr) and apportioned based on land cover data to generate an estimate of the value of the study area landscape, i.e., the nature-based tourism value of this area.

Based on this, the study area accounted for R680 million (26% of Limpopo's attraction-based tourism contribution). Further analysis of the spatial pattern suggested that 61% of this value, or R414 million, falls within 1km of rivers and wetlands in the study area and that approximately R380 million, or 56%, is found within protected areas (Table 7-18, Figure 7-25).

The Shingwedzi, Upper Nyl and Sterk and Lower Luvuvhu/Mutale IUAs accounted for 66% of the nature-based tourism value in the study area. The average photo user days (PUDs) per year, total PUDs and PUDs per hectare per year were all highest in these three IUAs. The Lower Lephalala and Kalkpan se Loop IUAs had the lowest estimated nature-based tourism values and the lowest per hectare values in the study area.

Previous studies in South Africa investigating the contribution of rivers to nature-based tourism (see DWA, 2010; Turpie & Joubert 2001) have found that about 30% of the total nature-based tourism value is derived from rivers. Applying this finding, the tourism value derived from rivers in the study area is estimated to be in the region of R203 million (Table 7-18).

Table 7-18. Mean PUDs per year and estimated nature-based tourism value (R millions, 2021).

IUA	Mean PUD/y	Nature-based tourism value (R millions)	Nature-based tourism value (R/ha)	% of study area total	Contribution of rivers to tourism value (R millions)
Upper Lephalala	2.9	7.2	26.4	1.1%	2.2
Lower Lephalala	0.9	2.3	8.2	0.3%	0.7
Upper Nyl & Sterk	41.5	102.1	186.3	15.1%	30.6
Lower Mogalakwena	10.0	24.6	23.2	3.6%	7.4
Kalkpan se Loop	1.3	3.2	12.4	0.5%	1.0
Upper Sand	22.4	55.0	111.0	8.1%	16.5
Lower Sand	24.9	61.3	67.2	9.0%	18.4
Mapungubwe	16.4	40.3	106.9	5.9%	12.1
Nzhelele/Nwanedi	9.7	23.8	56.5	3.5%	7.1
Upper Luvuvhu	4.5	11.0	52.0	1.6%	3.3
Lower Luvuvhu/Mutale	40.8	100.2	259.8	14.8%	30.1
Shingwedzi	100.2	246.3	462.5	36.4%	73.9
Total	23.0	677.2	117.8		203.2

(holiday, visiting friends and relatives, business, and other) based on information collated from tourism statistics reports and information related to tourist spending patterns.

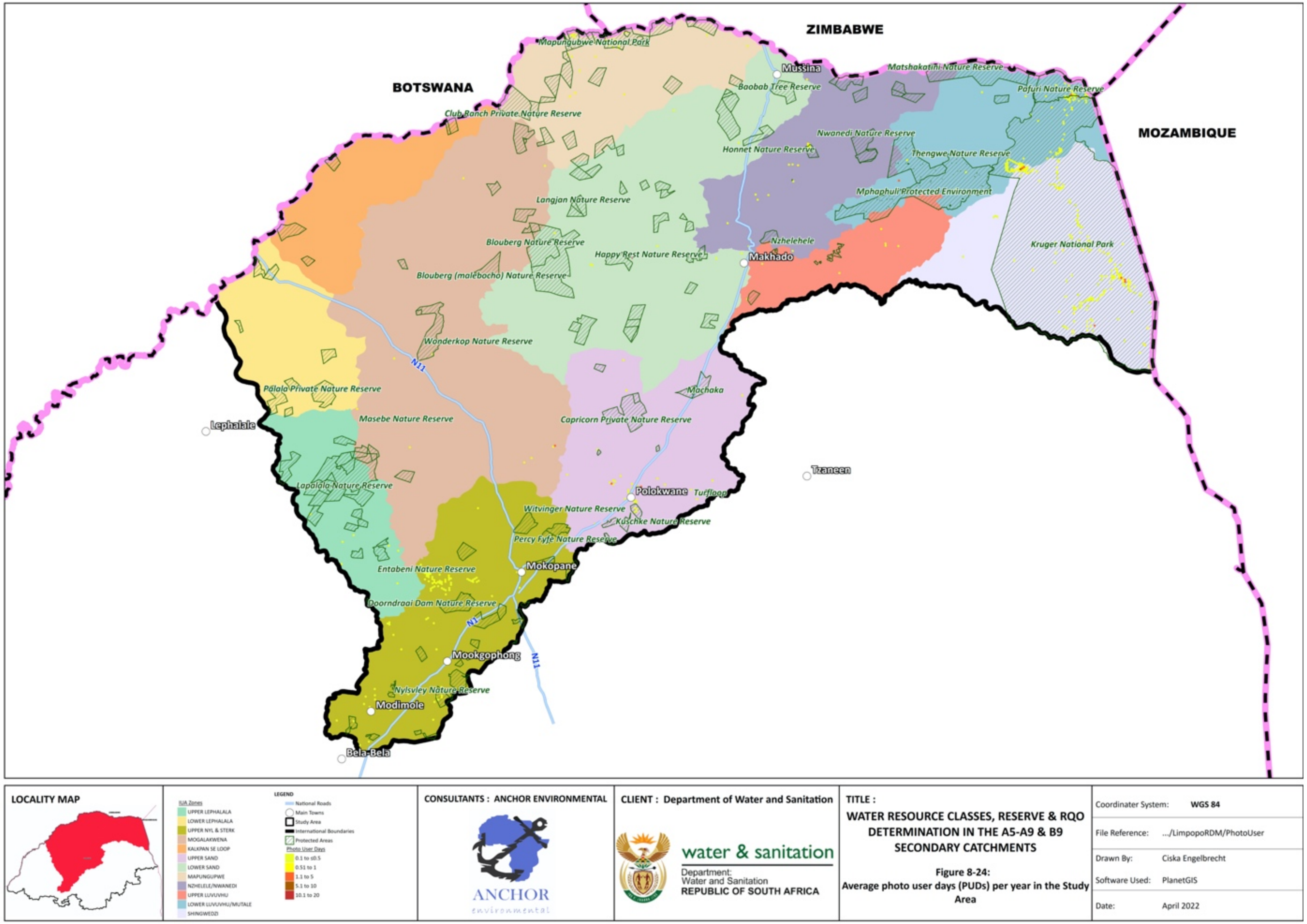

Figure 7-25. Average photo user days (PUDs) per year in the study area.

7.3.4.6 Flow regulation

Wetlands can be important for flow regulation, through flood attenuation, groundwater recharge and the maintenance of base flows. Flood attenuation occurs when wetlands ameliorate the potential impacts of flood events by absorbing the flood peaks and lengthening the flood period at a lower level. The benefits of this may be in reduced flood damages and/or avoided expenditure on flood protection infrastructure.

If wetlands were degraded or lost, flood risk could be maintained by increased investment in grey infrastructure. The losses in natural storage by wetlands could be replaced by equivalent artificial surface storage capacity. Thus, for each catchment in the study area, the replacement storage capacity required was taken as the total storage capacity of wetlands in m^3. This was a parsimonious way to capture the value of flow regulation services usually estimated through complex hydrological modelling.

The storage capacity of wetlands, which includes water stored in saturated soils, was estimated based on wetland type, and taking effective soil moisture storage depth into account (Turpie *et al.*, 2017). For each wetland a different extent was calculated, and a volume equation was applied based on wetland type. This approach was used by Turpie *et al.* (2017) at the national level who estimated the storage capacity and storage value of wetlands across South Africa. Since the capacity of wetlands to capture flows during a rainfall event depends on antecedent conditions, it was conservatively assumed that a maximum of 30% of total wetland volume is available for flood attenuation storage by (Turpie *et al.* 2017). Based on this, it was estimated that natural wetlands in the study area contribute about 94 Mm^3 in terms of flood attenuation storage, which represents about 4% of total storage for the country (Table 7-19). The flow regulation service performed by wetlands (attenuating floods) was estimated to be worth about R8.5 million per year, or R455 per ha per year for the wetlands in the study area. The value of this service was highest in the Upper Nyl & Sterk IUA and lowest in the Lower Lephalala IUA.

Table 7-19. Estimated effective storage values and approximate value of flood retention value within the study area (R millions, 2021).

IUA	Effective storage capacity (Million m^3)	Approximate value (R millions)
Upper Lephalala	2.56	0.25
Lower Lephalala	1.70	0.17
Upper Nyl & Sterk	35.98	3.18
Lower Mogalakwena	3.01	0.27
Kalkpan se Loop	3.31	0.31
Upper Sand	2.45	0.22
Lower Sand	4.91	0.44
Mapungubwe	6.09	0.54
Nzhelele/Nwanedi	7.55	0.69

IUA	Effective storage capacity (Million m^3)	Approximate value (R millions)
Upper Luvuvhu	2.75	0.26
Lower Luvuvhu/Mutale	18.25	1.74
Shingwedzi	4.96	0.43
Total	93.53	8.49

7.3.4.7 Sediment retention

Sediment yield from catchment areas is accelerated by land disturbance, elevating the sediment loads carried by rivers. Wetlands can trap some of these extra sediments, thus reducing the potential damage caused by elevated sediment loads downstream. These damages would include the costs associated with increased turbidity of aquatic systems, siltation of aquatic habitats and siltation of water supply infrastructure and monitoring weirs. Higher silt loads in rivers may decrease light penetration and thus primary productivity, which in turn affects fisheries. Silt deposition within rivers decreases habitat and hence biodiversity in these systems. Siltation of dams and weirs reduces their capacity and lifespan, incurring costs through increased maintenance and/or augmentation schemes.

The ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity and is thus closely related to their flow regulation capacity. Slope of the wetland is a key factor, as well as the roughness and holding capacity of the wetland (Novitzki, 1979). As the water slows down, the energy required to keep sediments in suspension is lost, and deposition occurs (Vellidis *et al.*, 2003).

The value of sediment retention can be measured using the replacement cost method or a damage cost avoided method. Damage costs of sedimentation are difficult to estimate in the absence of detailed studies. Furthermore, the ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity and is thus closely related to their flow regulation capacity. Therefore, the value of the sediment retention service is at least partly captured when valuing the flood attenuation service of wetlands.

7.3.4.8 Water quality amelioration

Water quality can be considered as the concentrations of desirable and undesirable constituents (physical, biological and chemical parameters) in water. The levels of these parameters dictate the purpose of water. Anthropogenic activities in catchment areas may lead to increased levels of nutrients, pathogens and sediments in rivers and other water supply reservoirs. This can result in reduced reservoir capacity and water quality and will affect ecosystems downstream. The impacts of leaching of fertilizers, salts and irrigation can make land as well as the receiving rivers unsuitable for use. Water quality is also affected by other factors including erosion and sediment and runoff waste or sewage discharge from urban or domestic areas. These impacts influence the ability of aquatic ecosystems to provide ecosystem goods and services (Turpie *et al.*, 2017).

Many economic activities in the area, including irrigation-based cultivation and mining also require water of a specific quality. When water quality declines the cost of treatment will increase. Other aquatic ecosystems such as wetlands play an important role in ameliorating water quality and thus a saving in terms of water treatment costs. Wetlands are known for their ability to remove pollutants because of their capacity to trap sediments. Furthermore, the vegetation along streams serves as a buffer between agricultural activity and rivers by removing sediments and nutrients.

Rapid growth of sectors like tourism, mining and agriculture may result in increased effluent which if not treated properly may become a problem. Changes in water quality can have negative impacts on users that depend directly and indirectly on it. Thus, the services provided by wetlands can save on water treatment costs and/or human health costs, as well as avoiding losses in tourism and other ecosystem values described in the preceding sections. Further research is required to fully understand this service and its value in the study area

8 DEFINE BIOPHYSICAL AND ALLOCATION NODES

8.1 General approach

The biophysical and allocation river nodes for the study area were defined according to the procedures described in DWAF (2007). Eleven (11) tiers of information were sequentially analysed and rules applied in order to establish nodes for each tier. Nodes were sequentially added for Tiers I to Tier VIII where after rationalisation rules were applied to eliminate nodes which were too close (less than 10km apart) or where the cumulative contribution to nMAR was less than 1%.

Further nodes were then added where additional information was likely to be needed for planning or allocation purposes. Nodes were also added to cater for Strategic Water Source Areas, FEPA status 1 and Fish Support Areas. if they were not already captured in the initial node delineation process.

8.2 Biophysical and Allocation Nodes

A total of seventy four (74) biophysical and allocation nodes were identified in the study area. The location of the nodes per catchment and reasons for their selection are provided in the subsequent sections.

8.2.1 Lephalala Catchment

Large groundwater SWSA runs along the western boundary of the catchment. The upper areas have high conservation value, while the lower areas are in a poorer condition due to the numerous weirs and abstractions for commercial and domestic use. No major storage dams, however there are farm dams in the upper catchment and weirs for abstraction in the middle catchment. Villages predominately use groundwater for domestic purposes. No significant developments have been planned in the catchment.

A total of six (6) nodes were identified in the Lephalala catchment. Five nodes were identified in the Upper Lephalala IUA and one node in the Lower Lephalala IUA as shown in Figure 8-1 and Figure 8-2 and described in Table 8-1.

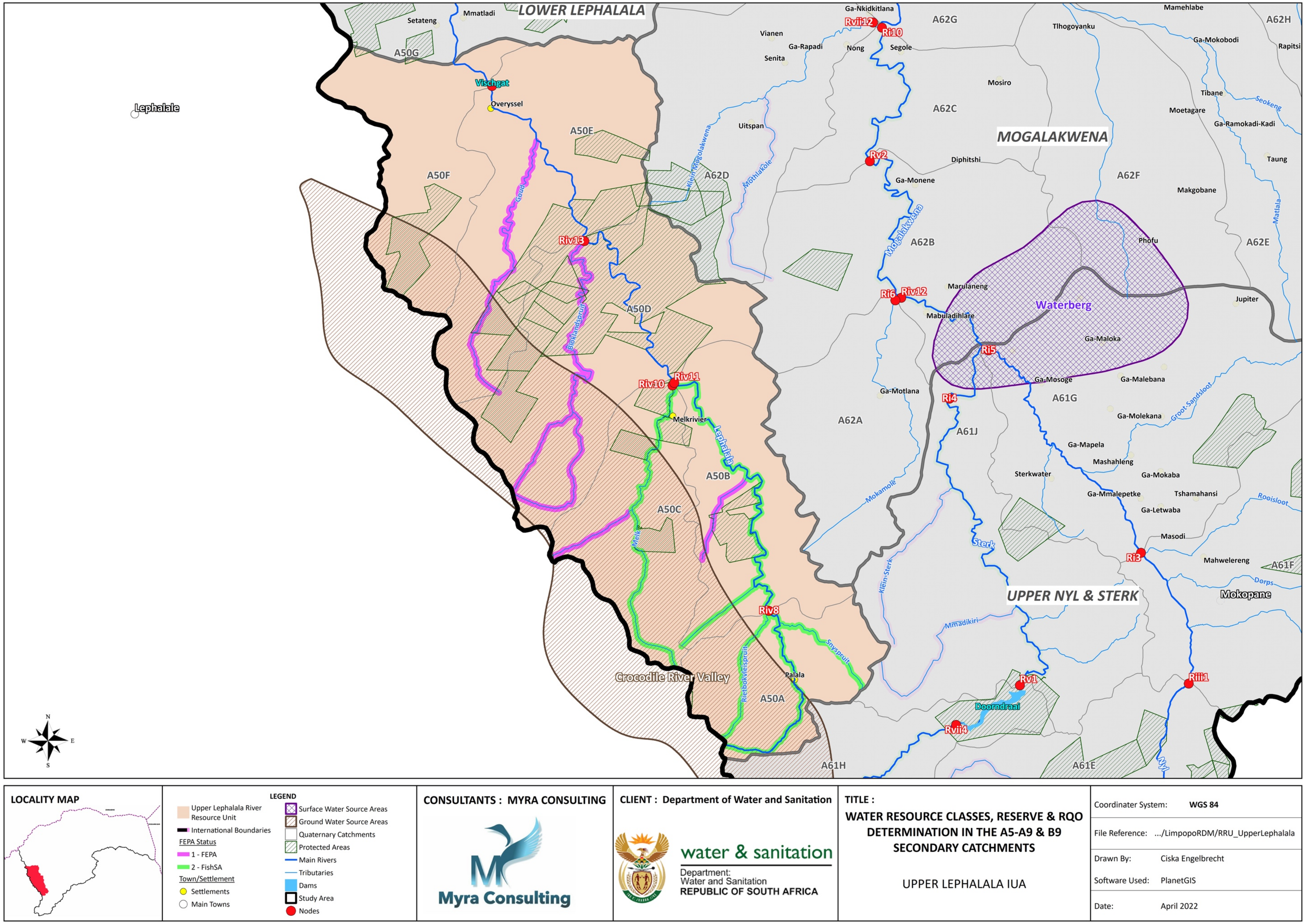

Figure 8-1. Nodes in the Upper Lephalala Resource Unit

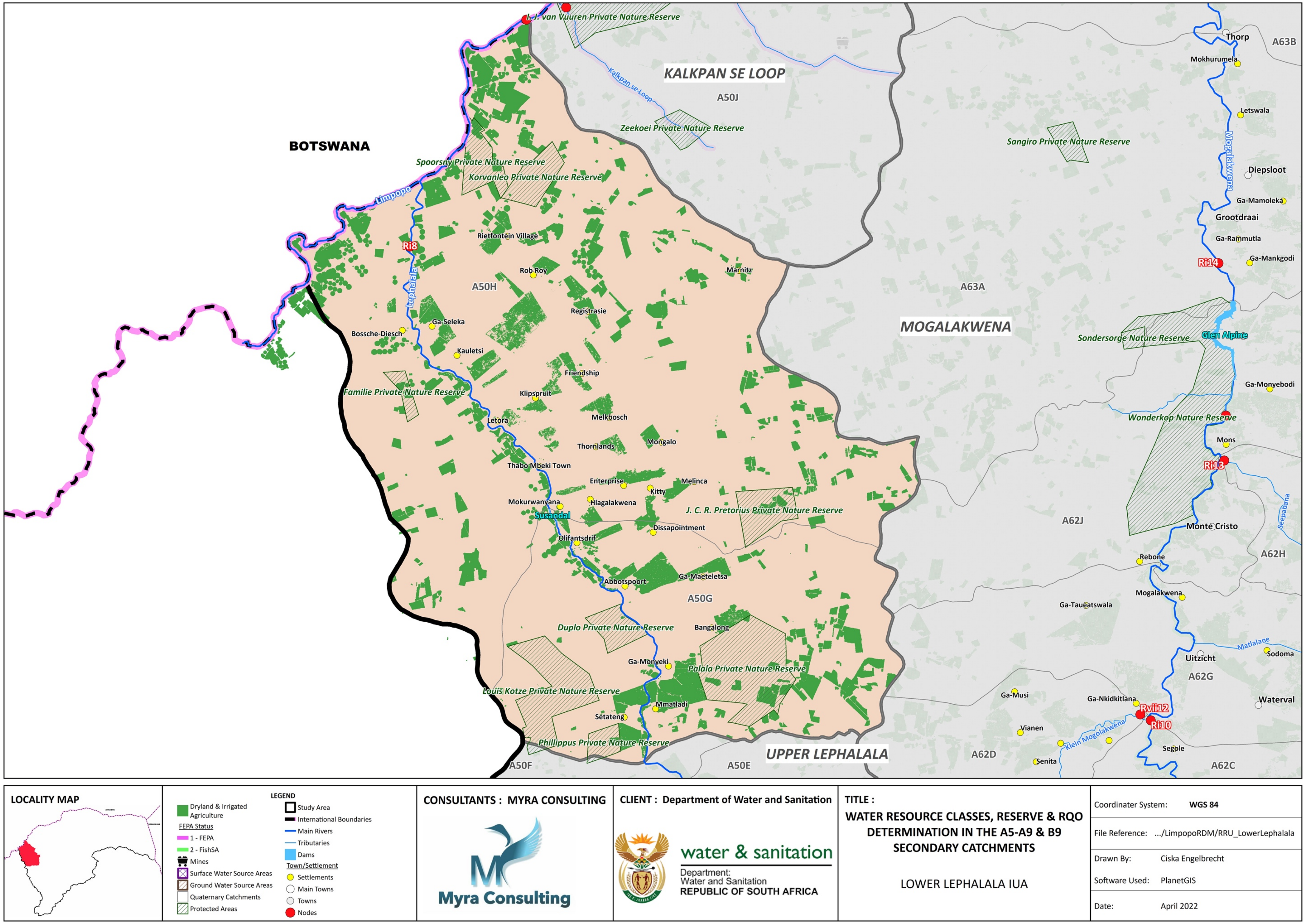

Figure 8-2. Nodes selected in the Lower Lephalala Resource Unit

Table 8-1. Biophysical and allocation nodes in the Lephalala catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Upper Lephalala	Riv8	A50A	A50A-00354	Lephalala	Downstream of three tributaries which are in a poor ecological condition but have a high EI and ES.
Upper Lephalala	Riv11	A50B	A50B-00262	Lephalala	Lephalala River is in a good ecological condition and flows into the large nature reserve downstream.
Upper Lephalala	Riv10	A50C	A50C-00273	Melk	Melk River feeds in from a SWSA. The river is in a good condition and flows into the large nature reserves downstream.
Upper Lephalala	Riv13	A50D	A50D-00237	Boklandspruit	Main tributary in a good condition at the lower end of the nature reserve. The river flows from a SWSA.
Upper Lephalala	Riii3	A50E	A50H-00110	Lephalala	Downstream of nature reserve before river passes through the settlements and weirs.
Lower Lephalala	Ri8	A50H	A50H-00110	Lephalala	At the bottom of the catchment before the Lephalala enters the Limpopo River. This node is at a high confidence IWMI EFlow site.

8.2.2 A50J and A63C

The two (2) quaternary catchments, A50J and A63C, are made up of small separate rivers that flow into the Limpopo River. Two nodes have been identified in these catchments as shown in Figure XX and Table 8-2.

Table 8-2. Biophysical and allocation nodes in the A50J and A63C catchments

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Kalkpan se Loop	Ri38	A50J	A50J-00073	Kalkpan se Loop	Private Nature Reserves in the upper and lower reaches of the river
Kalkpan se Loop	Rvi15	A50J	A50J-00061	No Name	FEPA. De Beers The Oaks opencast diamond mine in the upper reaches
Kalkpan se Loop	Rvi1	A63C	A63C-00033	Unknown	FEPA

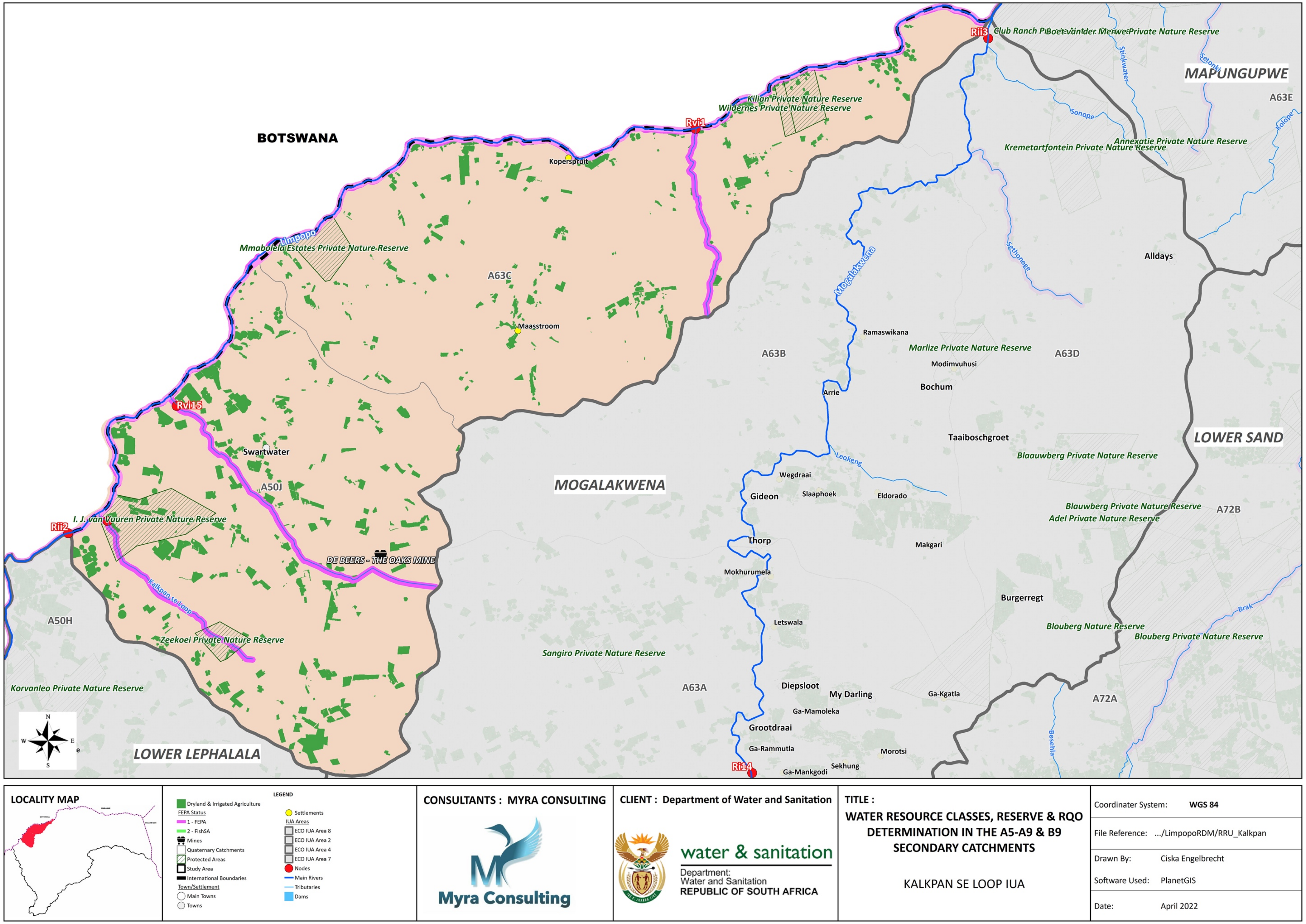

Figure 8-3. Nodes in A50J and A63C (Kalkpan se Loop)

8.2.3 Mogalakwena catchment

The catchment experiences low rainfall, the surface water is limited and groundwater is over-exploited. The catchment is densely populated and industrialised. There are major towns in the upper region where there is more rain. There are water quality concerns from wastewater treatments and sanitation issues. Surface water is fully developed with the Glen Alpine and Doorndraai dams fully allocated. There are many mines in the area and more are anticipated in Mokopane.

There are eighteen (18) nodes in the Mogalakwena catchment (Table 8-3). Three (3) of these nodes are on the Nyl River focusing on the Nylsvley, a Ramsar wetland in the catchment. Seven (7) are on the tributaries to the Mogalakwena and twelve (12) on the Mogalakwena River itself. Figure 8-4 and Figure 8-5 illustrate the nodes in the Nyl/Sterk IUA and the Mogalakwena IUA.

Table 8-3. Biophysical and allocation nodes in the Mogalakwena catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Upper Nyl & Sterk	Ri1	A61A	A61B-00552	Nyl	FSA. Node downstream of Phagament (Phomolong) and flows into Nylsvley
Upper Nyl/Sterk	Riv3	A61C	A61C-00501	Nyl	In the Nylsvley RAMSAR wetland
Upper Nyl/Sterk	Riii1	A61E	A61E-00386	Nyl	FEPA. Records flow coming out of Nylsvley before the river becomes Mogalakwena
Upper Nyl/Sterk	Ri3	A61F	A61G-00297	Mogalakwena	Downstream of the Rooisloot and Dorps tributaries. Downstream of Mokopane
Upper Nyl/Sterk	Ri5	A61G	A61G-00248	Mogalakwena	Upstream of FEPA and downstream of FSA. Downstream of Mokopane and large mine. Just upstream of confluence with Sterk
Upper Nyl/Sterk	Rv1	A61H	A61H-00395	Sterk	Captures outfow from the Doorndraai Dam. Doorndraai

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
					Nature Reserve around the Dam
Upper Nyl/Sterk	Rvii4	A61H	A61H-00395	Sterk	Captures flow into Doorndraai Dam. Doorndraai Nature Reserve around the Dam
Upper Nyl/Sterk	Ri4	A61J	A61J-00267	Sterk	Significant tributary. High EI and ES. Downstream agricultural activities.
Mogalakwena	Ri6	A62A	A62A-00253	Mokamole	Significant tributary. High EI and ES. Poor ecological condition. Downstream of settlements
Mogalakwena	Riv12	A62B	A62B-00223	Mogalakwena	Upstream of confluence with Mokamole
Mogalakwena	Rv2	A62B	A62B-00188	Mogalakwena	Downstream of settlements. High EI and ES.
Mogalakwena	Ri10	A62C	A62C-00188	Mogalakwena	Upstream of confluence with Klein Mogalakwena. High EI and High ES.
Mogalakwena	Rvii12	A62D	A62D-00179	Klein Mogalakwena	Significant tributary. High EI and ES. Passes through Nature Reserve
Mogalakwena	Ri12	A62F	A62G-00167	Matlalane	Significant tributary. Captures the impacts from settlements upstream. Proposed mine in middle reaches of tributary
Mogalakwena	Ri13	A62H	A62H-00148	Seepabana	Captures the flow from Seepabana into Glen Alpine Dam

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Mogalakwena	Ri14	A62J	A63A-00071	Mogalakwena	FEPA. SWSA. Captures outflow from Glen Alpine Dam
Mogalakwena	Rvii13	A62J	A62J-00143	Mogalakwena	FEPA, SWSA. Captures flow into Glen Alpine Dam
Mogalakwena	Rii3	A63D	A63D-00034	Mogalakwena	Most downstream point before the river enters the Limpopo. It is the location of the IWMI Eflow site.

8.2.4 A63E and A71L catchments (Mapungubwe)

The A63E and A71L quaternary catchments are made up of separate ephemeral rivers flowing into the Limpopo River. Five (5) nodes have been placed on the rivers in these catchments. These are illustrated in Figure 8-6 and described in Table 8-4.

Table 8-4. Biophysical and allocation nodes in the A63E and A71L catchments

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Mapungubwe	Riv32	A63E	A63E-00008	Kolope	Inflow into Mapungubwe National Park. Supports the Greefswald Gallery Forest
Mapungubwe	Rvi2	A63E	A63E-00011	Stinkwater	Phase 2 FEPA. Good condition
Mapungubwe	Rvi4	A71L	A71L-00005	Kongoloop	Good ecological condition
Mapungubwe	Rvi7	A71L	A71L-00003	No Name	FEPA. Mining
Mapungubwe	Rvi9	A71L	A71L-00015	Soutsloot	River in PES A

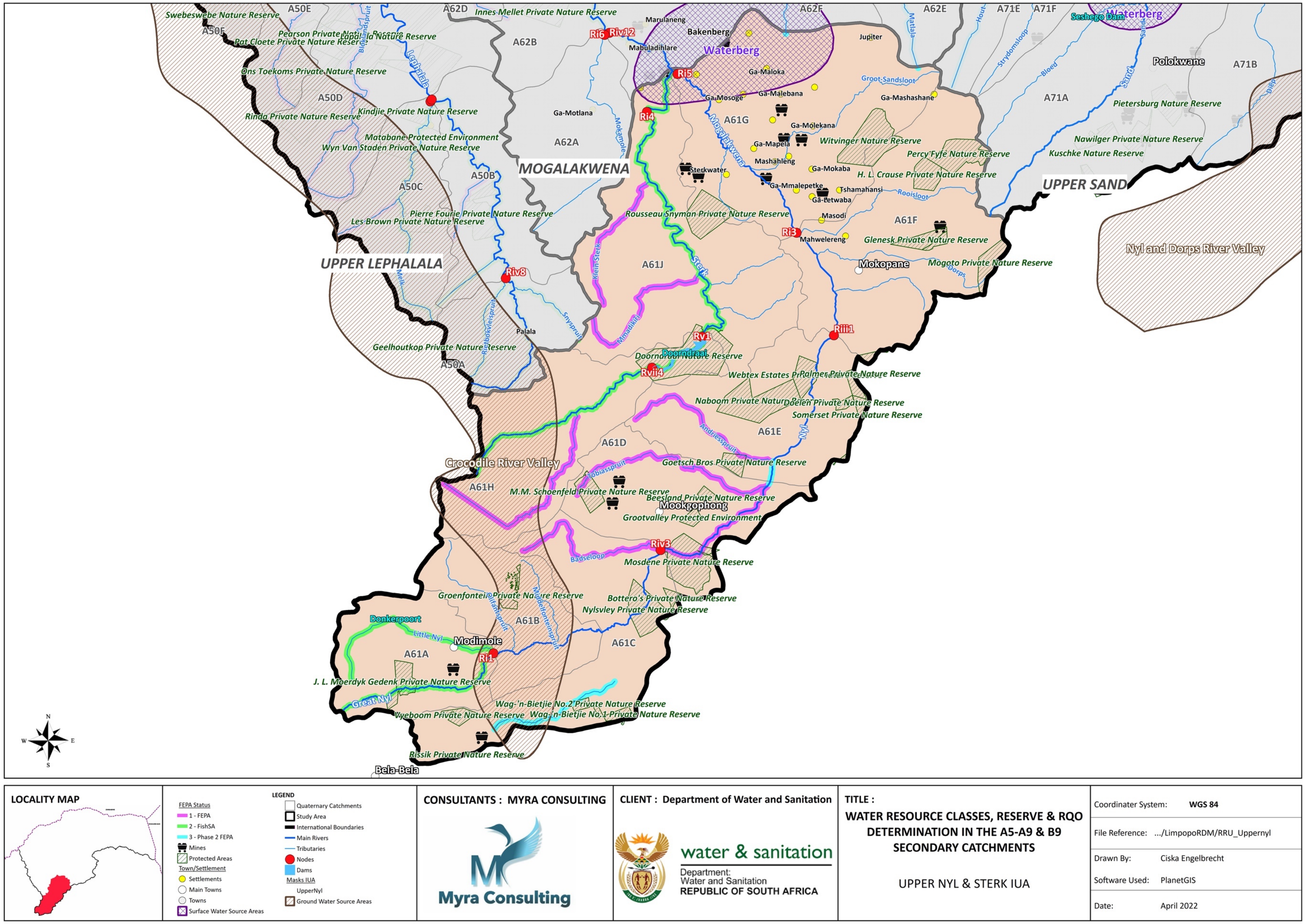

Figure 8-4. Nodes in the Nyl/Sterk IUA

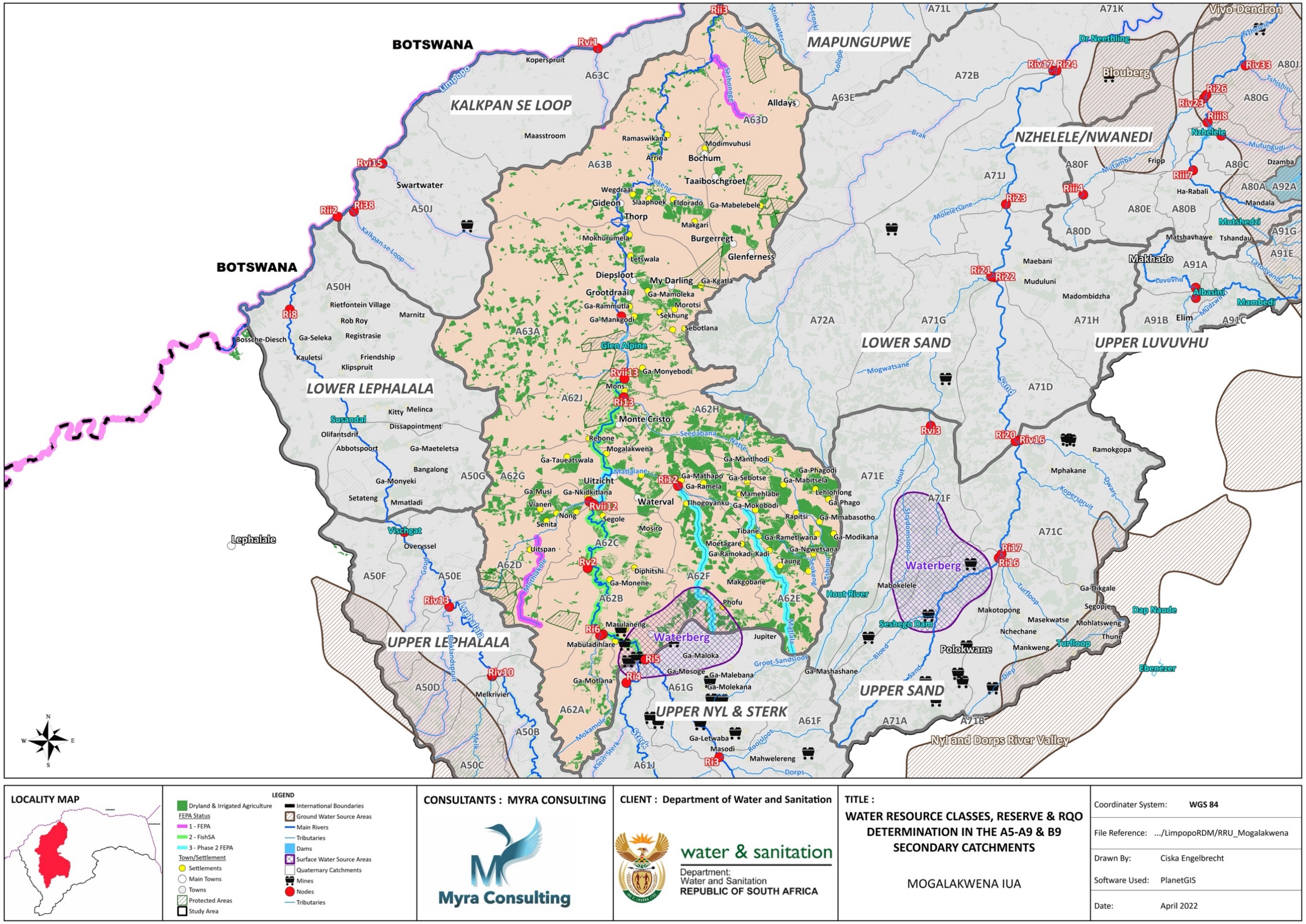

Figure 8-5. Nodes in the Mogalakwena IUA

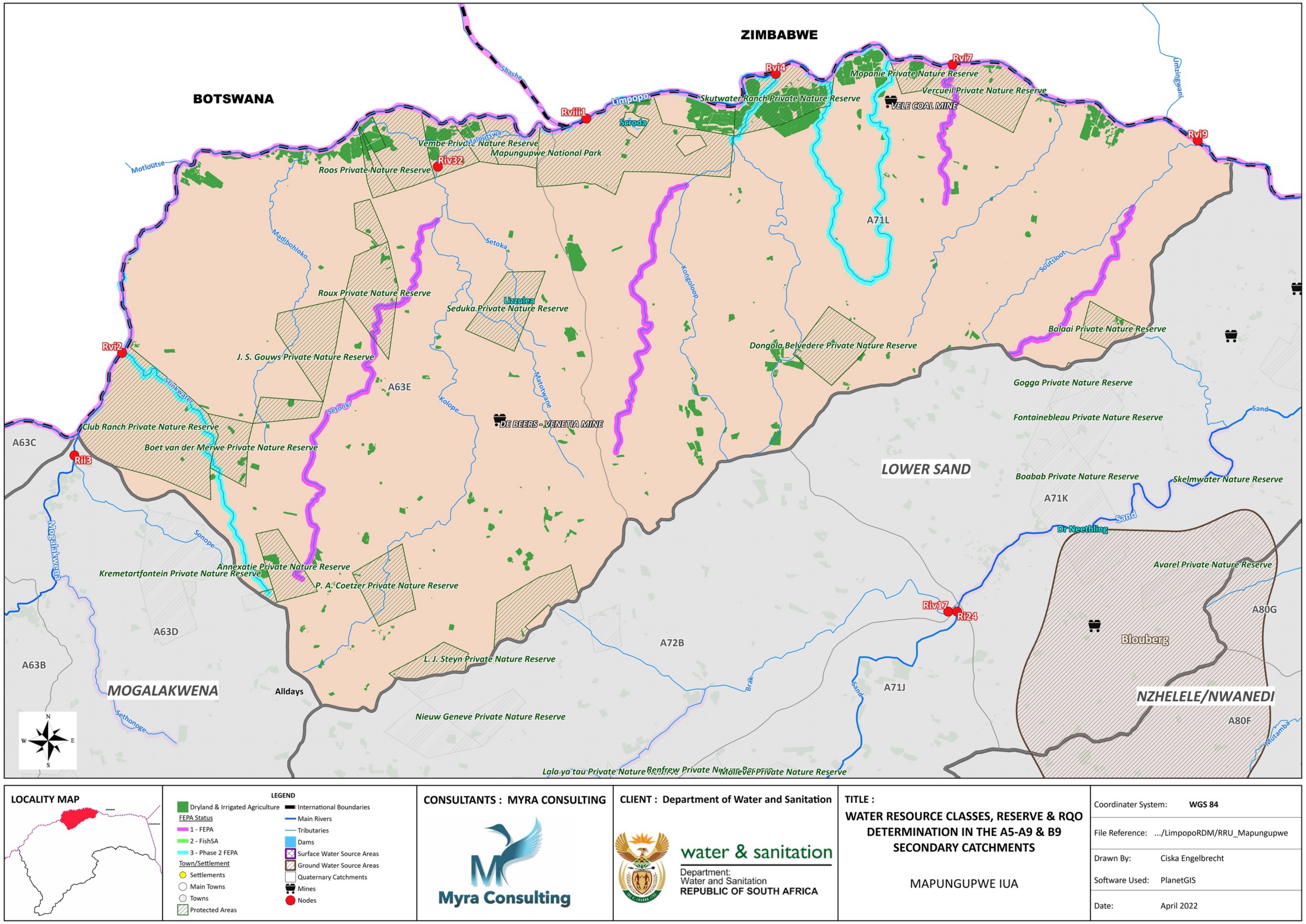

Figure 8-6. Nodes in the Mapungubwe IUA

8.2.5 Sand catchment

The Sand catchment is the driest catchment in the study area with the largest water requirement. Major urban areas include Polokwane, Louis Trichardt and Musina. Industrial users include SAB and Anglo Platinum Mine. Other mining activities include the Vele Coal Mine, Messina Copper Mine and Artonvilla Copper Mine. There are no major dams in the catchment and water supply depends on inter-basin transfers from neighbouring catchments. Groundwater is fully exploited in the catchment. Planned developments include coal mines in Musina and the Special Economic Zone (SEZ) and the Limpopo Eco-Industrial Park (LEIP). Water would need to be sourced for these developments.

Eleven (11) nodes were placed on the ephemeral rivers in the Sand catchment as shown in Figure 8-7 and Figure 8-8 and described in Table 8-5.

Table 8-5. Biophysical and allocation nodes in the Sand catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Upper Sand	Ri16	A71A	A71A-00211	Sand	Downstream of Polokwane. In a SWSA. Poor ecological condition.
Upper Sand	Ri17	A71B	A71B-00214	Diep	Downstream of the confluence with the Diep and Turfloop Rivers. Poor ecological condition.
Upper Sand	Ri20	A71C	A71D-00118	Sand	Downstream of the Dwars and Koperspruit tributaries. Downstream of main towns.
Upper Sand	Riv16	A71C	A71C-00156	Dwars	Significant tributary. Downstream of settlements and mines.
Lower Sand	Ri22	A71D	A71D-00118	Sand	Significant wetlands
Upper Sand	Rvi3	A71F	A71G-00131	Hout	Significant tributary. Upper reaches below settlements and some agriculture
Lower Sand	Ri21	A71G	A71G-00107	Hout	Significant tributary. Lower reaches below agriculture
Lower Sand	Ri23	A71H	A71H-00088	Sand	Significant wetlands. High EI and ES.
Lower Sand	Ri24	A71J	A71J-00055	Sand	Upstream confluence with Brak. High EI.
Lower Sand	Ri25	A71K	A71K-00019	Sand	Good ecological condition. High EI. Is an existing IWMI EFlow site.
Lower Sand	Riv17	A72B	A72B-00038	Brak	Significant tributary in a good condition.

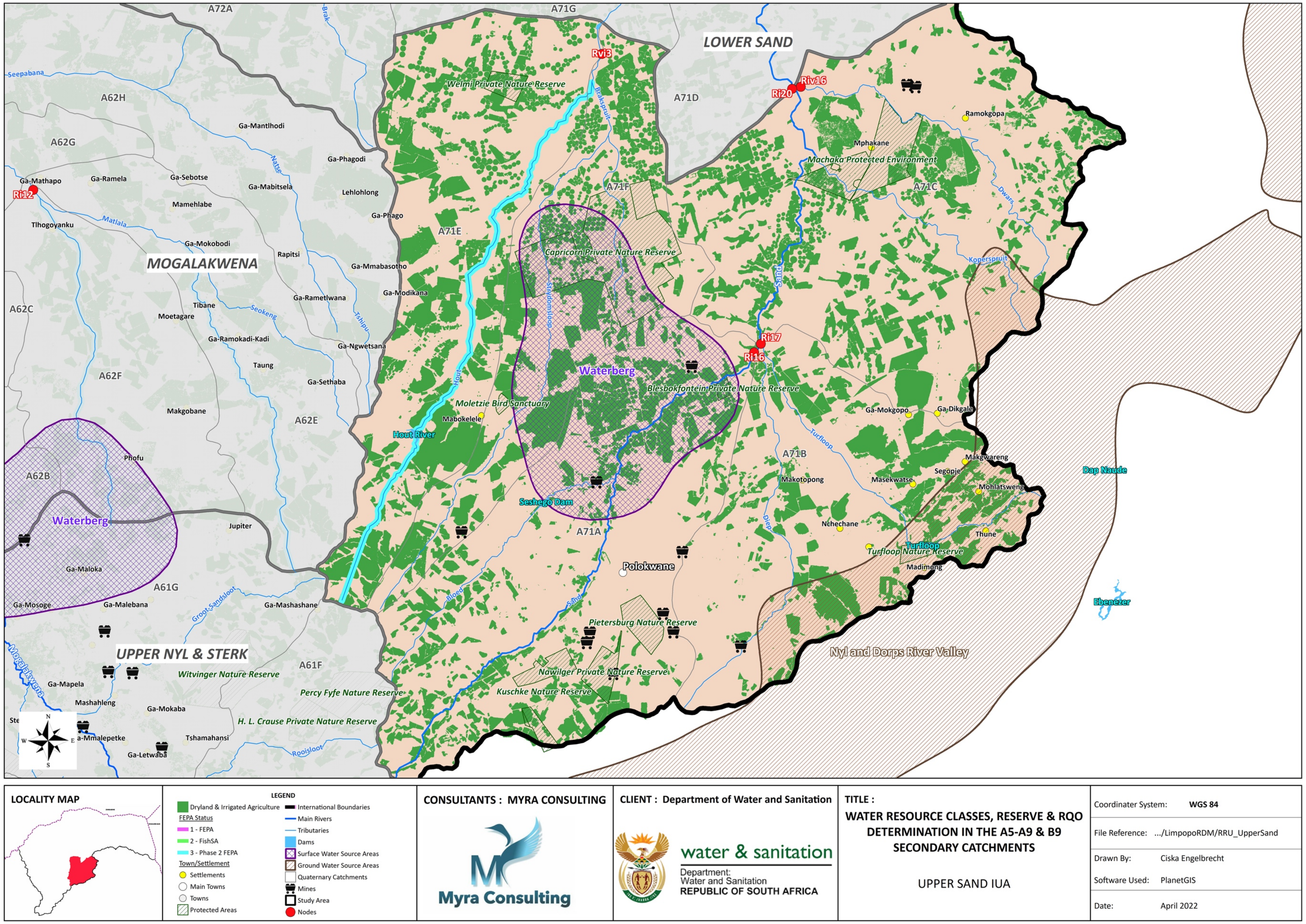

Figure 8-7. Nodes in the Upper Sand IUA

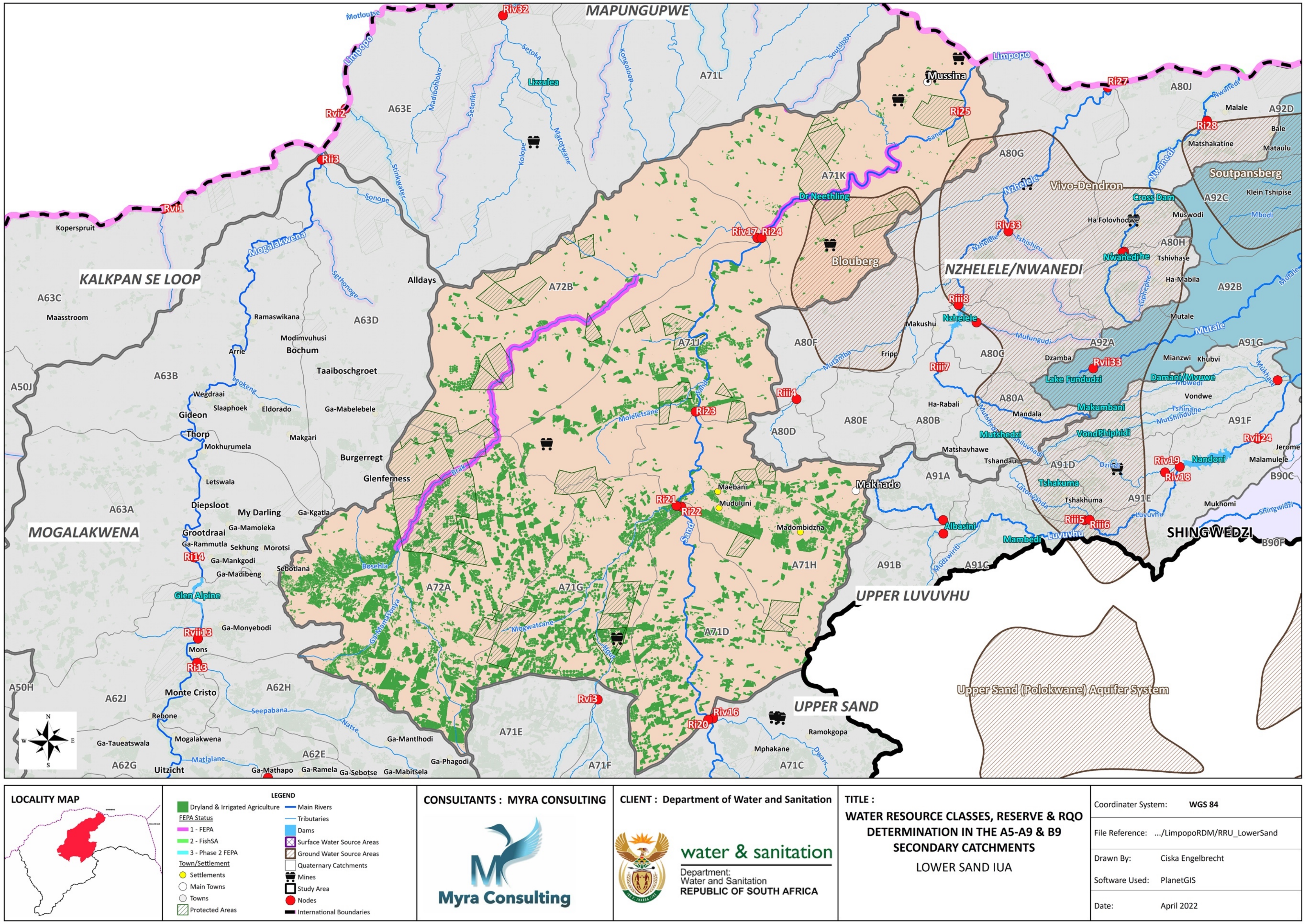

Figure 8-8. Nodes in the Lower Sand IUA

8.2.6 Nzhelele and Nwanedi catchment

The headwaters of the catchment are well populated. The surface water is fully developed with many dams, such as the Nzhelele, Mutshedzi, Luphelele and Ṅwaneḓi Dams. There has been reduced inflow to the Mutshedzi and Nzhelele dams due to forestry and groundwater use. Coal mining has been identified along the Mutamba River and the Makhado coal mine expected from 2019-2034. If water source can be secured there is interest to expand citrus and tomato in the Nzhelele valley.

There are a few conservation areas in the area and very rivers in a good ecological condition. The EI and ES are mostly high to very high.

Eleven (11) nodes were identified in the catchment. See Figure 8-9 and Table 8-6.

Table 8-6. Biophysical and allocation nodes in the Nzhelele and Nwanedi catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Nzhelele/Nwanedi	Riii7	A80B	A80B-00069	Nzhelele	Downstream of Mutshedzi and inflow to the Nzhelele Dam
Nzhelele/Nwanedi	Rvii34	A80C	A80C-00068	Mafungudi	Inflow to the Nzhelele Dam
Nzhelele/Nwanedi	Riii4	A80D	A80D-00075	Mutamba	Downstream of the confluence of the Mutamba and Nzhelele. Below the Nzhelele Dam
Nzhelele/Nwanedi	Ri26	A80F	A80G-00053	Nzhelele	Downstream of the confluence of the Mutamba and Nzhelele. Below the Nzhelele Dam
Nzhelele/Nwanedi	Riv23	A80F	A80F-00063	Mutamba	Upstream of the confluence with Nzhelele.
Nzhelele/Nwanedi	Riii8	A80F	A80F-00065	Nzhelele	Outflow from Nzhelele Dam
Nzhelele/Nwanedi	Ri27	A80G	A80G-00026	Nzhelele	Lowest point of Nzhelele before it flows into the Limpopo River. Situated in the Phillip Herd Nature Reserve.
Nzhelele/Nwanedi	Riv33	A80G	A80G-00054	Tshishiru	Significant tributary. Downstream of Dangadzhiva Dam.
Nzhelele/Nwanedi	Riii9	A80H	A80H-00064	Nwanedi	Outflow from Ṅwaneḓi Dam
Nzhelele/Nwanedi	Riii10	A80H	A80H-00060	Luphephe	Outflow from the Ṅwaneḓi Dam
Nzhelele/Nwanedi	Ri28	A80J	A80J-00028	Nwanedi	Lowest point on Ṅwaneḓi before it enters the Limpopo River. Downstream of the Adwen Nature Reserve.

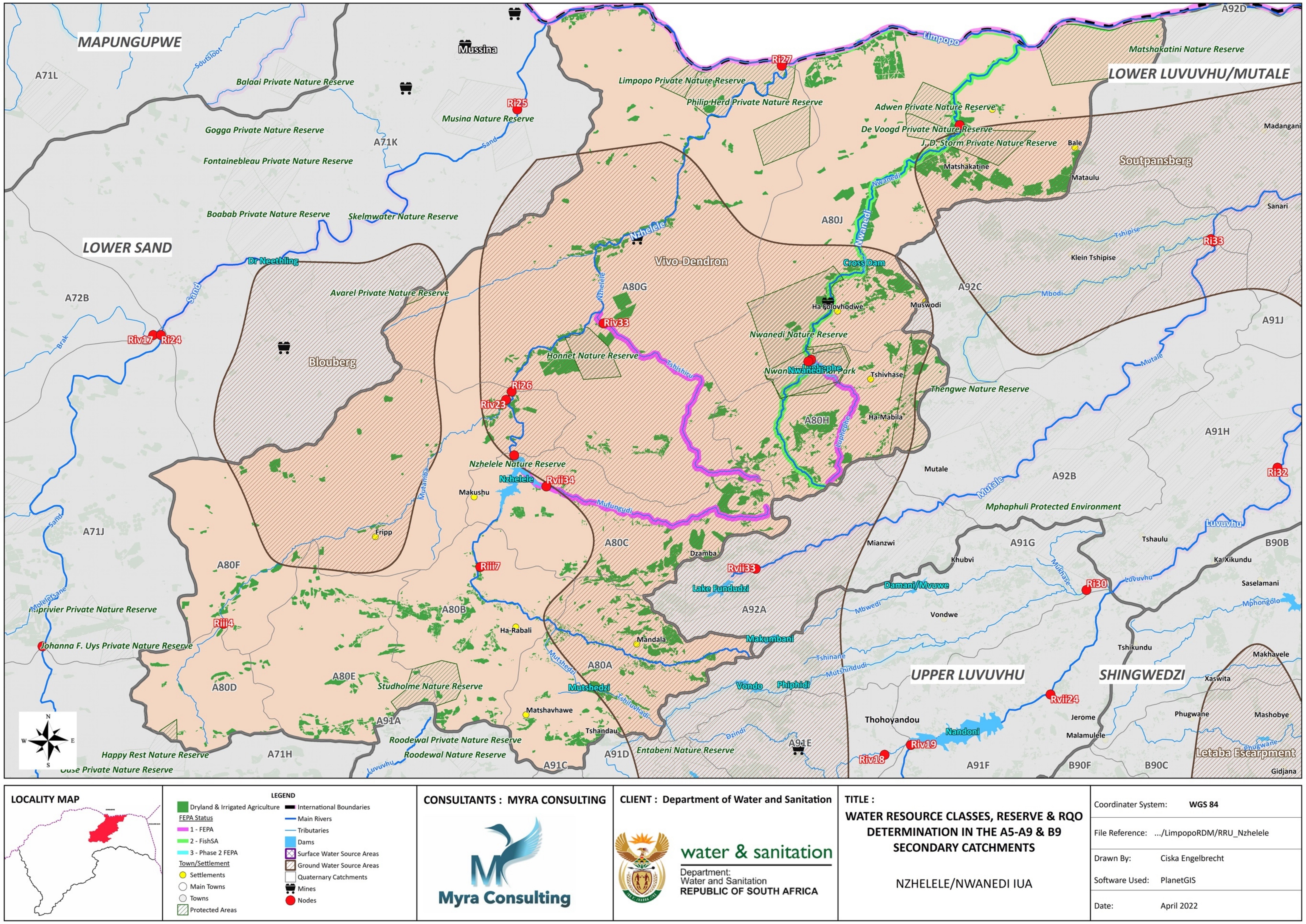

Figure 8-9. Nodes in the Nzhelele / Nwanedi IUA

8.2.7 Luvuvhu catchment

The Luvuvhu catchment has well developed surface water resources, with the Ṋanḓoni, Albasini, Vonḓo, Phiphi and Tshakuma dams. There are small, localised surface and groundwater abstractions. The middle and lower reaches of the catchment experience water quality issues. Many interventions are planned in this catchment such as raising of dams, new dams, and forest clearing to name a few.

As shown in Figure 8-10 and Figure 8-11, eight (8) nodes were identified in the Upper Luvuvhu IUA and seven (7) nodes in the Lower Luvuvhu/Mutale IUA. The nodes are summarised in Table 8-7.

Table 8-7. Biophysical and allocation nodes in the Luvuvhu catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Upper Luvuvhu	Rvi14	A91A	A91A-00105	Luvuvhu	Inflow to Albasini Dam
Upper Luvuvhu	Rvii19	A91B	A91B-00120	Doringspruit	Inflow to Albasini Dam
Upper Luvuvhu	Riii5	A91C	A91C-00115	Luvuvhu	Downstream of Albasini Dam and agricultural area. Very poor ecological condition.
Upper Luvuvhu	Riii6	A91D	A91D-00108	Latonyanda	Significant tributary. Forestry in headwaters.
Upper Luvuvhu	Riv18	A91E	A91E-00103	Dzindi	Inflow to Ṋanḓoni Dam. Downstream of Thohoyandou
Upper Luvuvhu	Riv19	A91F	A91F-00111	Luvuvhu	Inflow to Ṋanḓoni Dam
Upper Luvuvhu	Rvii24	A91F	A91F-00093	Luvuvhu	Outflow from Ṋanḓoni Dam
Upper Luvuvhu	Ri30	A91G	A91G-00086	Mutshinduḓi	Significant tributary. Downstream of large settlement and the Vonḓo and Mvume dams
Lower Luvuvhu/Mutale	Ri32	A91H	A91H-00045	Luvuvhu	Downstream of the settlements
Lower Luvuvhu/Mutale	Ri35	A91J	A91J-00040	Luvuvhu	Upstream of confluence with Mutale River. Good ecological condition.
Lower Luvuvhu/Mutale	Ri36	A91K	A91K-00035	Luvuvhu	Lower end of river as it enters Kruger National Park. At Pafuri Gate. An existing IWMI Eflows Site. Good ecological condition.
Lower Luvuvhu/Mutale	Rvii33	A92A	No Reach Code	Mutale	Downstream of Lake Fundudzi
Lower Luvuvhu/Mutale	Ri33	A92B	A92B-00051	Mutale	Good condition. Very high EI and ES. Downstream of Lake Fundudzi and settlements.

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Lower Luvuvhu/Mutale	Riv24	A92C	A92C-00049	Mbodi	Upstream of confluence of Mbodi and Mutale.
Lower Luvuvhu/Mutale	Ri34	A92D	A92D-00030	Mutale	Upstream of the confluence of Mutale and Luvuvhu.

8.2.8 Shingwedzi catchment

The river condition in the Shingwedzi catchment is excellent. Water quality is good. The catchment falls predominantly in the Kruger National Park. There are no major water resource developments. Small dams are used for game watering and small scale agriculture.

Five (5) nodes were placed in the catchment as shown in Figure 8-12 and Table 8-8.

Table 8-8. Biophysical and allocation nodes in the Shingwedzi catchment

PROPOSED IUA	NODE	QUAT	SQ CODE	RIVER NAME	REASON FOR SELECTION
Shingwedzi	Rvi10	B90A	B90D-00067	Shisha	Upstream management area. Ecological condition is natural. SWSA. Significant tributary.
Shingwedzi	Rvi13	B90F	B90F-00114	Shingwedzi	FEPA. SWSA Good ecological condition. Upstream of confluence with Tshange River.
Shingwedzi	Riv27	B90G	B90G-00124	Shingwedzi	Ecological condition is natural. Downstream of confluence with Bububu River.
Shingwedzi	Ri37	B90H	B90H-00145	Shingwedzi	Very good ecological condition. An existing IWMI EFlow site
Shingwedzi	Riv28	B90H	B90H-00113	Mphongolo	Ecological condition is natural. Significant tributary.

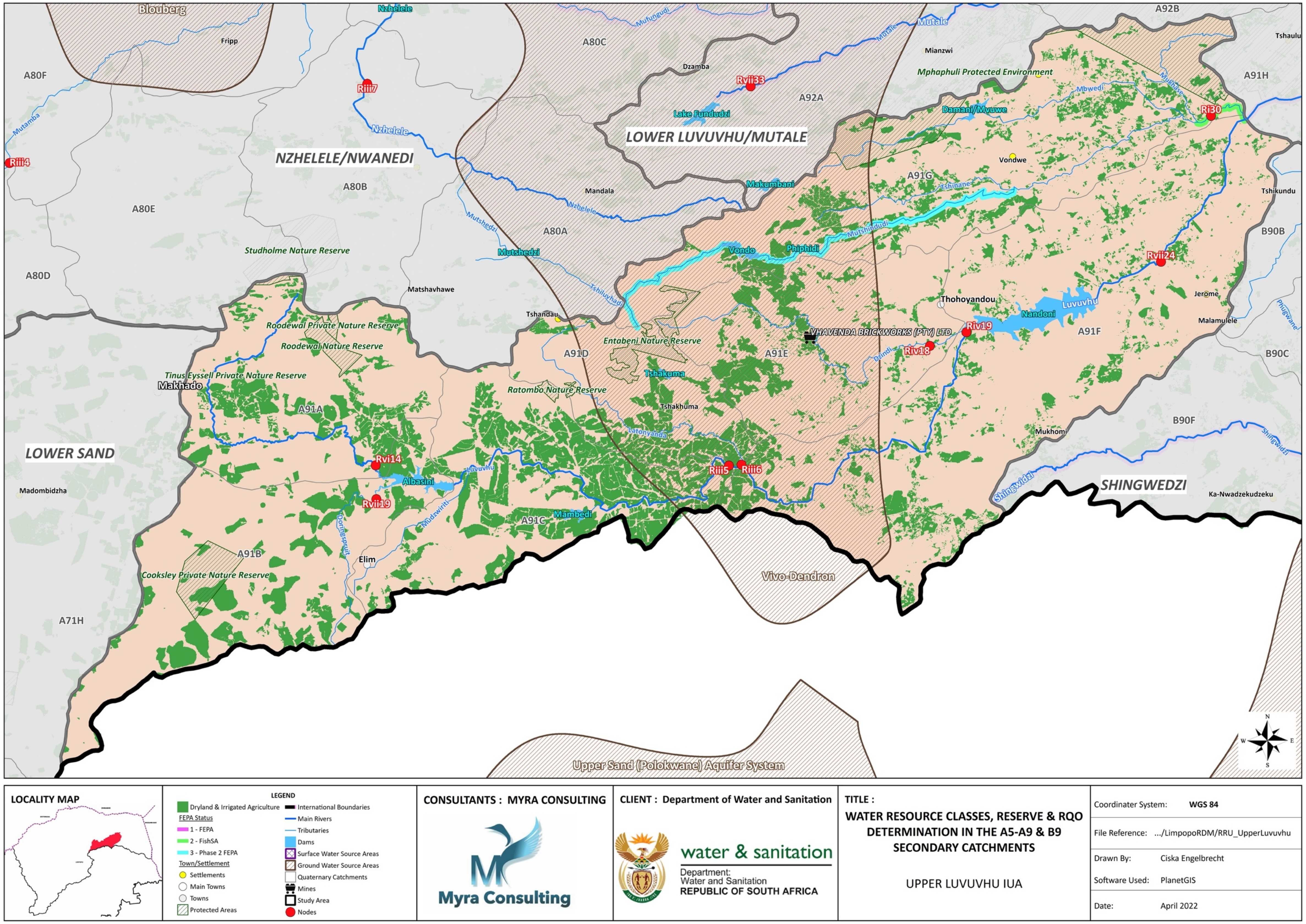

Figure 8-10. Nodes in the Upper Luvuvhu IUA

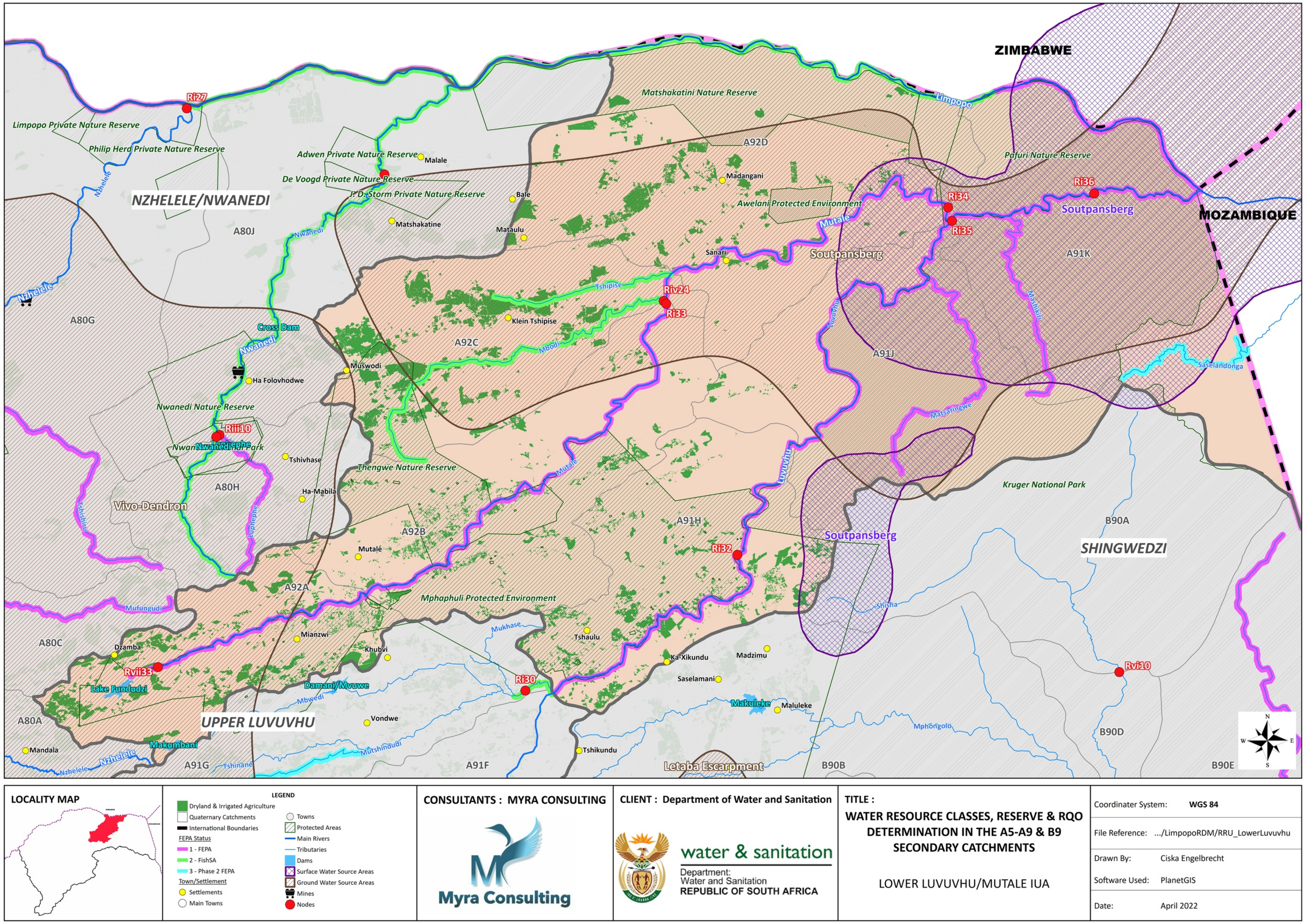

Figure 8-11. Nodes in the Lower Luvuvhu/Mutale IUA

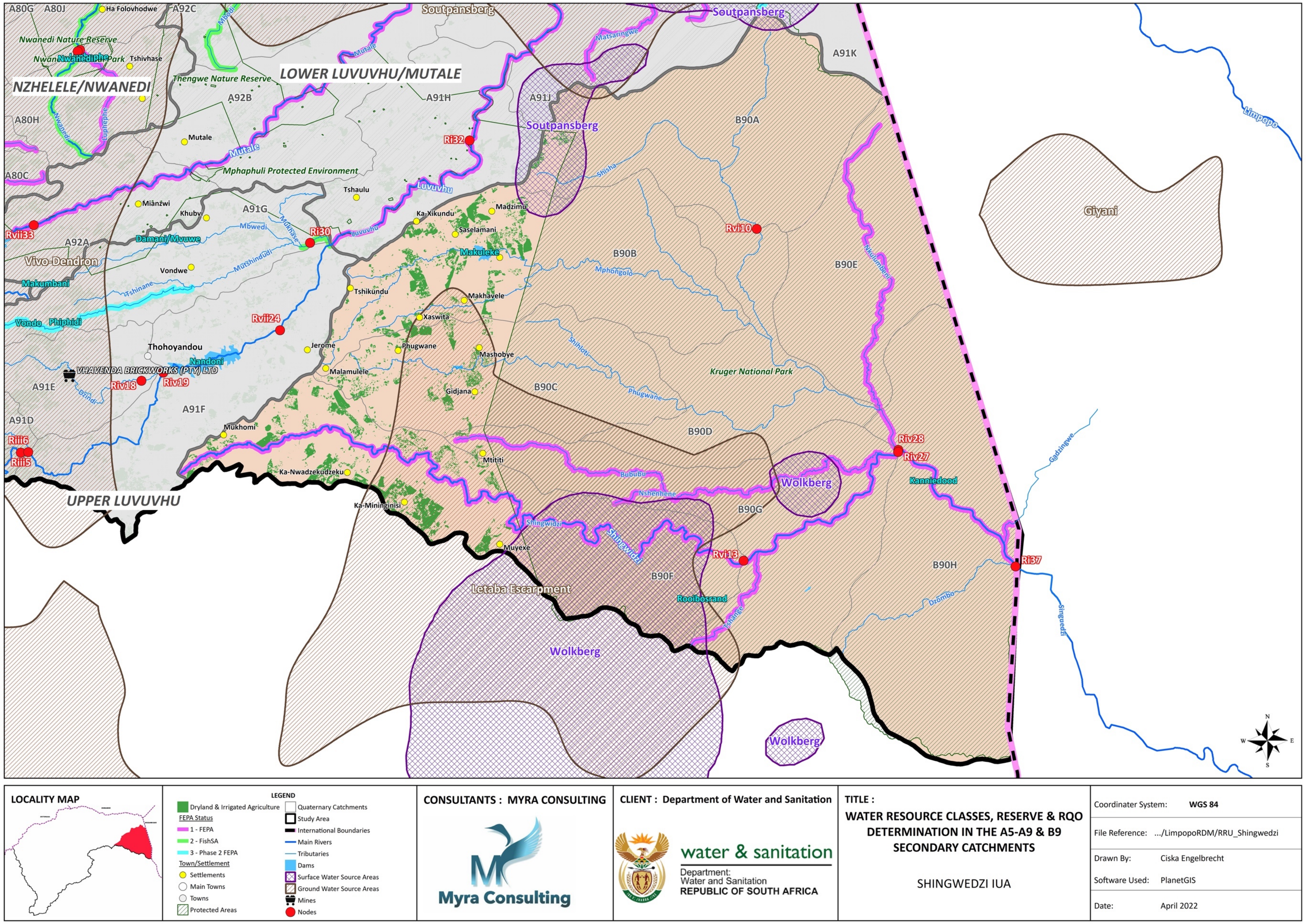

Figure 8-12. Nodes in the Shingwedzi IUA

8.3 Summary nodes

A summary of the nodes and the ecological characteristics at the site/sub-quaternary reach are provided in Table 8-9.

Table 8-9. Summary of nodes in the study area

PROPOSED IUA	NODE	QUAT	SQ REACH CODE	RIVER NAME	X-COORDINATE	Y-COORDINATE	ER	FLOW	HI	GZ	MEAN EI	MEAN ES	PES MEDIAN	SWSA-SW	FEPA STATUS
Upper Lephalala	Riv8	A50A	A50A-00354	Lephalala	28°29'5.0809"E	24°11'54.6908"S	WB	P	1 to =< 4.98	UF	M	HIGH	B		FSA
Upper Lephalala	Riv11	A50B	A50B-00262	Lephalala			WB	P	1 to =< 4.98	LF	H	VH	C		
Upper Lephalala	Riv10	A50C	A50C-00273	Melk	28°22'27.61"E	23°57'15.14"S	WB	P	1 to =< 4.98	UF	H	VH	C		
Upper Lephalala	Riv13	A50D	A50D-00237	Boklandspruit	28°22'32.23"E	23°57'20.43"S	WB	P	1 to =< 4.98	UF	H	VH	B		
Upper Lephalala	Riii3	A50E	A50H-00110	Lephalala	28°16'10.01"E	23°48'7.83"S	LP	P	1 to =< 4.98	LF	H	H	D		
Lower Lephalala	Ri8	A50H	A50H-00110	Lephalala.	28° 6'58.02"E	23°36'38.23"S	LP	S	4.99 to 5	LL	H	H	D		
Kalkpan se Loop	Ri38	A50J	A50J-00073	Kalkpan Se Loop	27°53'6.10"E	23° 8'28.60"S	LP	E	5.1 to 9	UF	M	VL	B	WB	UMA
Kalkpan se Loop	Rvi15	A50J	A50J-00061	No Name	21°6'30.4779"E	22°49'3.3245"S	LP	E	5.1 to 9	UF	H	VL	B		FEPA
Upper Nyl & Sterk	Ri1	A61A	A61B-00552	Nyl	28°27'59.3704"E	24°42'42.9578"S	BB	P	1 to =< 4.98	LF	M	H	C		FSA
Upper Nyl/Sterk	Riv3	A61C	A61C-00501	Nyl	28°42'58.54"E	24°34'14.55"S	BB	P	1 to =< 4.98	LL	H	H	C	WB	
Upper Nyl/Sterk	Riii1	A61E	A61E-00386	Nyl	28°37'38.91"E	22°33'36.58"S	EBK	P	1 to =< 4.98	LL	M	M	D		
Upper Nyl/Sterk	Ri3	A61F	A61G-00297	Mogalakwena	28°44'29.17"E	23°55'10.03"S	WBK	P	1 to =< 4.98	LF	M	M	D		
Upper Nyl/Sterk	Ri5	A61G	A61G-00248	Mogalakwena	28°58'31.10"E	24°16'36.47"S	LP	P	1 to =< 4.98	LF	M	M	D		
Upper Nyl/Sterk	Rv1	A61H	A61H-00395	Sterk	28°55'10.37"E	24° 8'11.48"S	WBK	P	1 to =< 4.98	LF	M	H	E		
Upper Nyl/Sterk	Rvii4	A61H	A61H-00395	Sterk	28°55'11.40"E	22°28'34.49"S	WBK	P	1 to =< 4.98	LF	M	H	E		
Upper Nyl/Sterk	Ri4	A61J	A61J-00267	Sterk	28°42'12.73"E	24°19'15.74"S	LP	P	1 to =< 4.98	LF	H	H	C		
Mogalakwena	Ri6	A62A	A62A-00253	Mokamole	28°46'41.12"E	24°16'43.09"S	LP	P	1 to =< 4.98	LF	H	H	D		
Mogalakwena	Riv12	A62B	A62B-00223	Mogalakwena	28°41'44.87"E	23°58'16.14"S	LP	P	1 to =< 4.98	LF	M	M	C		
Mogalakwena	Rv2	A62B	A62B-00188	Mogalakwena	28°37'57.33"E	23°51'56.86"S	LP	P	1 to =< 4.98	LF	H	H	C		
Mogalakwena	Ri10	A62C	A62C-00188	Mogalakwena	28°38'22.22"E	23°51'46.86"S	LP	P	1 to =< 4.98	LL	H	H	C		

PROPOSED IUA	NODE	QUAT	SQ REACH CODE	RIVER NAME	X-COORDINATE	Y-COORDINATE	ER	FLOW	HI	GZ	MEAN EI	MEAN ES	PES MEDIAN	SWSA-SW	FEPA STATUS
Mogalakwena	Rvii12	A62D	A62D-00179	Klein Mogalakwena	28°36'10.14"E	23°42'59.95"S	WB	P	1 to =< 4.98	LF	H	H	C		
Mogalakwena	Ri12	A62F	A62G-00167	Matlalane	28°37'1.16"E	23°34'24.04"S	LP	E	5.1 to 9	LF	M	VL	C		
Mogalakwena	Ri13	A62H	A62H-00148	Seepabana	28°36'23.80"E	23°34'4.37"S	LP	E	5.1 to 9	UF	M	VL	D		
Mogalakwena	Ri14	A62J	A63A-00071	Mogalakwena	28°49'13.85"E	23°32'0.38"S	LP	P	1 to =< 4.98	LF	H	M	D	SPB	FEPA
Mogalakwena	Rvii13	A62J	A62J-00143	Mogalakwena	28°41'22.49"E	23°20'10.85"S	LP	P	1 to =< 4.98	LL	M	M	C	SPB	FEPA
Kalkpan se Loop	Rvi1	A63C	A63C-00033	Unknown	28°37'38.91"E	22°33'36.58"S	LP	E	5.1 to 9	UF	M	VL	B	SPB	FEPA
Mogalakwena	Rii3	A63D	A63D-00034	Mogalakwena	28°41'44.87"E	23°58'16.14"S	LP	P	1 to =< 4.98	LF	M	M	C		
Mapungubwe	Riv32	A63E	A63E-00008	Kolope	29°35'34.22"E	23°41'36.63"S	LP	E	5.1 to 9	LF	M	LOW	C		
Mapungubwe	Rvi2	A63E	A63E-00011	Stinkwater	28°57'49.50"E	22°23'18.58"S	LP	E	5.1 to 9	UF	M	VL	B		Phase 2 FEPA
Upper Sand	Ri16	A71A	A71A-00211	Sand	29°17'5.13"E	22°19'44.92"S	LP	E	5.1 to 9	LF	M	LOW	D	WB	UMA
Upper Sand	Ri17	A71B	A71B-00214	Diep	30° 5'57.85"E	22°23'39.56"S	LP	E	5.1 to 9	LF	M	LOW	D		
Upper Sand	Ri20	A71C	A71D-00118	Sand	30°38'54.64"E	22°57'11.25"S	LP	E	5.1 to 9	LF	M	LOW	C		
Upper Sand	Riv16	A71C	A71C-00156	Dwars	29°35'59.96"E	23°41'6.52"S	LP	E	5.1 to 9	LF	M	M	C		
Lower Sand	Ri22	A71D	A71D-00118	Sand	29°38'34.16"E	23°25'54.67"S	LP	E	5.1 to 9	LF	M	LOW	C		
Upper Sand	Rvi3	A71F	A71G-00131	Hout	28°9'40.2852"E	23°38'9.5037"S	LP	E	5.1 to 9	LF	M	LOW	C		
Lower Sand	Ri21	A71G	A71G-00107	Hout	29°35'2.52"E	23° 4'10.36"S	LP	E	5.1 to 9	LF	M	M	C		
Lower Sand	Ri23	A71H	A71H-00088	Sand	29°34'29.76"E	23° 4'4.32"S	SPB	E	5.1 to 9	LF	H	H	C		
Lower Sand	Ri24	A71J	A71J-00055	Sand	29°36'37.51"E	22°54'25.73"S	LP	E	5.1 to 9	UF	H	M	C		
Lower Sand	Ri25	A71K	A71K-00019	Sand	29°43'56.71"E	22°36'35.47"S	LP	E	5.1 to 9	UF	HH	M	B		
Mapungubwe	Rvi4	A71L	A71L-00005	Kongoloop	31°12'46.50"E	22°25'32.50"S	LP	E	5.1 to 9	LF	M	VL	C		
Mapungubwe	Rvi7	A71L	A71L-00003	No Name	29°43'42.26"E	22°8'30.2158"S	LP	E	5.1 to 9	UF	H	VL	B		FEPA
Mapungubwe	Rvi9	A71L	A71L-00015	Soutsloot	29°57'17.6659 "E	22°12'28.6117 "S	LP	E	5.1 to 9	UF	M	VL	A		0
Lower Sand	Riv17	A72B	A72B-00038	Brak	29°43'27.78"E	22°36'35.21"S	LP	E	5.1 to 9	LF	M	M	C		

PROPOSED IUA	NODE	QUAT	SQ REACH CODE	RIVER NAME	X-COORDINATE	Y-COORDINATE	ER	FLOW	HI	GZ	MEAN EI	MEAN ES	PES MEDIAN	SWSA-SW	FEPA STATUS
Nzhelele/Nwanedi	Riii7	A80B	A80B-00069	Nzhelele	30° 3'40.50"E	22°49'52.97"S	SPB	P	1 to =< 4.98	UF	M	H	D		
Nzhelele/Nwanedi	Rvii34	A80C	A80C-00068	Mafungudi	30° 7'45.63"E	22°45'15.65"S	SPB	P	1 to =< 4.98	UF	H	H	D		
Nzhelele/Nwanedi	Riii4	A80D	A80D-00075	Mutamba			SPB	P	1 to =< 4.98	UF	H	VH	C		
Nzhelele/Nwanedi	Ri26	A80F	A80G-00053	Nzhelele	30° 5'15.89"E	22°40'18.17"S	SPB	P	1 to =< 4.98	LF	M	H	C		
Nzhelele/Nwanedi	Riv23	A80F	A80F-00063	Mutamba			SPB	P	1 to =< 4.98	LF	M	H	C		
Nzhelele/Nwanedi	Riii8	A80F	A80F-00065	Nzhelele	30° 5'46.42"E	22°43'28.72"S	SPB	P	1 to =< 4.98	LF	M	M	D		
Nzhelele/Nwanedi	Ri27	A80G	A80G-00026	Nzhelele	30°11'17.45"E	22°35'55.44"S	LP	P	1 to =< 4.98	LF	H	H	C		
Nzhelele/Nwanedi	Riv33	A80G	A80G-00054	Tshishiru	31°33'33.09"E	23°13'22.35"S	SPB	P	1 to =< 4.98	UF	H	L	C		
Nzhelele/Nwanedi	Riii9	A80H	A80H-00064	Nwanedi	30°23'56.45"E	22°38'6.08"S	SPB	P	1 to =< 4.98	UF	H	VH	B		
Nzhelele/Nwanedi	Riii10	A80H	A80H-00060	Luphephe	30°24'7.06"E	22°38'0.18"S	SPB	P	1 to =< 4.98	UF	H	VH	C		
Nzhelele/Nwanedi	Ri28	A80J	A80J-00028	Nwanedi	27°53'6.10"E	23° 8'28.60"S	LP	P	1 to =< 4.98	LF	H	VH	D		
Upper Luvuvhu	Rvi14	A91A	A91A-00105	Luvuvhu	30° 4'3.09"E	23° 5'32.98"S	LV	P	1 to =< 4.98	UF	H	H	C	WLB	
Upper Luvuvhu	Rvii19	A91B	A91B-00120	Doringspruit	30° 4'4.96"E	23° 6'56.11"S	LV	P	1 to =< 4.98	LF	M	H	C		
Upper Luvuvhu	Riii5	A91C	A91C-00115	Luvuvhu	30°19'43.90"E	23° 5'33.46"S	LV	P	1 to =< 4.98	LF	M	H	E		
Upper Luvuvhu	Riii6	A91D	A91D-00108	Latonyanda	30°20'17.38"E	23° 5'31.22"S	LV	P	1 to =< 4.98	LL	M	VH	D		
Upper Luvuvhu	Riv18	A91E	A91E-00103	Dzindi	30°28'39.11"E	23° 0'38.52"S	LV	P	1 to =< 4.98	LF	H	VH	D		
Upper Luvuvhu	Riv19	A91F	A91F-00111	Luvuvhu	30°30'16.60"E	23° 0'4.85"S	LV	P	1 to =< 4.98	LF	M	H	C		
Upper Luvuvhu	Rvii24	A91F	A91F-00093	Luvuvhu	30° 4'3.09"E	23° 5'32.98"S	LV	P	1 to =< 4.98	LF	M	H	D		
Upper Luvuvhu	Ri30	A91G	A91G-00086	Mutshindudi	30°41'7.80"E	22°51'11.99"S	SPB	P	1 to =< 4.98	LF	M	H	C		
Lower Luvuvhu/Mutale	Ri32	A91H	A91H-00045	Luvuvhu	30°52'55.81"E	22°44'11.40"S	LV	P	1 to =< 4.98	LF	H	H	C		
Lower Luvuvhu/Mutale	Ri35	A91J	A91J-00040	Luvuvhu	31° 4'52.02"E	22°26'57.10"S	SPB	P	1 to =< 4.98	LF	H	H	B		
Lower Luvuvhu/Mutale	Ri36	A91K	A91K-00035	Luvuvhu	30°22'19.87"E	22°20'55.39"S	LP	P	1 to =< 4.98	LL	VH	H	B		

PROPOSED IUA	NODE	QUAT	SQ REACH CODE	RIVER NAME	X-COORDINATE	Y-COORDINATE	ER	FLOW	HI	GZ	MEAN EI	MEAN ES	PES MEDIAN	SWSA-SW	FEPA STATUS
Lower Luvuvhu/Mutale	Rvii33	A92A	NO REACH CODE	Mutale	30°20'41.82"E	22°49'59.38"S	SPB	P	1 to =< 4.98	UF	HIGH		C		
Lower Luvuvhu/Mutale	Ri33	A92B	A92B-00051	Mutale	30°48'58.13"E	22°31'13.99"S	SPB	P	1 to =< 4.98	LF	VH	VH	C		
Lower Luvuvhu/Mutale	Riv24	A92C	A92C-00049	Mbodi	30°48'49.48"E	22°31'5.27"S	SPB	P	1 to =< 4.98	UF	M	VL	D		
Lower Luvuvhu/Mutale	Ri34	A92D	A92D-00030	Mutale	30°36'57.41"E	22°19'46.85"S	SPB	P	1 to =< 4.98	UF	H	H	C		
Shingwedzi	Rvi10	B90A	B90D-00067	Shisha	31°14'12.2369"E	22° 50'13.8751"S	LV	E	5.1 to 9	LF	H	M	A	SPB	UMA
Shingwedzi	Rvi13	B90F	B90F-00114	Shingwedzi	31°13'9.6229"E	23°12'59.92"S	LV	E	5.1 to 9	LF	H	M	C	WLK	FEPA
Shingwedzi	Riv27	B90G	B90G-00124	Shingwedzi	31°24'37.69"E	23° 5'30.82"S	LV	E	5.1 to 9	LF	H	M	A		
Shingwedzi	Ri37	B90H	B90H-00145	Shingwedzi	31° 4'38.82"E	22°26'15.65"S	LV	P	1 to =< 4.98	LF	H	H	B		
Shingwedzi	Riv28	B90H	B90H-00113	Mphongolo	31°24'39.27"E	23° 5'22.74"S	LV	E	5.1 to 9	LL	M	VL	A		

Notes

ER-Ecoregion; GZ-Geomorphic Zone; HI-Hydrological Index; SWSA-SW-Strategic Water Source Area - Surface Water
ER: WB-Waterberg; BB-Bushveld Basin; EBK-Eastern Bakenveld; WBK-Western Bankenveld; LP-Limpopo Plain; SPB-Soutpansberg; LV-Lowveld
FLOW: P-Perennial; S-Seasonal; E-Ephemeral
GZ: Upper Foothills-UF; Lower Foothills-LF; Lowland River-LL
Mean EI/Mean ES: VH-Very High; H-High; M-Moderate; L-Low; VL-Very Low
PES Median: A: Natural; B: Largely Natural; C: Moderately Modified; D: Largely Modified
FEPA Status: FEPA-Freshwater Ecosystem Priority Area; FSA-Fish Support Area; UMA-Upstream Management Area
SWSA-SW: WB-Waterberg; SPB -Soutpansberg; WLB-Wolkberg

9 STATUS QUO SUMMARY OF INDIVIDUAL IUAs

A summary of the socio-economic, ecological, water quality and water resource situation in each of the delineated IUAs has been provided in this chapter.

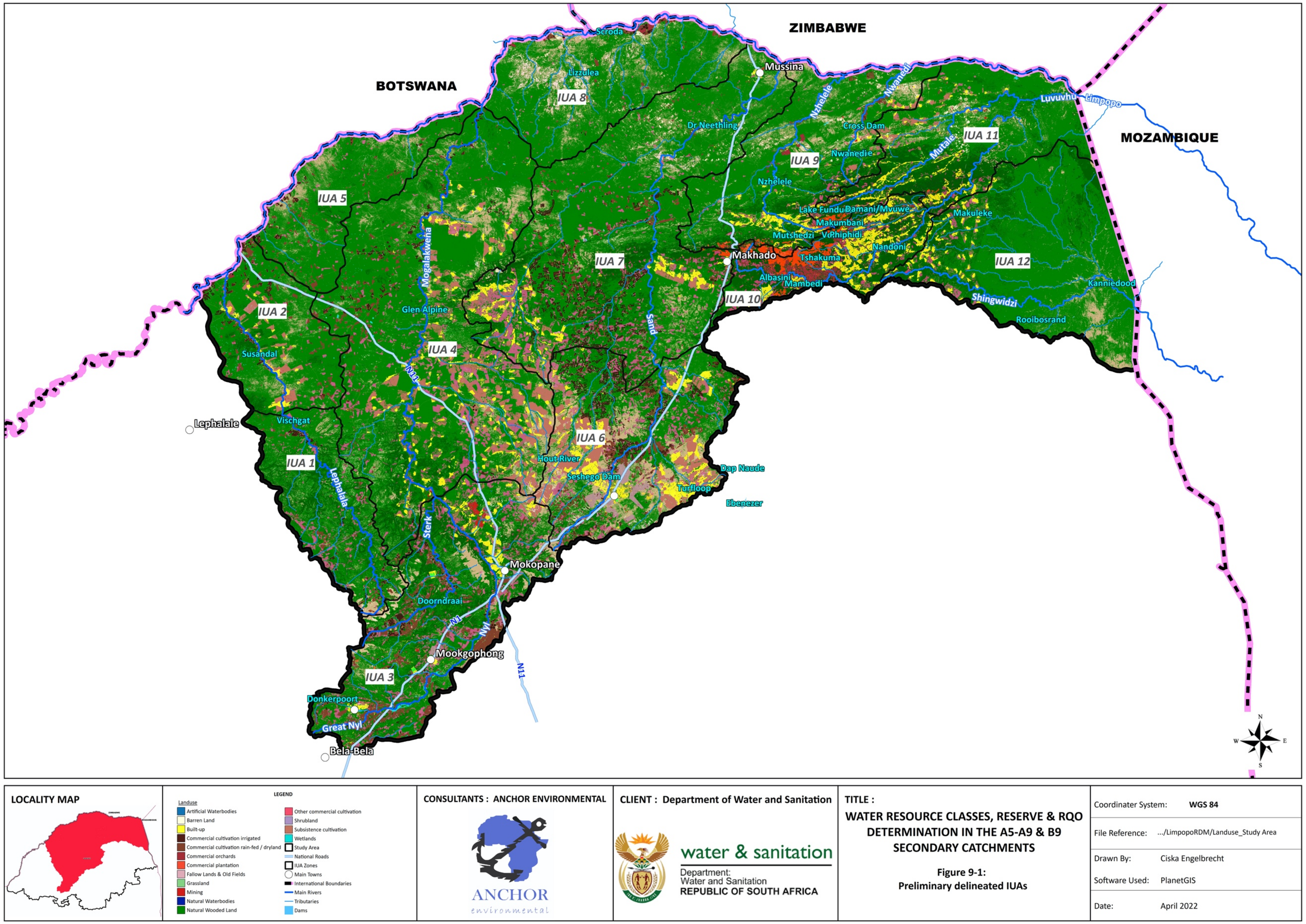

Figure 9-1. Preliminary delineated IUAs. Source: DEA, National Land Cover 2020.

9.4 IUA 1: Upper Lephalala

This IUA falls within the Waterberg District Municipality and includes the Lephalala, Modimole and to a smaller extent Mogalakwena Local Municipalities. In contrast to other IUAs in the study area, the Upper Lephalala IUA is relatively sparsely populated with no main towns. Also, this IUA does not include any former homeland area. There are also fewer households in this IUA that rely on aquatic ecosystems for their livelihoods.

Agriculture is the dominant land use activity in this IUA (3.8%). Cultivation takes place around small towns, particularly around Sondagsloop and Overyssel. Of the 10 313 ha of land that is cultivated, 7 283 ha is commercial cultivation and is a mix of rainfed/dryland and pivot irrigated practices (Figure 9-2). Fallow lands and old fields occupy almost 6.6% of the area.

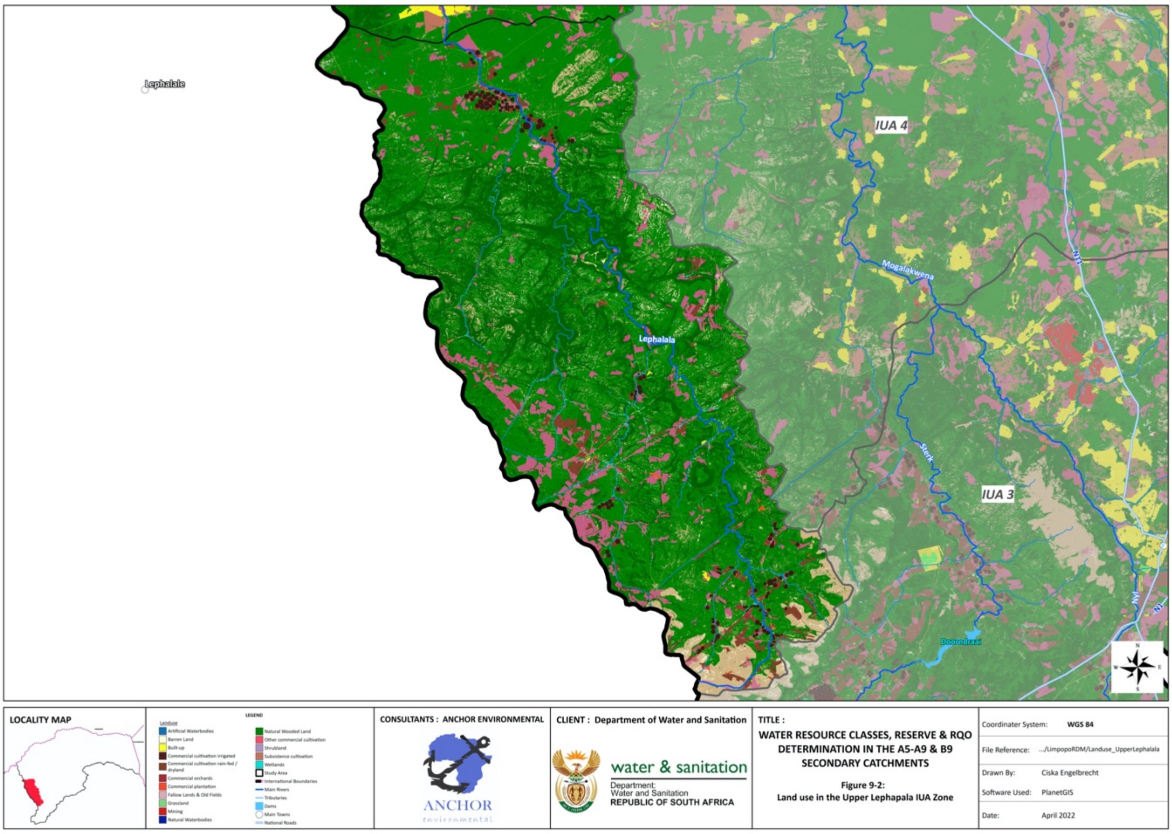

Figure 9-2. Land use in the Upper Lephalala IUA. Source: DEA, National Land Cover 2020.

This IUA has a far lower GVA than most other IUAs in the study area and only contributed 0.9% to the overall study area GVA in 2016. There was a small increase in GVA reported between 2011 (R720 million) and 2016 (R792 million). The community, social and government services sector made the greatest contribution to total GVA in 2016 (Table 9-1). This sector employed the most people (53%) followed by the agriculture, forestry, and fishing sector (21%). A significant number of people (13%) were also employed in manufacturing sector.

Table 9-1. GVA per sector in 2016 (R million, nominal 2016 prices) for Upper Lephalala IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	68.3	9%
Mining and Quarrying	0	0%
Manufacturing	228.9	29%
Electricity, Gas and Water	4.1	1%
Wholesale and Retail Trade, Catering & Accommodation	58.2	7%
Transport, Storage and Communication	187.2	24%
Finance, Insurance, Real Estate and Business Services	0	0%
Community, Social and Government Services	244.8	31%
	791.5	

Table 9-2. The total area of irrigated crops in the Upper Lephalala IUA

Irrigated crop	Area (ha)
Cereals and other field crops	358
Vegetables	187
Citrus fruit	45
Subtropical fruit	86
Apples and Peaches	14
Table grapes	15
Nuts	9
Total	714

Table 9-3. Summary of population, income, living conditions and reliance on surface water. Source: StatsSA Census 2011, StepSA 2018.

Total population (2016)	15 899
Average annual household income (2011)	R78 268
% poor households in IUA (2011)	15%
% unemployed in IUA (2016)	23%
% households with good access to piped water in IUA (2011)	85%
% households dependant on river water in IUA (2011)	4%

Nature-based tourism is important for the Upper Lephalala IUA. Much of this IUA falls within the Waterberg Biosphere Reserve and includes the Lapalala Nature Reserve and Matabane Protected Environment. The IUA also includes several other smaller game farms, lodges, and private reserves. Almost all reserves are situated along rivers (Figure 7-24).

Table 9-4. Status Quo Summary for IUA 1 – Upper Lephalala

ASPECT	DESCRIPTION
Groundwater	The main aquifer types are the fractured Waterberg Group aquifers (predominately) and Intergranular Alluvial aquifers. GUA delineated comprise of A50-1. Average groundwater depths are 24 mbgl with average blow yields of 1.6 L/s. Registered groundwater use is ~0.7 Mm^3/a and can be regarded as underutilised because of the lower groundwater potential of the GUA (as well as lower demand). Groundwater levels show a strong response to significant recharge events with a decreasing trend during poor recharge seasons. GUA A50-1 is of acceptable groundwater quality with a Cl-anion dominant water type. Recharge to the aquifer, often discharged on the steep slopes, provides baseflow to the rivers
Surface water resources	Upper reaches are perennial. Most of the flow in the Lephalala River originates in the upper catchment (A50A to A50D). Water-use is this IUA is 26.2 Mm^3/a and the current day flow at A50E is 94.9 Mm^3/a. There are no major dams in the IUA.
Water Quality	Water quality in the Upper Lephalala IUA is in a very good state. Elevated phosphate concentrations occur from time-to-time but on average, it is low. Researchers have also found the river and its tributaries to be in an oligotrophic state (unenriched with plant nutrients).
Rivers	The upper Lephalala River within the Waterberg Ecoregion is considered of high conservation value with regards to its Freshwater Ecosystem Protection Area (FEPA) status. The Boklandspruit and two sections of the Lephalala River, upstream of the confluence with the Boklandspruit, are in a PES of a B Ecological Category. Most of the rivers in the IUA exhibit very high and high EI and ES status. The mainstem Lephalala River and many of its associated tributaries in quaternary catchments A50A, A50B and A50C, are important FEPA fish support areas, with some of the tributaries in these three quaternaries exhibiting full FEPA status. Numerous instream farm dams occur in this IUA.
Wetlands	HGM (% in IUA): Channelled valley bottoms 15.8 Depressions 7.6 Floodplains 0.0 Riverine 44.8 Seeps 5.0 Unchannelled valley bottoms 26.9 Wetland Condition (% in IUA): A/B 5.6 C 3.6 D/E/F 46.1 N/A 44.8

9.5 IUA 2: Lower Lephalala

Just over 90% of the Lower Lephalala IUA falls within the Lephalala Local Municipality. The IUA has two small towns and approximately 22% of its area is dense rural settlement. These settlements are generally limited to former homeland areas (Lebowa). Unlike the Upper Lephalala IUA, this IUA experienced an increase in population from 52 471 people in 1996 to 67 675 people in 2016. There was also a noticeable decline in the unemployment rate (51% to 21%) as well as the percentage of poor households (38% to 18%) between 1996 and 2011.

The Lower Lephalala IUA covers an area of approximately 277 000 ha. While much (81.8%) of the land within this IUA remains natural, a significant proportion (12.1%) is used for cultivation. Almost half of the cultivation is for commercial purposes and is largely rain-fed/dryland. Commercial cultivation is scattered throughout the IUA. Rain-fed/dryland practices take place in the southern parts of the IUA, while pivot irrigated practices mainly take place in the north along the Lephalala River and extending towards the South African border with Botswana (Figure 9-3). A smaller extent (5.0%) of land is used for subsistence cultivation which is restricted to the Lebowa former homeland area.

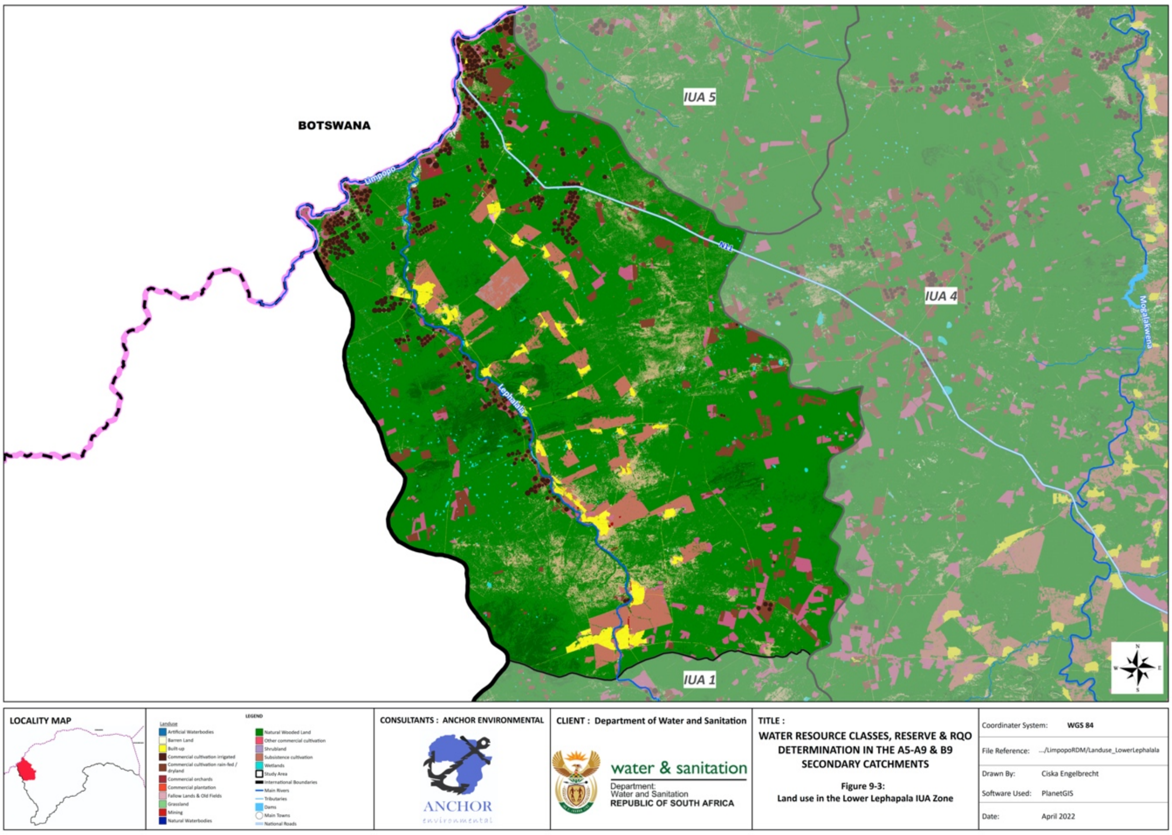

Figure 9-3. Land use in the Lower Lephalala IUA. Source: DEA, National Land Cover 2020.

The Lower Lephalala IUA made a small contribution (0.7%) to the overall study area GVA in 2016. Its GVA has remained relatively constant between 2011 (R579.2 million) and 2016 (R621.0 million). The community, social and government service sector made the biggest contribution (76%) to GVA in 2016 (Table 9-5). This sector and the agriculture, forestry and fishing sector employed the most people (65% or 13 564 people, and 31% or 6 534 people, respectively).

Table 9-5. GVA per sector in 2016 (R million, nominal 2016 prices) for Lower Lephalala IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	106.4	17%
Mining and Quarrying	0	0%
Manufacturing	0	0%
Electricity, Gas and Water	0.3	0%
Wholesale and Retail Trade, Catering & Accommodation	34.8	6%
Transport, Storage and Communication	8.3	1%
Finance, Insurance, Real Estate and Business Services	0	0%
Community, Social and Government Services	471.1	76%
	621.0	

Table 9-6. The total area of irrigated crops in the Lower Lephalala IUA

Irrigated crop	Area (ha)
Cereals and other field crops	451
Vegetables	993
Citrus fruit	2
Subtropical fruit	157
Apples and Peaches	0
Table grapes	0
Nuts	0
Total	1 603

Table 9-7. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	67 675
Average annual household income (2011)	R60 709
% poor households in IUA (2011)	18%
% unemployed in IUA (2016)	21%
% households with good access to piped water in IUA (2011)	57%
% households dependant on river water in IUA (2011)	3%

The Lower Lephalala IUA has far fewer nature reserves than the Upper Lephalala, the majority of which are situated further away from main rivers (Figure 7-24).

Table 9-8. Status Quo Summary for IUA 2 – Lower Lephalala

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include intergranular and fractured aquifer system from the Basement- and Bushveld Complex as well as intergranular alluvial aquifers. GUA delineated comprise of A50-2 and A50-3. Average groundwater depths are 21 to 24 mbgl with average blow yields of 2.0 to 2.6 L/s. Registered groundwater use is ~15 Mm^3/a and can be regarded as moderately exploited. While the groundwater potential of the GUA is high monitoring stations show a decline of 3 to 5 m in groundwater levels since 2009, which can relate to a localised to regional impact. A50-2 and A50-3 is of moderate to poor quality with notable elements of concern include NO_3 as N and fluoride. Groundwater samples indicate a variety of water types (e.g., Ca/Mg-HCO3, Na-HCO3 and Na-Cl).
Surface water	Middle to lower reaches of the Lephalala show a trend of increasing periods of zero flow during the dry season. Water-use exceeds runoff from this IUA. The current day flow generated in this IUA is 15.5 Mm^3/a and water-use is 16.4 Mm^3/a.
Water Quality	In general, water quality in the Lephalala River is good with low salinity, sulphates etc., but some elevated nutrients are observed in the lower reaches of the river. This could be due to agricultural return flows, domestic wastewater discharges and/or runoff from villages near the lower Lephalala River.
Rivers	The Lower Lephalala has no FEPA status, with the mainstem river in a D Ecological Category. The river is of high EI and ES. Numerous weirs for domestic and commercial abstraction occur in this IUA, which has a negative impact on the ecological integrity of the rivers in this IUA.
Wetlands	HGM (% in IUA): Channelled valley bottoms 0.0 Depressions 93.9 Floodplains 1.7 Riverine 4.4 Seeps 0.0 Unchannelled valley bottoms 0.0 Wetland Condition (% in IUA): A/B 79.6 C 7.6 D/E/F 8.4 N/A 4.4

9.6 IUA 3: Upper Nyl and Sterk

The Upper Nyl & Sterk IUA is located in the Waterberg District Municipality. The majority of the Modimolle-Mookgophong Local Municipality and approximately half of Mogalakwena Local Municipality fall within this IUA. There are three major towns in the IUA: Modimole (situated on the Little Nyl river) and Mookgophong (close to the Nyl) in the far south, and Mokopane (on the Mogalakwena river) further north. About 11% of the total study area's population live in the Upper Nyl & Sterk IUA. Although much of the IUA is characterized as sparsely populated, about 15% falls within a former homeland area that is densely populated.

The Upper Nyl & Sterk IUA is approximately 547 000 ha in size. About 13% of the zone is used for cultivation, most of which is used for commercial crop cultivation (rain-fed/dryland). Forty-seven percent (537 000 ha) of all commercial cultivation takes place in the Upper Nyl & Sterk IUA and is usually located close to rivers (Figure 9-4). Fallow lands and old fields occupy 10.5% of the area. This IUA has the largest extent of mining and quarrying (3 321 ha) in the study area.

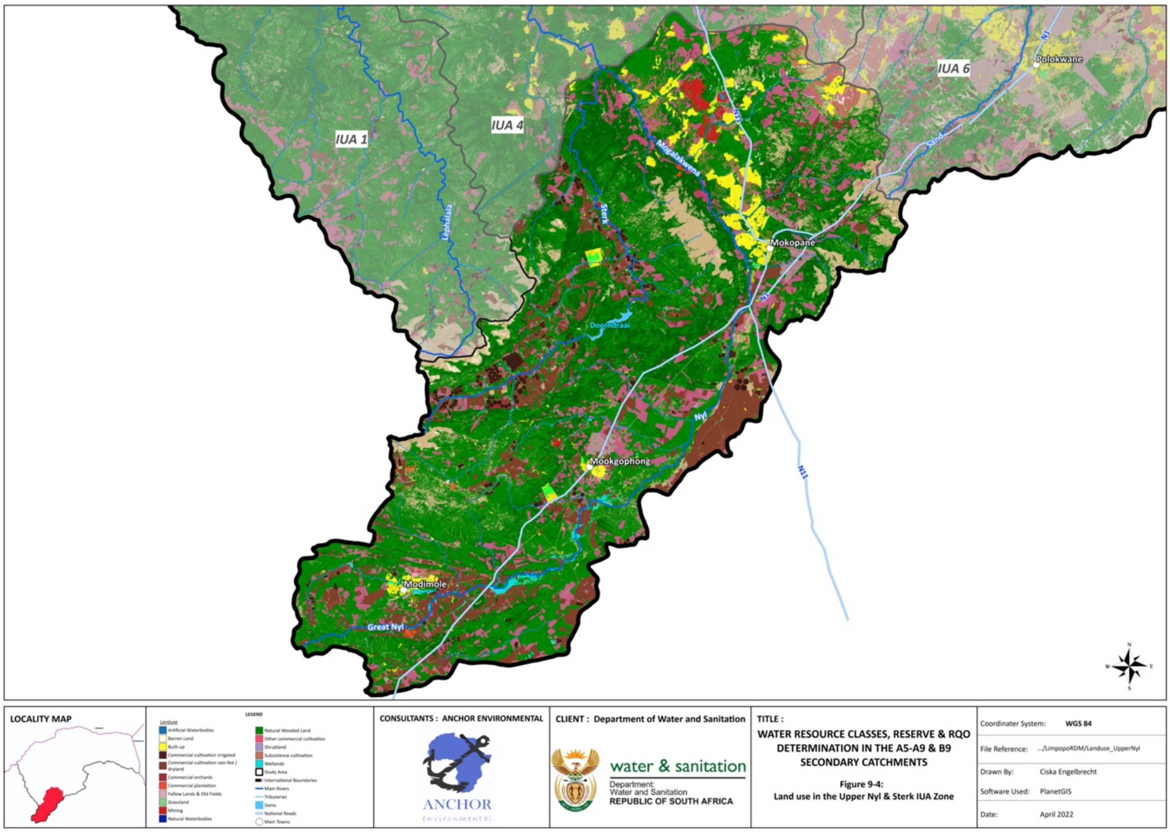

Figure 9-4. Land use in the Upper Nyl & Sterk IUA. Source: DEA, National Land Cover 2020.

The Upper Nyl & Sterk IUA made a 10.8% contribution to the study area GVA in 2016. The GVA was highest in areas surrounding the main towns. Despite the slight decrease between 2013 and 2016, overall, there was an increase in GVA between 1996 (R5 395 million) and 2016 (R9 622 million).

Furthermore, economic activity was more diverse in this IUA with three sectors contributing almost equally (combined contribution of 76%) to GVA (Table 9-9).

Although the wholesale and retail trade, catering and accommodation sector makes the largest contribution to GVA, it employed 14 209 (20%) people in contrast to the community, social and government services sector which contributes 23% to GVA and employs the most people (33%). Other important sectors, in terms of employment are the mining and quarrying sector (15%), the finance, insurance, real estate and business services sector (13%) and the manufacturing sector (9%).

Table 9-9. GVA per sector in 2016 (R million, nominal 2016 prices) for Upper Nyl & Sterk IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	252.7	3%
Mining and Quarrying	736.4	8%
Manufacturing	480.6	5%
Electricity, Gas and Water	181.2	2%
Wholesale and Retail Trade, Catering & Accommodation	2 869.9	30%
Transport, Storage and Communication	704.8	7%
Finance, Insurance, Real Estate and Business Services	2 221.2	23%
Community, Social and Government Services	2 175.7	23%
	9 622.6	

Table 9-10. The total area of irrigated crops in the Upper Nyl & Sterk IUA

Irrigated crop	Area (ha)
Cereals and other field crops	1 141
Vegetables	139
Citrus fruit	174
Subtropical fruit	404
Apples and Peaches	47
Table grapes	51
Nuts	30
Total	1 985

Table 9-11. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	332 663
Average annual household income (2011)	R77 134
% poor households in IUA (2011)	19%
% unemployed in IUA (2016)	31%
% households with good access to piped water in IUA (2011)	72%
% households dependant on river water in IUA (2011)	0%

There are many nature reserves in the Upper Nyl and Sterk IUA (Figure 7-24). Almost all reserves can be found along main rivers in the area. There are several resorts, lodges, and camps in the IUA, many of which are also located along or in close proximity to rivers. There are a few fishing spots between the towns of Mookgopong and Mokopane. Doorndraaidam is another popular fishing spot in the province. There are a few wetlands located around rivers in this IUA. Nylsvley, in the east of the IUA is a declared RAMSAR wetland site. A few bird watching areas are located along the Nyl river (and other areas within the IUA). Figure 7-25 shows that the Nyls Vlei and Entabeni reserves seem to be popular destinations for tourists.

Table 9-12. Status Quo Summary for IUA 3 – Upper Nyl and Sterk

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include are the fractured Waterberg Group aquifers and Intergranular Alluvial aquifers. The IUA also hosts the Mokopane (karst) dolomite aquifer. GUA delineated comprise of A61-1, A61-2, and A61-3. Average groundwater depths are 16 mbgl with average blow yields of 1.8 to 4.3 L/s. Registered groundwater use is ~30 Mm^3/a and can be regarded as low to moderately exploited. The groundwater potential of the GUAs is considered high. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Despite the groundwater fluctuation observed, most groundwater levels show a neutral trend with a few stations showing a decline of around 20 m which can relate to a localised impact. A61-1 and A61-2 is of acceptable groundwater quality with a dominant (Ca/Mg-HCO3) water type. A61-3 is of moderate to poor quality with notable elements of concern include NO_3 as N. Groundwater samples indicate a variety of water types (e.g., Ca/Mg-HCO3, Na-HCO3 and Na-Cl). Groundwater contribution to baseflow is an important component to sustain the flow in the Sterk and Nyl river.
Surface water	This IUA comprises of catchments in A61. Flows are perennial and influenced by the Nylsvley wetland. Current day flow is 21.1 Mm^3/a and water-use is 38.4 Mm^3/a.
Water Quality	Water quality in the Upper Nyl and Sterk River is in a very good state up to the point where wastewater effluents enter the river. In general, WWTWs in the IUA are not complying with effluent standards. Unionised ammonia concentrations are high downstream of effluent discharges which is detriments to aquatic biota. The Nylsvley wetland act as filter to reduce nutrient concentrations. Water quality in Doorndraai Dam and its outflow are in a very good state although elevated phosphate concentrations have been observed from time-to-time.
Rivers	The Badseloop, Tobiasspruit, Andriesspruit, Mmadikiri and Klein-Sterk Rivers are assigned full FEPA status, with the Great Nyl, Little Nyl and Sterk Rivers, assigned

ASPECT	DESCRIPTION
	FEPA fish support areas. The ephemeral Nylsvley wetland is situated in the Nyl River and has RAMSAR status. Most of the rivers in this IUA have a C and D PES status, with two tributaries of the Sterk River showing a B PES status. Many of the rivers in the upper IUA have a high I EI and ES, with the Great Nyl, Olifantspruit and Klein Sterk River exhibiting very high ES. The section of the Mogalakwena River in the Waterberg with its confluence with the Sterk River, is considered a Strategic Water Resource Area. Major towns occur in this IUA, it is densely populated and industrialized, with issues concerning its WWTWs. Many mines also occur in the IUA, with more mines anticipated. This all impacts on the ecological integrity of the rivers in the IUA.
Wetlands	HGM (% in IUA): Channelled valley bottoms 5.8 Depressions 0.5 Floodplains 85.6 Riverine 2.1 Seeps 1.4 Unchannelled valley bottoms 4.7 Wetland Condition (% in IUA): A/B 1.0 C 0.9 D/E/F 96.0 N/A 2.1

9.7 IUA 4: Lower Mogalakwena

The Lower Mogalakwena IUA is situated mostly within the Blouberg and Mogalakwena Local Municipalities. It is the largest IUA making up 18% of the study area. While there are no main towns, there are several small towns in the IUA, all of which are in former homeland areas. Almost half (5 109 km^2) of the IUA is former homeland. The remaining areas of the IUA are sparsely populated. In 2016 there were 330 280 people living here, the majority of which resided in former homeland areas.

The Lower Mogalakwena IUA is about 1 million ha. Like in other IUAs, much of the land remains natural (80.1%). In the Lower Mogalakwena IUA, subsistence cultivation (7.7%) is far more extensive than commercial cultivation (2.5%). Rain-fed/dryland farming is the main practice used in commercial cultivation. A significant amount of land is classified as fallow (61 000 ha). Despite its larger extent, only 3.0% (32 000 ha) of land is residential area (Figure 9-5).

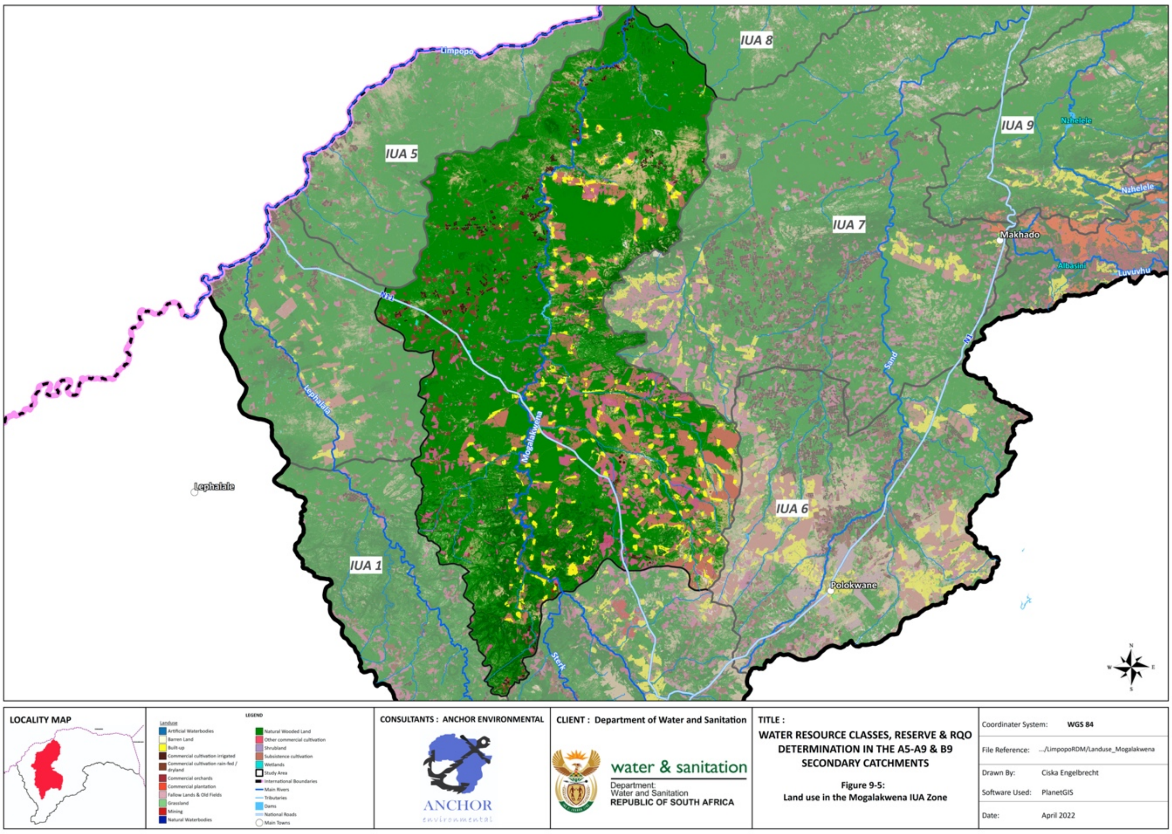

Figure 9-5. Land use in the Mogalakwena IUA. Source: DEA, National Land Cover 2020.

The Mogalakwena IUA made a 4.9% contribution to the study area's GVA in 2016. The community, social and government services sector made the largest contribution (71%) in this IUA to GVA (Table 9-13). In 2016, this sector also employed the most people (75%) in the IUA. The agriculture, forestry and fishing sector (11%) and wholesale and retail trade, catering and accommodation (9%) also employed a considerable number of people.

Table 9-13. GVA per sector in 2016 (R million, nominal 2016 prices) for Lower Mogalakwena IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	283.7	6%
Mining and Quarrying	46.1	1%
Manufacturing	61.5	1%
Electricity, Gas and Water	150.2	3%
Wholesale and Retail Trade, Catering & Accommodation	551.5	12%
Transport, Storage and Communication	188.3	4%
Finance, Insurance, Real Estate and Business Services	3.3	0%
Community, Social and Government Services	3 128.5	71%
	4 413.0	

Table 9-14. The total area of irrigated crops in the Mogalakwena IUA

Irrigated crop	Area (ha)
Cereals and other field crops	404
Vegetables	1 731
Citrus fruit	253
Subtropical fruit	88
Apples and Peaches	2
Table grapes	2
Nuts	3
Total	2 483

Table 9-15. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	330 280
Average annual household income (2011)	R50 078
% poor households in IUA (2011)	22%
% unemployed in IUA (2016)	39%
% households with good access to piped water in IUA (2011)	60%
% households dependant on river water in IUA (2011)	4%

Table 9-16. Status Quo Summary for IUA 5 – Mogalakwena

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include intergranular and fractured aquifer system from the Basement- and Bushveld Complex as well as intergranular alluvial aquifers. GUA delineated comprise of A61-1, A61-2, A61-3, and A63-1. Average groundwater depths are 13 to 24 mbgl with average blow yields of 1.4 to 2.9 L/s. Registered groundwater use is ~22 Mm^3/a and can be regarded as underutilised. The groundwater potential of the GUAs is considered as moderate. Groundwater level monitoring stations show a response to recharge events with variable (and seasonal) fluctuations. Groundwater levels show a decreasing trend during poor recharge seasons. A61-1, A61-2, A61-3, and A63-1 is of moderate to poor quality with notable elements of concern include NO_3 as N. Groundwater samples indicate a variety of water types (e.g., Ca/Mg-HCO3, Na-HCO3 and Na-Cl).
Surface water	The Mogalakwena IUA has occasional zero flows in the central region with increasingly zero flows periods in the lower reaches. Current day flow generated in this IUA is 90.1 Mm^3/a and water-use is 48.7 Mm^3/a.
Water Quality	Water quality in the lower Mogalakwena River upstream of the Limpopo confluence (A6H035Q01) is mostly in an Acceptable category due to elevated salts, pH values and some elevated phosphate concentrations. High sulphate concentrations are recorded in the Dorps River in Mokopane which could be due to runoff from the industrial area

<table>
<tr><th>ASPECT</th><th>DESCRIPTION</th></tr>
<tr><td></td><td>upstream of the sampling point. Water quality in the Pholotsi River downstream of the Mogalakwena platinum mines is poor with high salts, high phosphates and high sulphate concentrations, all in Unacceptable categories. In Glen Alpine Dam in the middle reaches of the Mogalakwena River the average water quality is in an Ideal category but elevated salts and nutrients are observed. Elevated orthophosphate concentrations are observed in the dam with median concentrations falling in an Acceptable category, 75th percentile concentration in a Tolerable category and the 95th percentile concentration in an Unacceptable category. The implication is that algal blooms can occur regularly in Glen Alpine Dam.</td></tr>
<tr><td>Rivers</td><td>The Mothlakole and Sethonoge Rivers are assigned full FEPA status, with sections of the mainstem Mogalakwena River assigned as fish support areas. Many of the tributaries in the upper IUA are assigned FEPA support areas. The Mothlakole River is assigned an A PES Category, the lower Mogalakwena River is considered as largely modified from its natural condition (D PES Category), with the Sethonoge River and some of its unnamed tributaries in a B PES Category. The upper Mogalakwena and mid-sections, as well as some of the upper tributaries, are assigned a high EI, with the Mokamole and Mothlakole and upper Mogalakwena Rivers showing a high ES.</td></tr>
<tr><td>Wetlands</td><td><u>HGM (% in IUA):</u>

Channelled valley bottoms 14.5
Depressions 20.6
Floodplains 0.0
Riverine 39.1
Seeps 3.4
Unchannelled valley bottoms 22.4

<u>Wetland Condition (% in IUA):</u>
A/B 35.6
C 3.0
D/E/F 22.2
N/A 39.1</td></tr>
</table>

9.8 IUA 5: Kalkpan Se Loop

The majority of the Kalkpan Se Loop IUA falls within the Capricorn District Municipality and the Blouberg Local Municipality (78%). This IUA is sparsely populated, with the population declining from 4 258 to 3 421 between 2001 and 2016. The unemployment rate increased in this area from 8% to 27% between 1996 and 2016.

The IUA covers 257 500 ha, of which 91.6% of the land is natural. Although the primary active land use, only a small proportion of the IUA is used for cultivation (5.2%), the majority of which is commercial rain-fed/dryland crops (3.7%). No subsistence cultivation takes place in this IUA (Figure 9-6).

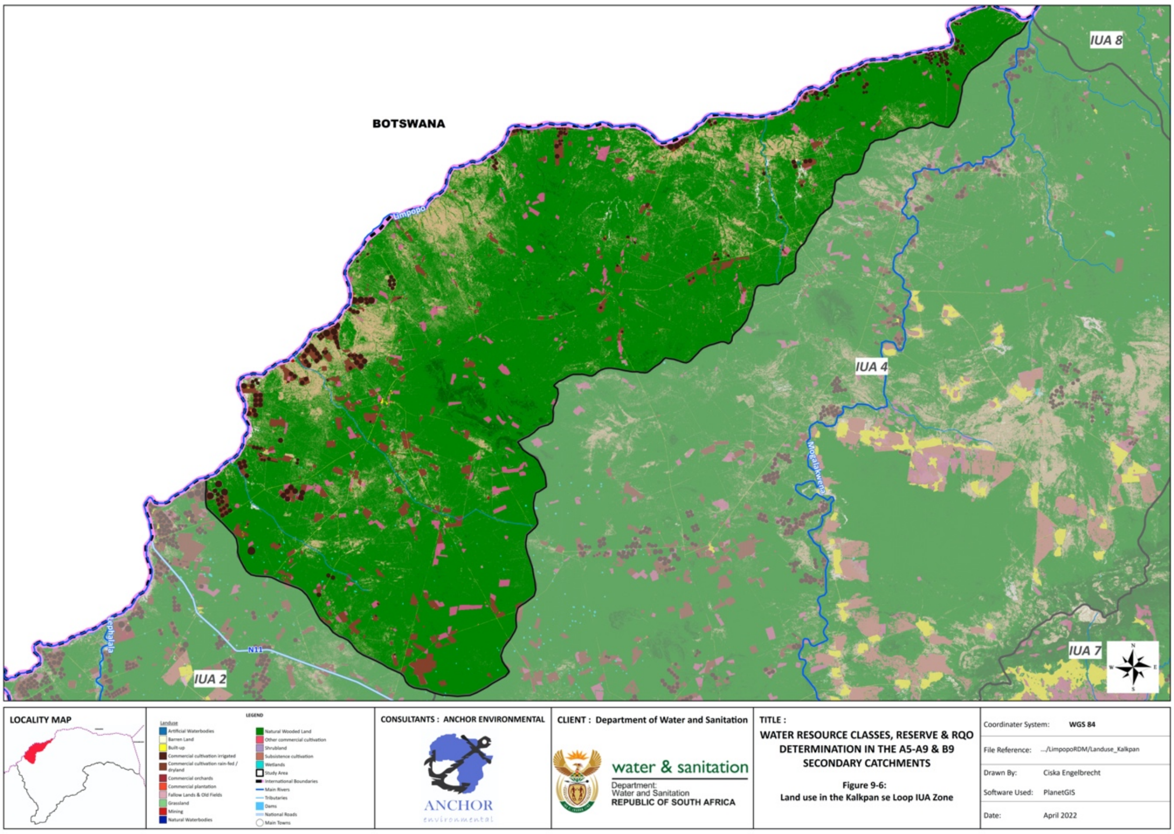

Figure 9-6. Land use in the Kalkpan Se Loop IUA. Source: DEA, National Land Cover 2020.

This IUA made the smallest contribution (0.1%) to the study area GVA in 2016 and has not changed much since 2011. The majority (63%) of the IUAs GVA comes from the agriculture, forestry and fishing sector (Table 9-17). Of the 12 IUAs, the lowest number of employed persons was reported in the Kalkpan Se Loop IUA. Those that were employed worked mainly in the agriculture, forestry and fishing (55%) and community, social and government services (38%) sectors.

Table 9-17. GVA per sector in 2016 (R million, nominal 2016 prices) for Kalkpan Se Loop IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	47.5	63%
Mining and Quarrying	0	0%
Manufacturing	0	0%
Electricity, Gas and Water	0	0%

Wholesale and Retail Trade, Catering & Accommodation	8.0	11%
Transport, Storage and Communication	0.9	1%
Finance, Insurance, Real Estate and Business Services	0	0%
Community, Social and Government Services	19.4	26%
	75.8	

Table 9-18. The total area of irrigated crops in the Kalkpan Se Loop IUA

Irrigated crop	Area (ha)
Cereals and other field crops	120
Vegetables	825
Citrus fruit	37
Subtropical fruit	30
Apples and Peaches	0
Table grapes	0
Nuts	0
Total	1 011

Table 9-19. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	3 421
Average annual household income (2011)	R71 219
% poor households in IUA (2011)	8%
% unemployed in IUA (2016)	27%
% households with good access to piped water in IUA (2011)	84%
% households dependant on river water in IUA (2011)	5%

While there are fewer public nature reserves in the Kalkpan Se Loop IUA, there are a several private game ranches offering wildlife safaris and hunting experiences.

Table 9-20. Status Quo Summary for IUA 5 – Kalkpan Se Loop

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the intergranular and fractured aquifer system from the Basement Complex and Intergranular Alluvial aquifers. GUA delineated comprise of A50-4/A63-2. Average groundwater depths are 20 to 26 mbgl with average blow yields of 1.5 to 2.0 L/s.

ASPECT	DESCRIPTION
	Registered groundwater use is ~5 Mm^3/a and can be regarded as underutilised. While the groundwater potential of the GUA is high monitoring stations show a decline of 3 to 5 m in groundwater levels since 2010, which can relate to a localised to regional impact. A50-4/A63-2 is of moderate to poor quality with notable element of concern NO_3 as N. Groundwater samples indicate a Ca/Mg-HCO3 and Ca/Mg/Cl water type.
Surface water	This IUA is non-perennial and very dry. Total current day flow is 6.0 Mm^3/a and water-use is 1.8 Mm^3/a.
Water Quality	There are no DWS water quality monitoring points in this IUA. Rivers are probably nonperennial and could exhibit fluctuations in salinity as rivers and Pools dry up in response to evaporation losses.
Rivers	The non-perennial tributaries, including the Kalkpan se Loop in quaternary catchment A50J, are assigned full FEPA status, with a B PES Category, and an unnamed tributary assigned a high Ecological Importance (EI). The rivers in this IUA are all non-perennial and occur within the Limpopo Plain Level I Ecoregion. Private Nature Reserves, as well as an opencast diamond mine occur in this IUA.
Wetlands	HGM (% in IUA): Channelled valley bottoms 0.0 Depressions 49.5 Floodplains 0.0 Riverine 50.5 Seeps 0.0 Unchannelled valley bottoms 0.0 Wetland Condition (% in IUA): A/B 42.2 C 3.7 D/E/F 3.6 N/A 50.5

9.9 IUA 6: Upper Sand

The Upper Sand IUA lies in the Polokwane (55%) and Molemole (43%) Local Municipalities within the Capricon District Municipality. A significant proportion of the IUA is made up of former homeland areas. The IUA also includes the city of Polokwane. Almost one quarter of the total study area population resides within the Upper Sand IUA. The population here increased by 151% since 1996. The unemployment rate has reduced slightly (less 9%) since 1996.

The Upper Sand IUA covers an area of about 494 000 ha. Natural cover is relatively low at 57.9%. Agriculture covers 20.1% of the area, 10.1% of which is used for commercial cultivation and is mainly a mix of pivot irrigated and rain-fed dryland. Fallow land is also relatively extensive (9.7%). The Upper Sand IUA also has the second largest extent of residential area (10.6%) (Figure 9-7).

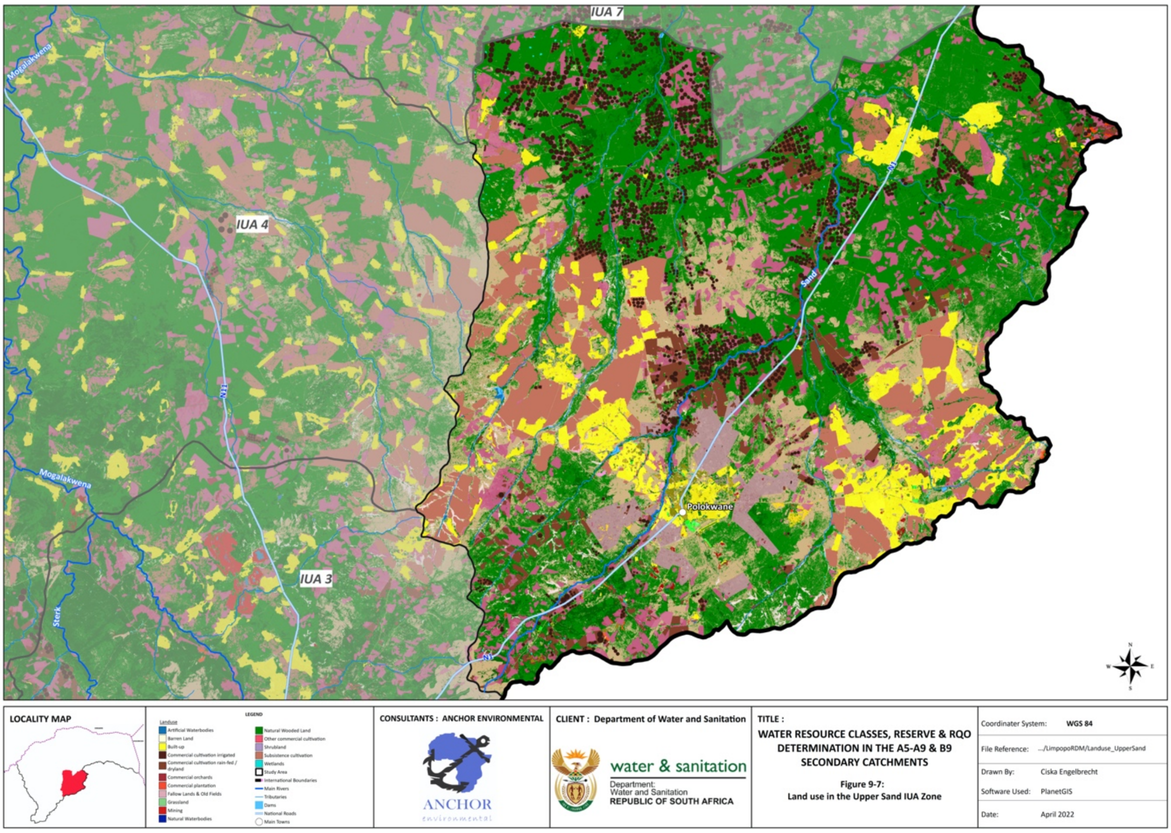

Figure 9-7. Land use in the Upper Sand IUA. Source: DEA, National Land Cover 2020.

The Upper Sand made the greatest contribution (38.4%) to the study area GVA in 2016. Economic activity was more diverse in this IUA with three sectors (Wholesale and retail trade, catering and accommodation sector, finance, insurance, real estate and business services sector, and community, social and government services sector) making a significant contribution to total GVA, 83% in total (Table 9-21).

Table 9-21. GVA per sector in 2016 (R million, nominal 2016 prices) for Upper Sand IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	450.1	1%
Mining and Quarrying	281.2	1%
Manufacturing	1 252.6	4%
Electricity, Gas and Water	909.6	3%
Wholesale and Retail Trade, Catering & Accommodation	8 175.6	24%
Transport, Storage and Communication	2 824.8	8%
Finance, Insurance, Real Estate and Business Services	10 280.8	30%
Community, Social and Government Services	10 095.8	29%

	34 270.4	

The Upper Sand IUA also had the highest number of employed persons (192 917) in the study area. Despite the finance and business services sector making the greatest contribution to GVA in the IUA, it only employed 32 184 (17%) people. The community, social and government services sector which made a similar contribution to GVA employed 92 750 (48%) people. Many people were also employed in the wholesale and retail trade, catering and accommodation (31 728 or 16%) and manufacturing (17 219 or 9%) sector.

Table 9-22. The total area of irrigated crops in the Upper Sand IUA

Irrigated crop	Area (ha)
Cereals and other field crops	653
Vegetables	5 458
Citrus fruit	52
Subtropical fruit	155
Apples and Peaches	94
Table grapes	0
Nuts	213
Total	6 625

Table 9-23. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	752 613
Average annual household income (2011)	R98 014
% poor households in IUA (2011)	20%
% unemployed in IUA (2016)	30%
% households with good access to piped water in IUA (2011)	73%
% households dependant on river water in IUA (2011)	1%

There are a few protected areas, for example Capricon Private Nature Reserve, Turfloop Nature Reserve and Machaka Protected Environment and the Moletzie bird sanctuary located along rivers in the Upper Sand IUA.

Table 9-24. Status Quo Summary for IUA 7 – Upper Sand

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the intergranular and fractured aquifer system associated with the Limpopo Mobile Belt as well as local intergranular alluvial aquifers. GUA delineated comprise of A71-1, A71-2, and A71-3. The latter two GUAs straddles the Upper Sand and Lower Sand IUAs.

ASPECT	DESCRIPTION
	Average groundwater depths are 16 to 26 mbgl with average blow yields of 2.4 to 4.9 L/s. Registered groundwater use is ~72 Mm^3/a and can be regarded as heavily exploited. The groundwater potential of the GUAs is considered high. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Despite the groundwater fluctuation observed most groundwater levels show a neutral to declining trend. Especially during poor recharge seasons.
Surface water	Current day flow is 47.1 Mm^3/a. This is greater than the natural flow of 35.4 Mm^3/a due to transfers of 24.7 Mm^3/a into the catchment. Flow is perennial largely due to these transfers. Water-use is 13.0 Mm^3/a.
Water Quality	Most of the sampling points in the Sand River were concentrated in the upper catchment, on the Sand River and Bloedrivier within the urban areas of Polokwane and Seshego. Their water quality therefore reflects the impacts of urban runoff, agricultural return flows upstream of Polokwane. At many of these sampling points high salts were recorded, high phosphate concentrations and elevated pH values, often in Unacceptable categories. High unionised ammonia concentrations were also recorded in the Sand and Bloedrivier downstream of WWTW discharge points.
Rivers	Most of the Sand River catchment is considered an upstream FEPA, excluding the Hout River which is assigned Phase 2 FEPA status. The Sand River and its tributaries in quaternary catchments A71A and A71F is classified as a Strategic Water Source Area. The upper Sand River is assigned a high EI. The mainstem Sand River and many of its tributaries are perennial in nature, with the Strydomsloop and Turfloop non-perennial.
Wetlands	<u>HGM (% in IUA):</u> Channelled valley bottoms 1.5 Depressions 1.1 Floodplains 0.0 Riverine 45.3 Seeps 0.1 Unchannelled valley bottoms 52.0 <u>Wetland Condition (% in IUA):</u> A/B 0.7 C 0.2 D/E/F 53.9 N/A 45.3

9.10 IUA 7: Lower Sand

The Lower Sand IUA falls within two district municipalities (Capricon and Vhembe) and four local municipalities (Blouberg, Makhado, Molemole and Musina). The towns Makhado and Musina lie in the south and north respectively. A small proportion of the IUA is made up of former homeland areas. Almost 10% of the total study area population resides in the Lower Sand IUA. While most of the area is sparse rural, population density is high around the larger towns (Makhado and Musina) and former homeland areas of the IUA.

The Lower Sand IUA has the second largest extent of natural cover in the study area. While just 6% of area is used for commercial cultivation, this IUA has the most extensive area of commercial irrigated crops. The Lower Sand also has the largest area (8% of its total area) of fallow land in the study area. Relatively little area is used for subsistence farming (1.7%). Almost 3% is built-up area (Figure 9-8).

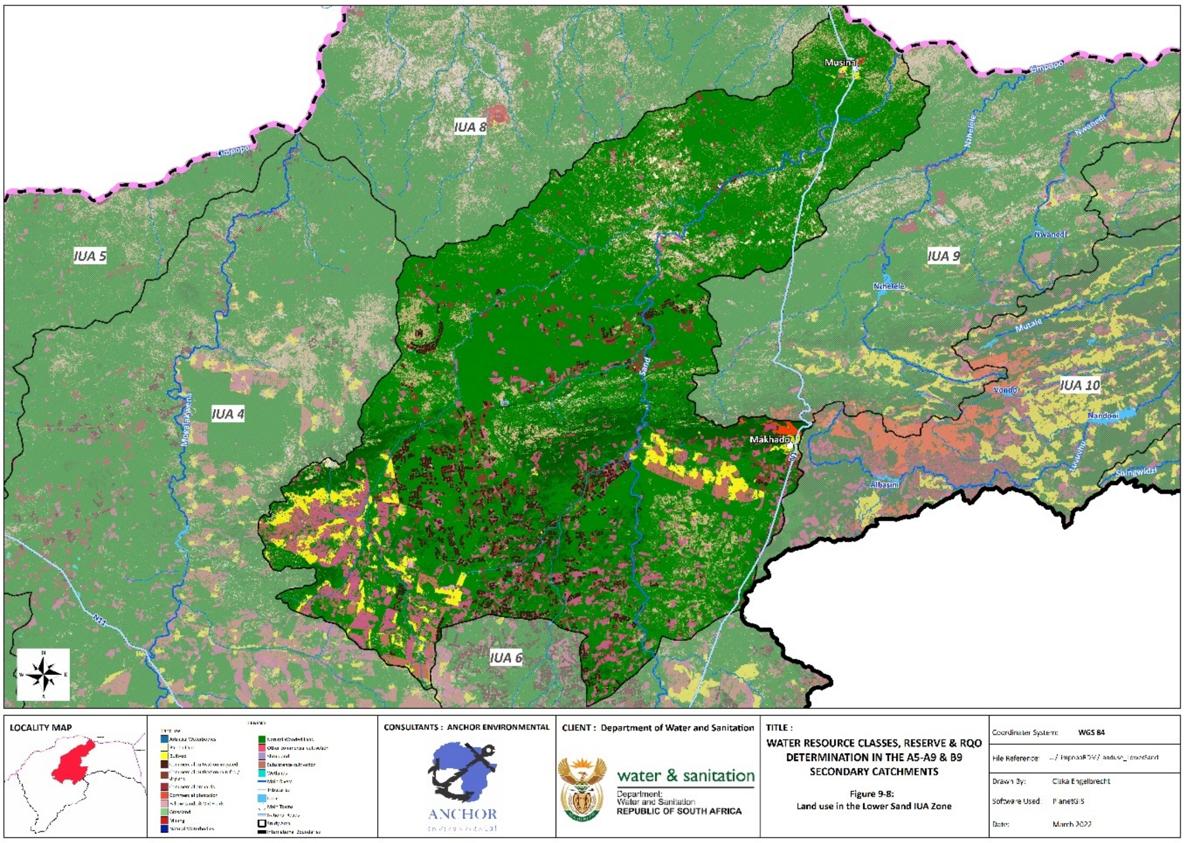

Figure 9-8. Land use in the Lower Sand IUA. Source: DEA, National Land Cover 2020.

The Lower Sand had the third highest GVA and contributed 13.6% to the study area's GVA in 2016. While primary production sectors make a very small contribution to GVA, others such as the wholesale and retail Trade, catering and accommodation sector, finance and business services sector, and community, social and government service sectors combined made a 78% contribution (Table 9-25).

The Lower Sand IUA made a significant contribution in terms of employment in the study area, employing 64 136 people. Most people were employed in either the community, social and government services sector (30%) or the wholesale and retail trade, catering and accommodation sector (9%). Primary sectors like mining and quarrying (6%) and agriculture, forestry and fishing (4%) employed relatively fewer people.

Table 9-25. GVA per sector in 2016 (R million, nominal 2016 prices) for Lower Sand IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	201.9	2%
Mining and Quarrying	344.3	3%
Manufacturing	438.6	4%
Electricity, Gas and Water	214.7	2%
Wholesale and Retail Trade, Catering & Accommodation	3647.6	35%
Transport, Storage and Communication	1046.1	10%
Finance, Insurance, Real Estate and Business Services	2299.5	22%
Community, Social and Government Services	2141.1	21%
	10333.9	

Table 9-26. The total area of irrigated crops in the Lower Sand IUA.

Irrigated crop	Area (ha)
Cereals and other field crops	315
Vegetables	4 082
Citrus fruit	184
Subtropical fruit	149
Apples and Peaches	0
Table grapes	0
Nuts	5 419
Total	10 149

Table 9-27. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011)

Total population	317 503
Average annual household income	R70 107
% poor households in IUA	20%
% unemployed in IUA	28%
% households with good access to piped water in IUA	60%
% households dependant on river water in IUA	3.1%

There are many protected areas in the Lower Sand IUA, most of which are located along the main rivers. The Brak river cuts through the Blouberg Nature Reserve which is in the central section of the IUA. In the north near the town of Musina is, among others the Boabab and Musina Nature Reserves which the Sand River cuts through. There are many lodges, especially in south around Leshaba

Wilderness Reserve and Happy Rest Nature Reserve. There is great potential to develop the sustainable ecotourism sector in the Musina Municipality part of the IUA (Ramaano, 2021).

Table 9-28. Status Quo Summary for IUA 8 – Lower Sand

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the intergranular and fractured aquifer system associated with the Limpopo Mobile Belt, Fractured aquifers associated with the Soutpansberg Group and Karoo Supergroup, as well as local intergranular alluvial aquifers. GUA delineated comprise of A71-2, A71-3, A71-4, and A71-5. However, the GUAs A71-2 and A71-3) straddles the Upper Sand and Lower Sand IUAs. Average groundwater depths are 16 to 27 mbgl with average blow yields of 1.3 to 4.9 L/s. Registered groundwater use is ~83 Mm^3/a and can be regarded as heavily exploited. The groundwater potential of the GUAs is considered high. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Groundwater levels show a decreasing trend during poor recharge seasons. Groundwater quality in the Lower Sand region is moderate to poor with notable elements of concern include NO_3 as N and Chloride. Groundwater samples indicate water types varying from a Ca/Mg-HCO_3 to a Na-Cl dominance.
Surface water	This IUA is characterised by intermittent flow. Current day flow from this IUA is 45.1 Mm^3/a and water-use is 9.9 Mm^3/a.
Water Quality	The lower reaches of the Sand River is poorly monitored with most sampling points located downstream of WWTW outflows. This is probably in response to the nonperennial nature of the lower reaches and the general absence of surface flows to sample.
Rivers	Most of the rivers in the IUA are assigned as upstream FEPA rivers, with only one section of the mainstem Sand River and a portion of the non-perennial Brakspruit assigned full FEPA status. Three non-perennial tributaries of the lower Sand River, including the Moleletsane River, are assigned a B PES. Sections of the lower Sand River and a portion of the non-perennial Brak River tributary and the Moletsane River tributary, are considered ecologically important and are assigned a high EI.
Wetlands	<u>HGM (% in IUA):</u> Channelled valley bottoms 1.7 Depressions 5.9 Floodplains 0.0 Riverine 12.6 Seeps 4.4 Unchannelled valley bottoms 75.4

ASPECT	DESCRIPTION
	Wetland Condition (% in IUA): A/B 3.7 C 1.8 D/E/F 81.9 N/A 12.6

9.11 IUA 8: Mapungubwe

Almost all of the Mapungubwe IUA falls within the Musina Local Municipality along the SA-Botswana and SA-Zimbabwe border. The Mapungubwe IUA is generally sparsely populated. In 2016 there were 14 625 people living here, almost double the population since 1996. Population density was greatest along the South African border. Despite the increase in unemployment (1% to 16% between 1996 and 2011), the proportion of poor households had reduced from 26% to 13% between 1996 and 2011.

The Mapungubwe IUA covers an area of approximately 377 000 ha. This IUA has the second highest cover of natural land (91.6%). Only 3.2% is used for commercial cultivation, most of which is situated along the Limpopo River in the north. There was no evidence of subsistence cultivation, and the Mapungubwe IUA has the smallest extent of built-up cover in the study area (0.1%). This IUA also has the least amount of fallow land and old fields (0.8%). The Venitia Diamond Mine is a large mine situated in the middle of the IUA (Figure 9-9).

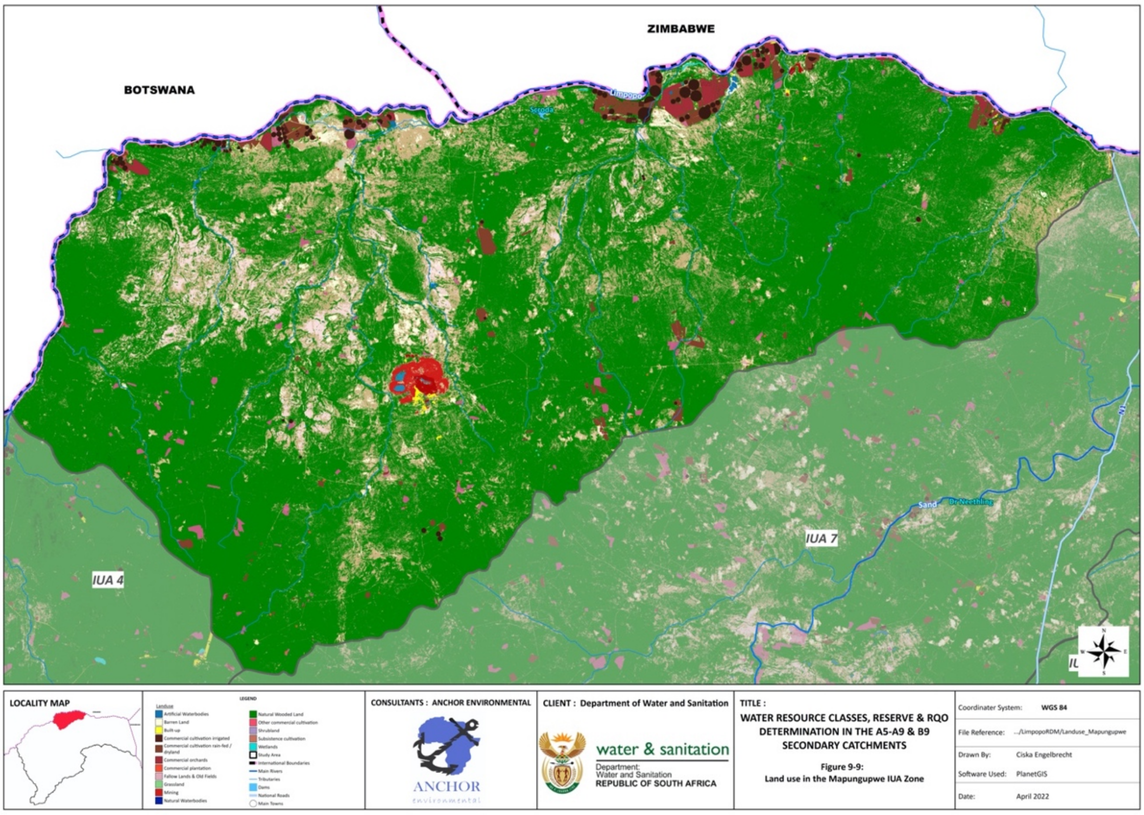

Figure 9-9. Land use in the Mapungubwe IUA. Source: DEA, National Land Cover 2020.

The Mapungubwe IUA only made a 0.6% contribution to the study areas GVA in 2016. Of the R527 million, the majority was from the primary production sector of mining (31%; Table 9-29). The Mapungubwe IUA also has far fewer (4801) employed persons than most other IUAs. Of the primary sectors, mining and quarrying employed the most people (45%).

Table 9-29. GVA per sector in 2016 (R million, nominal 2016 prices) for Mapungubwe IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	57.4	10%
Mining and Quarrying	179.2	31%
Manufacturing	28.8	5%
Electricity, Gas and Water	31.9	6%
Wholesale and Retail Trade, Catering & Accommodation	107.5	19%
Transport, Storage and Communication	57.1	10%
Finance, Insurance, Real Estate and Business Services	0	0%
Community, Social and Government Services	112.7	20%
	572.0	

Table 9-30. The total area of irrigated crops in the Mapungubwe IUA

Irrigated crop	Area (ha)
Cereals and other field crops	603
Vegetables	1 221
Citrus fruit	4 871
Subtropical fruit	84
Apples and Peaches	0
Table grapes	0
Nuts	22
Total	6 802

Table 9-31. Summary of population, income, living conditions and reliance on surface water. Source: StatsSA Census 2011, StepSA 2018.

Total population (2016)	14 625
Average annual household income (2011)	R66 612
% poor households in IUA (2011)	13%
% unemployed in IUA (2016)	19%
% households with good access to piped water in IUA (2011)	69%
% households dependant on river water in IUA (2011)	12%

The Mapungubwe IUA includes several nature reserves and a major national park. The Mapungubwe Cultural Landscape World Heritage Site (MCLWHS) (incl. Mapungubwe National Park) which is located in the Mapungubwe IUA, is a well-known heritage site. While the Mapungubwe National Park makes up the core area, surrounding reserves (Vhembe Nature Reserve, Venetia -Limpopo Reserve and Limpopo Valley Game Reserve), other private land makes up the buffer zone. Currently, games farms in Mapungubwe area are planning to facilitate large-scale eco-tourism operations (DFFE 2014). In addition, there is the proposed Vhembe Biosphere Reserve which includes the Limpopo Valley Conservancy and the Western Soutmansberg Conservancy expected near the Mapungubwe National Park (Vhembe district Municipality 2021).

Table 9-32. Status Quo Summary for IUA 6 – Mapungubwe

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the Fractured aquifers associated with the Karoo Supergroup and Soutpansberg Group. Intergranular Alluvial aquifers from the Limpopo River are recharged during periods of high stream-flows as well as during the rainfall season and is associated with high yielding potential. GUA delineated comprise of A63-3/71-3. Average groundwater depths are 19 mbgl with average blow yields of 1.3 L/s.

ASPECT	DESCRIPTION
	Registered groundwater use is ~46 Mm^3/a and can be regarded as heavily-utilised. Groundwater levels show a strong response to significant recharge events with a decreasing trend during poor recharge seasons. Limited groundwater quality data is available for the GUA.
Surface water	This IUA is non-perennial and very dry. Total current day flow is 7.8 Mm^3/a and water-use is 3.2 Mm^3/a.
Water Quality	There are no DWS water quality monitoring points in the Mapungupwe IUA. The rivers are probably ephemeral in nature and could exhibit wide fluctuations a salinity, with moderate salinities observed when there is flow, and it would increase when flow stops and pools start to form. As water evaporates, salinity would increase as constituents are progressively concentrated in a smaller volume of water. Suspended sediment concentrations would be high when there is runoff and it would decrease with a reduction in flow. Pools would probably have high clarity. The impacts of extensive irrigation next to the Limpopo River would be evident in the Limpopo River and short river reaches that receive irrigation return flows.
Rivers	The Setongi, Kongoloop and Soutsloot are assigned full FEPA status, with the Stinkwater and two unnamed tributaries assigned Phase 2 FEPA status. The Kongoloop and Lower Soutsloot Rivers are assigned A PES Categories, meaning that they are considered unmodified/natural in ecological condition. Many of the tributaries including the Stinkwater, Setonki and Setoka Rivers are assigned a B PES Category. Most of the rivers are assigned a high EI. Various nature reserves including the Mapungubwe National Park occur in the IUA. Mining has a potential negative impact on the ephemeral rivers in this IUA.
Wetlands	<u>HGM (% in IUA):</u> Channelled valley bottoms 0.9 Depressions 2.3 Floodplains 4.7 Riverine 87.1 Seeps 5.0 Unchannelled valley bottoms 0.0 <u>Wetland Condition (% in IUA):</u> A/B 2.7 C 4.5 D/E/F 5.8 N/A 87.1

9.12 IUA 9: Nzhelele / Nwanedi

This Nzhelele/Nwanedi IUA falls within the Vhembe District Municipality and Makhado and Musina Local Municipalities. The town Makhado lies in the southern part of the IUA while the northern part borders the town of Musina. In 2016, there were 224 066 people living in this IUA. Population density was greatest in the former homeland area which makes up about half of the IUA. Both unemployment and the proportion of poor households declined slightly between 1996 and 2011.

The Nzhelele/Nwanedi IUA is 423 000 ha in size and 85.6% of its land area is natural. Approximately 3.1% of land is used for commercial cultivation, most of which is situated along the main Nzhelele and Nwanedi rivers that cross this IUA. The majority of the commercial crops in this IUA are citrus. Some subsistence activity (2.3%) takes place and only 3.4% is built-up area (Figure 9-10).

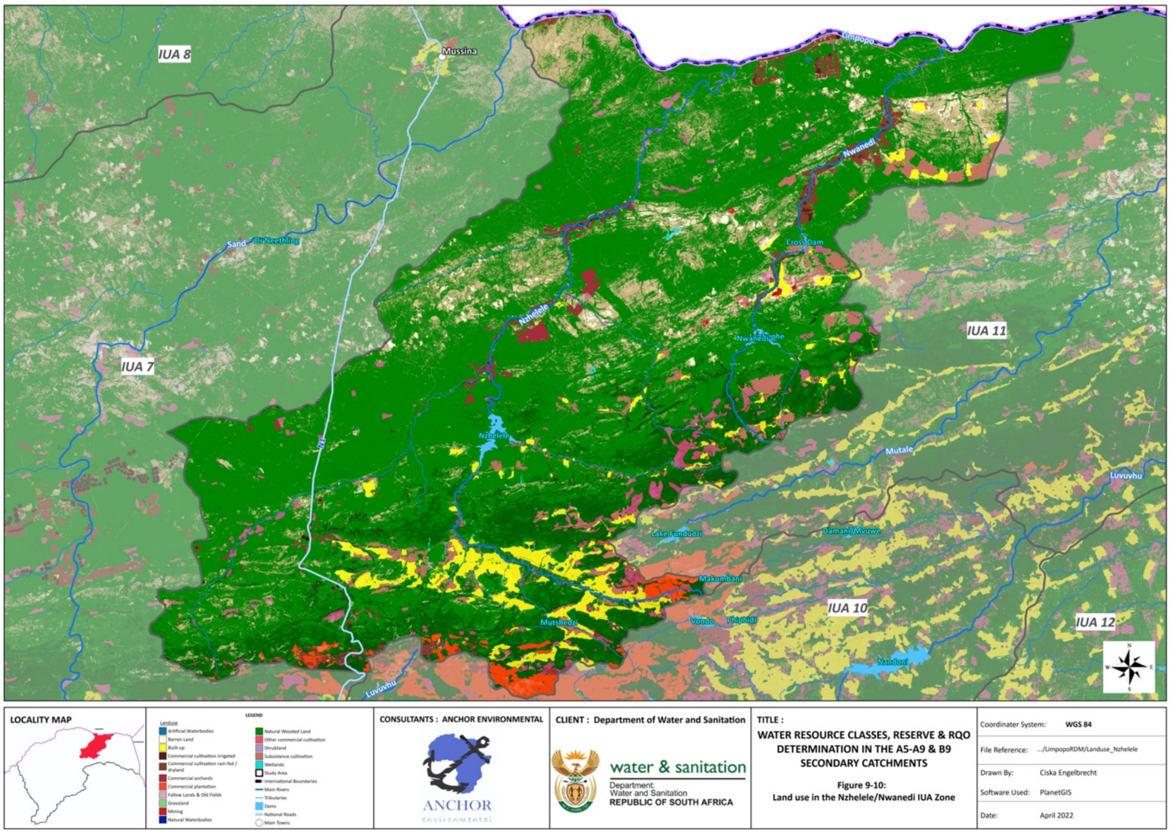

Figure 9-10. Land use in the Nzhelele / Nwanedi IUA. Source: DEA, National Land Cover 2020.

The Nzhelele/Nwanedi IUA contributed 3.8% to the study area’s GVA in 2016, with the majority coming from the community, social and government services sector and the agriculture, forestry and fisheries sector (Table 9-33). A considerable number of people were employed (39 765) in this IUA, with most being employed in the community, social and government services sector (62%) and the agriculture, forestry and fisheries sector (24%).

Table 9-33. GVA per sector in 2016 (R million, nominal 2016 prices) for Nzhelele/Nwanedi IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	457.8	14%
Mining and Quarrying	39.2	1%
Manufacturing	8.9	0%
Electricity, Gas and Water	105.6	3%
Wholesale and Retail Trade, Catering & Accommodation	284.1	8%
Transport, Storage and Communication	34.1	1%
Finance, Insurance, Real Estate and Business Services	375.8	11%
Community, Social and Government Services	2 079.9	61%
	3 385.2	

Table 9-34. The total area of irrigated crops in the Nzhelele/Nwanedi IUA

Irrigated crop	Area (ha)
Cereals and other field crops	74
Vegetables	154
Citrus fruit	4 745
Subtropical fruit	473
Apples and Peaches	0
Table grapes	0
Nuts	52
Total	5 497

Table 9-35. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	224 066
Average annual household income (2011)	R54 562
% poor households in IUA (2011)	21%
% unemployed in IUA (2016)	34%
% households with good access to piped water in IUA (2011)	41%
% households dependant on river water in IUA (2011)	8%

Although fewer in number than in some of the other IUAs there are several nature reserves as well as the Nwanedi National Park in the Nzhelele/Nwanedi IUA. Almost all of these protected areas are situated along the Nzhelele and Nwanedi rivers.

Table 9-36. Status Quo Summary for IUA 9 – Nzhelele / Nwanedi

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the Fractured aquifers associated with the Soutpansberg Group and Karoo Supergroup, the Basement Complex as well as local intergranular alluvial aquifers. GUA delineated comprise of A81-1, A81-2, and A81-3. Average groundwater depths are 15 to 20 mbgl with average blow yields of 1.5 to 3.4 L/s. Registered groundwater use is ~20 Mm^3/a and can be regarded as moderately exploited. The groundwater potential of the GUAs is considered moderate. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Despite the groundwater fluctuation observed, most groundwater levels show a neutral trend with a few stations showing a decline of around 3 to 8 m which can relate to a localised impact. Groundwater quality in the Nzhelele / Nwanedi region is acceptable to moderate with notable elements of concern include Chloride. Groundwater samples indicate water types varying from a $Ca/Mg\text{-}HCO_3$ to a Na-Cl dominance.
Surface water	Flow is classified as perennial rivers although there is minimal flow in the lower reaches during the dry season. Current day flow for this IUA is 106 Mm^3/a and water-use is 34 Mm^3/a.
Water Quality	Water quality in the Mutshedzi River is in an Ideal category except some elevated phosphates (Acceptable category). In the Tshitavha River, a tributary of the Mutshedzi River, water quality is in an Ideal category except for elevated phosphates (Acceptable category). These rivers are surrounded by villages and subsistence agriculture close to the river. Grey water runoff and agricultural seepage could account for the elevated nutrient concentrations in the rivers. In catchment A80B of the Nzhelele River water quality is in a poorer state. Salts are elevated in Acceptable and Tolerable categories, elevated pH values occur (Unacceptable category) and elevated phosphate concentrations are recorded (median in an Acceptable category, 95^{th} percentile in an Unacceptable category). Here the Nzhelele River is surrounded by villages and subsistence agriculture up to the edge of the river. Grey water runoff and agricultural seepage could account for the elevated salt and nutrient concentrations in the rivers. Water quality in Nzhelele Dam has slightly elevated salt concentrations in an Acceptable category, elevated pH values in Acceptable/Tolerable categories and elevated phosphate concentrations, mostly in an Acceptable category but infrequently elevated to an Unacceptable category. Chlorophyll *a* data indicate that Nzhelele Dam is consistently in an Oligotrophic state. Luphephe Dam generally has good water quality (Ideal category) with low salinity although elevated phosphate concentrations have been observed that was classified in an Acceptable category but high concentrations

ASPECT	DESCRIPTION
	occurring from time to time. Chlorophyll *a* data indicate that the dam is consistently in an Oligotrophic state (unenriched with nutrients). Nwanedzi Dam on the Nwanedi River (A8R003Q01) is in a similar water quality state as Luphephe Dam.
Rivers	Two tributaries of the Nzhelele River are assigned full FEPA status, namely the non-perennial Mufungudi and Tshishiru Rivers, as well as the non-perennial Luphephe River in the Soutpansberg. The Nwanedi River is classified as a Fish Support Area, with the upper section of the river non-perennial in nature. Sections of the Catchment are classified as high EI and high ES, with the upper Mutamba River classified as very high ES. A small tributary of the Mutamba River in quaternary catchment A80F and a tributary of the Nzhelele in quaternary catchment A80G are in a B PES Category, with the remainder of the catchment mostly in C and D PES Categories. Two sites with recent macroinvertebrate data, were assigned a B/C Ecological Category when conducting the MIRAI (C. Thirion, *Pers. Comm.,* March 2022), namely the REMP (River Ecostatus Monitoring Programme) sites A8LUPH-GUMEL on the Luphephe River and site A8NWAN-GORGE, on the Nwanedi River. Numerous instream dams, forestry and coal mining, as well as densely populated areas, have a negative impact on the ecological integrity of the rivers in this IUA.
Wetlands	<u>HGM (% in IUA):</u> Channelled valley bottoms 21.4 Depressions 4.5 Floodplains 0.0 Riverine 19.6 Seeps 3.1 Unchannelled valley bottoms 51.3 <u>Wetland Condition (% in IUA):</u> A/B 0.3 C 0.8 D/E/F 79.3 N/A 19.6

9.13 IUA 10: Upper Luvuvhu

The majority of the Upper Luvuvhu IUA falls within Thulamela and Makhado and a small extent in Collins Chabane Local Municipalities in the Vhembe District Municipality. The IUA also borders the town of Makhado. The Upper Luvuvhu is densely populated with 28% of the study area population living here. Density is greatest in the former homeland areas, which cover a large proportion of the IUA. Both unemployment and the proportion of poor households declined by 6% and 7%, respectively between 1996 and 2011.

The Upper Luvuvhu IUA is approximately 226 000 ha in size. This IUA has smallest extent of natural cover (47.9%) and the largest extent of commercial cultivation (14.8%) and forestry (8.7%) of the study area. Almost all commercial cultivation is permanent orchards (7.0%) and irrigated crops (7.1%). About 10.6% of land remains fallow, which is again the largest extent of the IUAs in the study area. A significant proportion (16.1%) is residential built-up area. The Upper Luvuvhu IUA also has the second largest residential extent (16 500 ha; Figure 9-11).

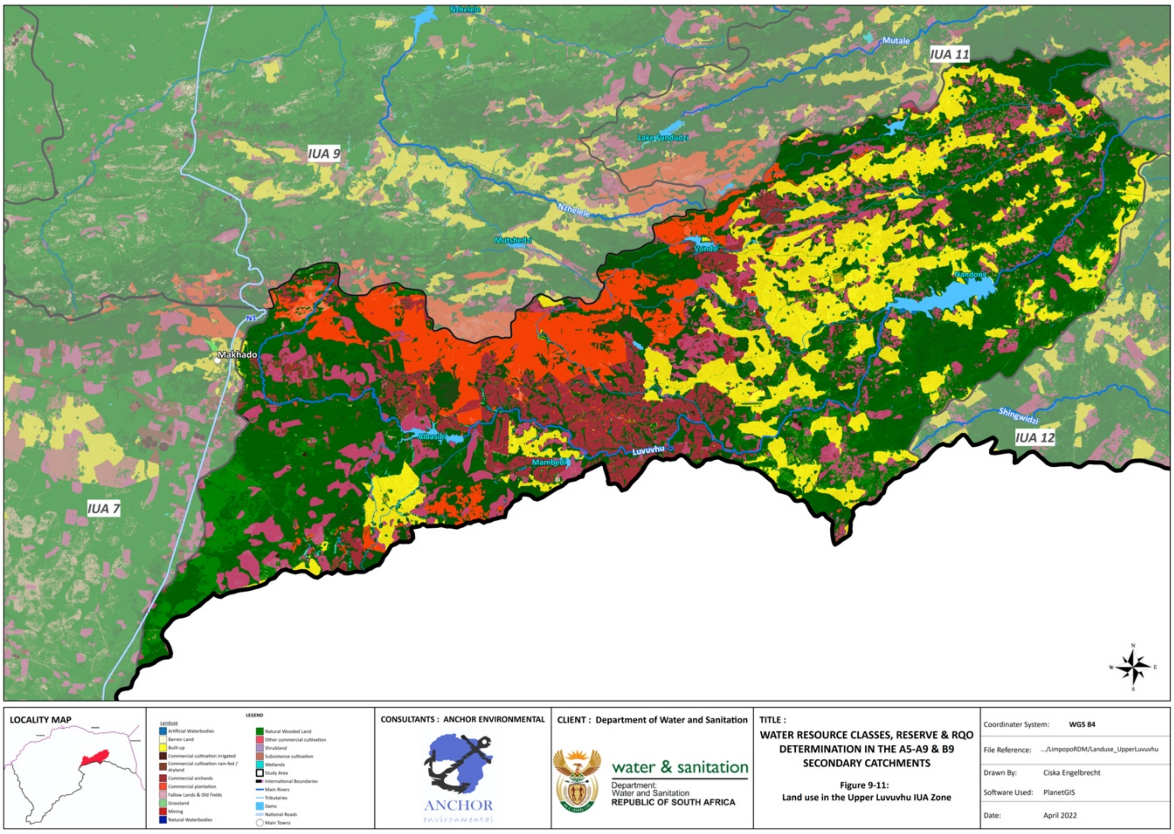

Figure 9-11. Land use in the Upper Luvuvhu IUA. Source: DEA, National Land Cover 2020.

The Upper Luvuvhu made the second largest contribution (20.3%) to study area GVA in 2016. The agriculture, forestry and fishing sector only made up 3% of the Upper Luvuvhu's GVA. The community, social and government services sector (38%), the wholesale and retail trade, catering and accommodation sector (27%) and finance, insurance, real estate and business services sector (22%) contributed the most to GVA in this IUA (Table 9-37).

Table 9-37. GVA per sector in 2016 (R million, nominal 2016 prices) for Upper Luvuvhu

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	470.6	3%
Mining and Quarrying	2.7	0%
Manufacturing	247.4	1%
Electricity, Gas and Water	706.1	4%
Wholesale and Retail Trade, Catering & Accommodation	4 883.6	27%
Transport, Storage and Communication	947.8	5%
Finance, Insurance, Real Estate and Business Services	3 978.9	22%
Community, Social and Government Services	6 922.2	38%
	18 159.3	

The Upper Luvuvhu IUA has the second highest number of employed persons (121 295) in the study area. Most of these people (48%) are employed in the community, social and government services sector and 26% are employed in the wholesale and retail trade, catering and accommodation sector. Only 6% are employed in the agriculture, forestry and fishing sector.

Table 9-38. The total area of irrigated crops in the Upper Luvuvhu IUA

Irrigated crop	Area (ha)
Cereals and other field crops	1
Vegetables	6
Citrus fruit	444
Subtropical fruit	4 299
Apples and Peaches	0
Table grapes	0
Nuts	50
Total	4 800

Table 9-39. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	748 968
Average annual household income (2011)	R67 098
% poor households in IUA (2011)	21%
% unemployed in IUA (2016)	37%
% households with good access to piped water in IUA (2011)	50%
% households dependant on river water in IUA (2011)	4%

Table 9-40. Status Quo Summary for IUA 10 – Upper Luvuvhu

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the Fractured aquifers associated with the Soutpansberg Group and the Basement Complex as well as local intergranular alluvial aquifers. GUA delineated comprise of A91-1. Average groundwater depths are 16 mbgl with average blow yields of 2.9 L/s. Registered groundwater use is ~61 Mm^3/a and can be regarded as moderate to heavily exploited. The groundwater potential of the GUAs is considered moderate to high. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Despite the groundwater fluctuation observed, most groundwater levels show a neutral trend with a few stations showing a decline of around 3 to 15 m which can relate to a localised to regional impact. Groundwater quality in the Upper Luvuvhu region is acceptable. Groundwater samples indicate water types varying from a Ca/Mg-HCO_3 to a Na-Cl dominance. In the upper catchments groundwater contributes to baseflow via sub surface seepage and springs.
Surface water	A perennial IUA with a current day flow of 266 Mm^3/a and water-use of 116.8 Mm^3/a.
Water Quality	There are no water quality monitoring points in the Levuvhu River catchment upstream of Albasini Dam. The median water quality in the outflow from Albasini Dam is in an Ideal category but elevated salts in the Acceptable category are observed infrequently, as are elevated phosphate concentrations in the Unacceptable category (95^{th} percentile).. At the Luvhuvu sampling point just upstream of the headwaters of Ṋanḓoni Dam, the median water quality is an Ideal category except for salts which could increase to a Tolerable category and elevated phosphate concentrations (Acceptable & infrequent Unacceptable categories). In the Mutshinduḓi River at the Vonḓo Dam outflow, the median and 95^{th} percentile water quality is in an Ideal category although slightly elevated phosphate concentrations (Acceptable category) occur from time-to-time. In the Mutshinduḓi River upstream of the Luvhuvu confluence, water quality is in an Ideal category for all the constituents assessed.
Rivers	The upper Luvuvhu River is considered an Upstream FEPA, meaning that human activities need to be managed in order not to compromise the downstream FEPA rivers. The upper Mutshinduḓi River is assigned a Phase 2 FEPA . The entire mainstem Luvuvhu River and lower Mutale River is classified as having high ES. Most of the rivers in the IUA are assigned a D PES Category, with some assigned a C PES Category. The upper Luvuvhu, Dzindi, upper Mutshinduḓi and Mbwedi Rivers are assigned a high ES, with the Dzindi, upper Mutshinduḓi, Tshinane and Mbwedi assigned a very high ES. The mainstem Luvuvhu, including the Doringspruit tributary are assigned a high ES. Various instream dams occur in the IUA, localized

ASPECT	DESCRIPTION
	abstractions, potential dam raising and forestry all impact negatively on the river integrity in this IUA.
Wetlands	HGM (% in IUA): Channelled valley bottoms 90.5 Depressions 0.7 Floodplains 1.0 Riverine 2.7 Seeps 1.7 Unchannelled valley bottoms 3.5 Wetland Condition (% in IUA): A/B 1.3 C 0.9 D/E/F 95.1 N/A 2.7

9.14 IUA 11: Lower Luvuvhu/Mutale IUA

The Lower Luvuvhu/Mutale IUA lies in the far east of the study area and falls within the Musina and Thulamela Local Municipalities in the Vhembe District Municipality. A large proportion of this IUA, which lies outside the Kruger National Park is classified as former homeland (Venda). The IUA only includes approximately 1.5% of the study area population. The unemployment rate declined by 7%, while the proportion of poor households declined by 9%, between the period 1996 and 2011.

The Lower Luvuvhu/Mutale IUA is 384 000 ha in size, 85.9% of which is natural. Of the remaining land, 3.7% is used for subsistence farming and 4.3% is built-up residential area (Figure 9-12). Only 0.5% of the land is used for commercial cultivation.

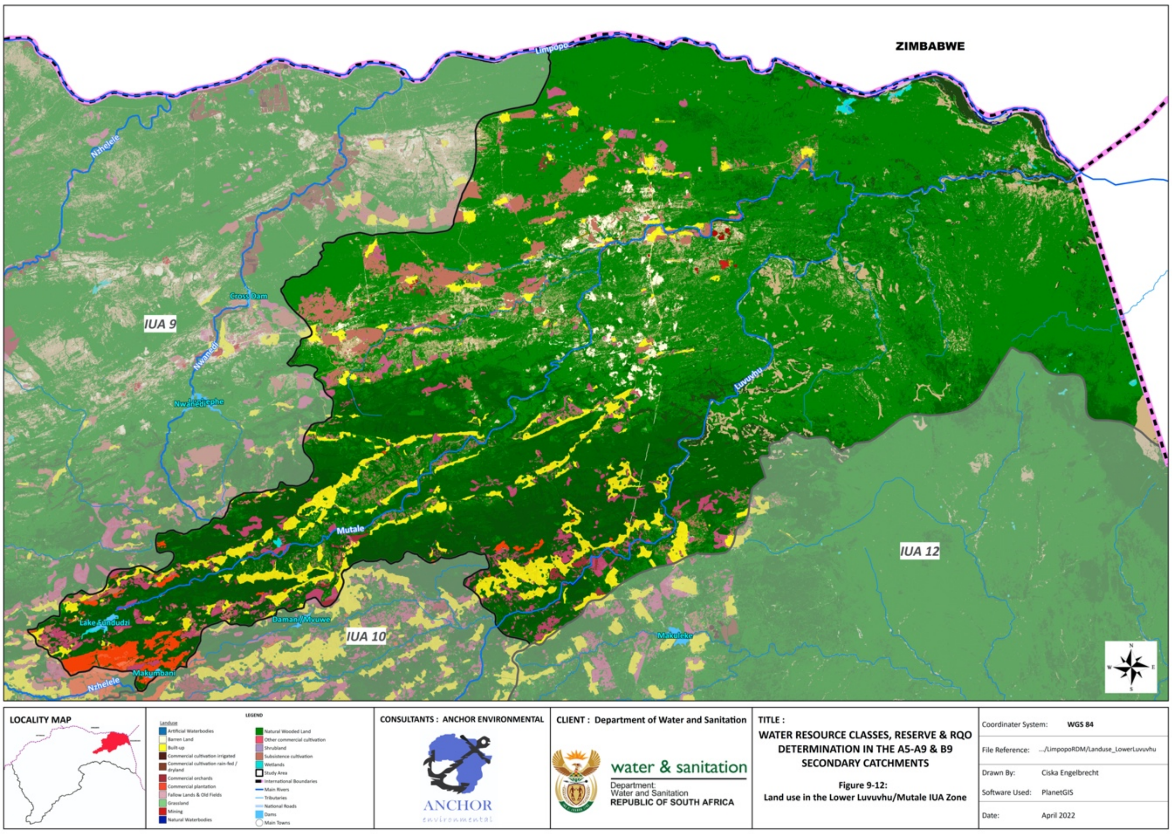

Figure 9-12. Land use in the Lower Luvuvhu/Mutale IUA. Source: DEA, National Land Cover 2020.

The Lower Luvuvhu/Mutale IUA contributed 4.5% (R3.9 billion) to the study area's GVA in 2016. The community, social and government services sector contributed the most to the IUAs GVA for 2016 (73%; Table 9-41). Unlike in the Upper Luvuvhu, there were fewer people employed (41 952) in the Lower Luvuvhu/Mutale IUA. Most people were employed in the community, social and government services (71%) sector. Others were employed in the mining and quarrying (9%) or the wholesale and retail trade, catering and accommodation (8%) sectors.

Table 9-41. GVA per sector in 2016 (R million, nominal 2016 prices) for Lower Luvuvhu/Mutale IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	150.4	4%
Mining and Quarrying	272.3	7%
Manufacturing	13.0	0%
Electricity, Gas and Water	151.4	4%
Wholesale and Retail Trade, Catering & Accommodation	196.9	5%
Transport, Storage and Communication	61.2	2%
Finance, Insurance, Real Estate and Business Services	213.6	5%
Community, Social and Government Services	2 918.0	73%
	3 976.9	

Table 9-42. The total area of irrigated crops in the Lower Luvuvhu/Mutale IUA

Irrigated crop	Area (ha)
Cereals and other field crops	0
Vegetables	0
Citrus fruit	9
Subtropical fruit	83
Apples and Peaches	0
Table grapes	0
Nuts	0
Total	91

Table 9-43. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011, StepSA 2018)

Total population (2016)	298 930
Average annual household income (2011)	R47 648
% poor households in IUA (2011)	26%
% unemployed in IUA (2016)	41%
% households with good access to piped water in IUA (2011)	28%
% households dependant on river water in IUA (2011)	14%

Nature-based tourism is very important in this IUA. In addition to existing activities and infrastructure, there is potential to expand tourism in the Lower Luvuvhu/Mutale, this is associated with the Pafuri Tourism Node (Vhembe district Municipality 2021). In this IUA there is the Awelani Eco Lodge, which the government recently invested R50 million towards the development and upkeep of the lodge. The lodge is owned by the Mutele Community. Its proximity to the Kruger National Park also increases in tourism potential (DFFE, 2020). Lake Fundudzi is a sacred Venda site in the Nzhelele valley. There are also unique waterfalls in the Upper Luvuvhu/Mutale IUA.

Table 9-44. Status Quo Summary for IUA 11 – Lower Luvuvhu/Mutale

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the Fractured aquifers associated with the Soutpansberg Group and Karoo Supergroup, the Basement Complex as well as local intergranular alluvial aquifers. GUA delineated comprise of A91-2. However, the GUA A91-2 straddles the Upper Luvuvhu/Mutale and the Lower Luvuvhu IUAs. Average groundwater depths are 14 mbgl with average blow yields of 3.6 L/s. Registered groundwater use is ~3.7 Mm^3/a and can be regarded as underutilised. The groundwater potential of the GUAs is considered low to moderate.

ASPECT	DESCRIPTION
	Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Despite the groundwater fluctuation observed, most groundwater levels show a neutral trend with a few stations showing a decline of around 5 to 20 m which can relate to a localised to regional impact. Groundwater quality in the Lower Luvuvhu region is acceptable. Groundwater samples indicate water types varying from a Ca/Mg-HCO_3 to a Na-Cl and Ca/Mg-Cl type.
Surface water	Perennial river with a current day flow of 176.8 Mm^3/a and water-use of 15.0 Mm^3/a..
Water Quality	Water quality in the upper Mutale River is in an Ideal category except for elevated phosphate concentrations. In the Sambandou River at Tshitavha Village Bridge, a tributary of the middle Mutale River, all constituents assessed are in an Ideal category except for slightly elevated phosphate concentrations. In the lower Mutale River, water quality is in an Ideal category for salts but for elevated phosphate concentrations (median Acceptable and 95th percentile in an Unacceptable category). In the Mutale River just upstream of the confluence with the Luvuvhu River, at water quality is in ideal category and only slightly elevated phosphate concentrations are recorded in an Acceptable category. In the lower Luvuvhu River at Pafuri (Kruger National Park) water quality is in ideal category and only slightly elevated phosphate concentrations are recorded in an Acceptable category
Rivers	The lower Luvuvhu and Mutale Rivers are assigned full FEPA status, with the Mbodi and Tshipise Rivers assigned Fish Support FEPA status. The lower Luvuvhu River in quaternary A91J and A91K have unnamed tributaries in a B PES Category, with the lower Luvuvhu in an A PES Category before it enters the Limpopo River. This section of the river is a floodplain wetland system, the Makuleke Wetland and Pafuri floodplain. Sections of the lower Luvuvhu catchment in quaternary catchments A91H, A91J and A91K comprise a Strategic Water Source Area. The lower Luvuvhu River and lower Mutale Rivers are considered rivers of high EI, with the upper Mutale classified as having a very high ES.
Wetlands	HGM (% in IUA): Channelled valley bottoms 66.1 Depressions 5.6 Floodplains 0.0 Riverine 0.2 Seeps 14.7 Unchannelled valley bottoms 13.5 Wetland Condition (% in IUA): A/B 1.3 C 45.8 D/E/F 52.8 N/A 0.2

9.15 IUA 12: Shingwedzi

The majority of the Shingwedzi IUA falls within the Collins Chabane Local Municipality. Only a small proportion of the IUA lies in the Greater Giyani Local Municipality. About 22% of the IUA is made up of former homeland area. Just 7% of the total study area population resides in the Shingwedzi IUA. Despite its relatively large area (in contrast to some other IUAs), the large majority of the people live in the western part of the IUA (mainly in the former homeland), outside of the Kruger National Park. Between 1996 and 2011, the unemployment rate increased by 7% but the proportion of poor households declined by 8%. While figures for the proportion of poor households are unavailable for 2016, the employment rate has reportedly declined by 30% since 2011.

This IUA is 5 300 km^2 in size and almost entirely natural (95%). Only about 2% of the land rea is residential. A large extent of the IUA falls within the Kruger National Park (Figure 9-13).

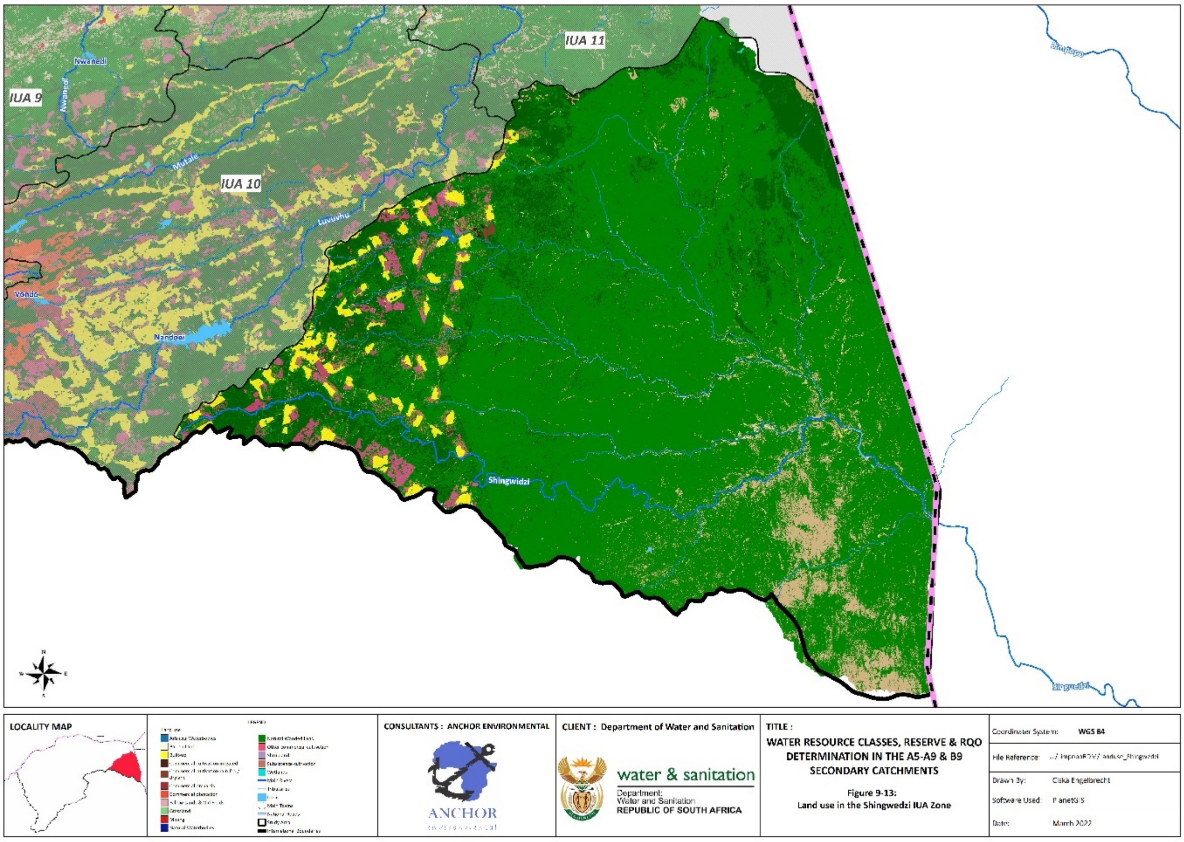

Figure 9-13. Land use in the Shingwedzi IUA. Source: DEA, National Land Cover 2020.

The Shingwedzi IUA contributed 3% to the total GVA for the study area in 2016. The GVA only increased by R112 million since 2011. The community, social and government services sector made the largest contribution to GVA in the Shingwedzi IUA in 2016 (Table 9-45). Of the 33 574 people employed in the Shingwedzi IUA, 67% were working in the community, social and government services sector. Fewer people were employed in the finance, insurance, real estate and business services (4%), manufacturing (12%) and agriculture, forestry and fishing (4%) sectors.

Table 9-45. GVA per sector in 2016 (R million, nominal 2016 prices) for Shingwedzi IUA

Sector	GVA R million	% of total
Agriculture, Forestry and Fishing	36.2	2%
Mining and Quarrying	0	0%
Manufacturing	60.7	3%
Electricity, Gas and Water	30.9	1%
Wholesale and Retail Trade, Catering & Accommodation	266	11%
Transport, Storage and Communication	260.3	11%
Finance, Insurance, Real Estate and Business Services	261.5	11%
Community, Social and Government Services	1 421.7	61%
	2 337.2	

Table 9-46. The total area of irrigated crops in the Shingwedzi IUA

Irrigated crop	Area (ha)
Cereals and other field crops	1
Vegetables	4
Citrus fruit	0
Subtropical fruit	5
Apples and Peaches	0
Table grapes	0
Nuts	36
Total	46

Table 9-47. Summary of population, income, living conditions and reliance on surface water (Source: StatsSA Census 2011)

Total population	227 565
Average annual household income	R44 468
% poor households in IUA	27%
% unemployed in IUA	40%
% households with good access to piped water in IUA	38%
% households dependant on river water in IUA	0.6%

A large proportion of this IUA is made up of the Kruger National Park, the largest and most significant protected area in the study area.

Table 9-48. Status Quo Summary for IUA 12 – Shingwedzi

ASPECT	DESCRIPTION
Groundwater	The main aquifer types include the Intergranular and fractured aquifer systems from the Karoo Supergroup (Letaba Group) and fractured basement aquifer associated with the Limpopo Belt as well as the Intergranular Alluvial aquifer. GUA delineated comprise of B90-1. Average groundwater depths are 16 mbgl with average blow yields of 1.6 L/s. Registered groundwater use is ~2.2 Mm^3/a and can be regarded as underutilised. The groundwater potential of the GUAs is considered low to moderate. Groundwater level monitoring stations show a significant response to recharge events with variable (and seasonal) fluctuations. Monitoring stations show a decline of 4 to 10 m in groundwater levels since 2016, which can relate to a localised to regional impact. Groundwater quality in the Shingwedzi region is moderate to poor with notable element of concern include NO_3 as N. Groundwater samples indicate water types varying from a Ca/Mg-HCO_3 to a Na-Cl dominance.
Surface water	A non-perennial river with very little water-use (3.8 Mm^3/a) flowing intermittently even during the wet season with a current day flow of 87.5 Mm^3/a.
Water Quality	There is a small dam in the upper reaches downstream of the Malamulele WWTW near the village of Boltman. At this sampling point, salts (Chloride and EC) are elevated and in an Acceptable/Tolerable category. Unionised ammonia is very high and in an Unacceptable category and therefore detrimental to aquatic organisms. At Silvervis Dam in the Kruger National Park elevated salt concentrations and pH values are observed. The median Chloride and Dissolved Mineral Salt concentrations are in an Ideal category, but elevated concentrations are observed from time to time that takes the dam into Tolerable categories. At Kanniedood Dam, further downstream in the Kruger National Park, water quality is mostly in Acceptable or Tolerable categories. The salts, namely Chloride, Dissolved Mineral Salts, and Electrical Conductivity, are classified in Acceptable or Tolerable categories while pH is also in an Acceptable/Tolerable category. Nutrients are low and in an Ideal category.
Rivers	The mainstem Shingwedzi River, the Bububu and Nkulumbeni Rivers are assigned full FEPA status, with unnamed tributaries in catchments B90A, B90B and B90C classified as Upstream FEPAs. Sections of the Shingwedzi and Bububu Rivers in quaternary catchments B90F and B90G are situated in Strategic Water Source Areas. Most of the Shingwedzi Catchment is assigned a high EI, with the lower Shingwedzi River assigned a high ES. The lower Shingwedzi River as well as many of its tributaries, including the Nkulumbeni, Shisha, Shihloti and Bububu Rivers are currently in an A or B PES Ecological Category. The Shingwedzi mainstem river is perennial, as well as a portion of the Mphongolo River, upstream of its confluence with the Shingwedzi River. Many of the tributaries within the Catchment are non-perennial in nature. Most of the IUA is situated within the Kruger National Park.
Wetlands	HGM (% in IUA): Channeled valley bottoms 51.5 Depressions 0.9

ASPECT	DESCRIPTION
	Floodplains 6.1 Riverine 4.0 Seeps 0.2 Unchanneled valley bottoms 37.3 Wetland Condition (% in IUA): A/B 2.0 C 50.4 D/E/F 43.6 N/A 4.0

10 REFERENCES

Adekola, O., Morardet, S., De Groot, R. & Grelot, F. (2008). The economic and livelihood value of provisioning services of the Ga-Mampa wetland, South Africa. 13th IWRA World Water Congr. 24.

Annon (Unknown) Determination of the trophic status of the Lephalala and Mokolo rivers and the prediction of future trophic changes through the use of microcosm studies. Unpublished report by the CISR.

Baker, NJ (2018). An assessment of the aquatic macroinvertebrate diversity within the Nyl River Floodplain system, Limpopo, South Africa. MSc Thesis, University of Johannesburg.

Barbier, E.B. (1994). Valuing environmental functions: tropical wetlands. Land Econ. **70**, 155–173.

Bruyns, L (2016). Investigating the relationship between coal usage and the change in cations and sulphate fluxes in three rivers in the Waterberg, South Africa. MSc Thesis, University of the Witwatersrand, Johannesburg.

COGTA. (2020a). Waterberg District Municipality: Profile and analysis. Cooperative governance and traditional affairs, South Africa.

COGTA. (2020b). Mopani District Municipality: Profile and analysis. Cooperative governance and traditional affairs, South Africa.

COGTA. (2020c). Capricorn District Municipality: Profile and analysis. Cooperative governance and traditional affairs, South Africa.

COGTA. (2020d). Vhembe District Municipality: Profile and analysis. Cooperative governance and traditional affairs, South Africa.

Conte, M., Ennaanay, D., Mendoza, G., Walter, M.T., Wolny, S., Freyberg, D., Nelson, E. & Solorzano, L. (2011). Chapter 6: Retention of nutrients and sediment by vegetation. In Natural Capital: theory and practice of mapping ecosystem services.. Kareiva, P., Tallis, H., Ricketts, T. H., Daily, G. C. & Polasky, S. (Ed.). Oxford University Press Inc., New York.

Department of Tourism. (2016). South Africa: State of Tourism Report 2016/17. South Africa.

Department of Water Affairs (2011) Development of a Reconciliation Strategy for All Towns in the Northern Region. 2011. A suite of reports by SRK Consulting (Pty) Ltd for the Department of Water Affairs, Pretoria, South Africa

Department of Water Affairs, South Africa, 2014. Development of a Reconciliation Strategy For The Luvuvhu And Letaba Water Supply System: Hydrology Report. Prepared by: WRP Consulting Engineers, DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting. Report No. P WMA 02/B810/00/1412/5

Department of Water Affairs, South Africa, 2015. Limpopo Water Management Area North Reconciliation Strategy: Hydrology Analysis. Prepared by: AECOM in association with Hydrosol, Jones & Wagner and VSA Rebotile Metsi Consulting. Report No. P WMA 01/000/00/02914/3

Department of Water Affairs and Forestry (DWAF) (2004). Luvuvhu/Letaba Water Management Area: Internal Strategic Perspective. Prepared by Goba Moahloli Keeve Steyn (Pty) Ltd in association with Tlou and Matji, Golder Associates Africa and BKS on behalf of the Directorate: National Water Resource Planning. DWAF Report No. P WMA 02/000/00/0304.

Department: Water Affairs and Forestry. 2007. Development of the Water Resource Classification System (WRCS). By Chief Directorate: Resource Directed Measures.

Department of Water and Sanitation. 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: A5-A9; B9. Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx accessed on 2021/11/01.

Driver, A., Maze, K., Rouget, M., Lombard, A.T, Nel, J., Turpie, J.K., Cowling, R.M., Desmet, P, Goodaaan, R, Harris, J., Jonas, Z., Reyers, B., Sink, K. & Strauss, T. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa. Strelitzia 1 7. South African National Biodiversity Institute, Pretoria.

DWA. (2010). The nature, distribution and value of aquatic ecosystem services of the Olifants, Inkomati and Usutu to Mhlatuze Water Management Areas. Contract Report by Anchor Environmental Consultants for Department: Water Affairs, 362pp.

DWS. (2015). Development of a reconciliation strategy for the Luvuvhu and Letaba Water Supply System: Water requirements and return flows. Report submitted to Department of Water and Sanitation.

DWS. (2017a). Determination of Water Resources Classes and Resource Quality Objectives for the Water Resources in the Breede- Gouritz Water Management Area: Status Quo. Report No: RDM/WMA8/00/CON/CLA/0516.

DWS. (2017b). The development of the Limpopo Water Management Area North Reconciliation Strategy. Prepared by AECOM for the Department of Water and Sanitation.

Edokpayi, JN, Odiyo, JO, Popoola, EO, and Msagati, TAM. (2018). Evaluation of Microbiological and Physicochemical Parameters of Alternative Source of Drinking Water: A Case Study of Nzhelele River, South Africa. The Open Microbiology Journal, 12: 18-27.

Ekka, A., Pande, S., Jiang, Y. & Zaag, P. van der. (2020). Anthropogenic modifications and river ecosystem services: A landscape perspective. Water (Switzerland) **12**, 1–21.

for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems.

Fouche, PSO (2009) Aspects of the ecology and biology of the Lowveld largescale yellowfish (Labeobarbus marequensis, Smith, 1843) in the Luvuvhu River, Limpopo River System, South Africa. PhD Thesis, University of Limpopo.

Fouche, PSO, and Vlok, W. (2010). Water quality impacts on instream biota of the Shingwedzi River, South Africa. African Journal of Aquatic Science, 35(1): 1-11

Godsmark, R. & Oberholzer, F. (2019). The South African forestry and forest products industry 2018. Forestry South Africa.

Grundling,P-L., Grundling,AT., 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.

In Nzhelele Valley, Limpopo Province, South Africa. 3rd International Conference on Biology, Environment and Chemistry, IPCBEE vol.46

Jogo, W. & Hassan, R. (2010). Balancing the use of wetlands for economic well-being and ecological security: The case of the Limpopo wetland in southern Africa. Ecol. Econ. **69**, 1569–1579.

Kori, E and Mathada, H (2012). An Assessment of Environmental Impacts of Sand and Gravel Mining

Lannas, K.S.M. & Turpie, J.K. (2009). Valuing the provisioning services of wetlands: Contrasting a rural wetland in lesotho with a peri-urban wetland in south africa. Ecol. Soc. **14**.

Le Maitre, D., Seyler, H., Holland, M., Smith-Adao, L., Maherry, A., Nel, J. and Witthuser. K. (2019). Strategic Water Source Areas: Vital for South Africa’s Water, Food and Energy Security. Report to the Water Research Commission. WRC Report No. SP128/19.

Limpopo Provincial Government. (2015). Limpopo province: Agri-hubs identified by the Province. In association with Department of Rural Development and Land Reform and Department of Agriculture, Forestry and Fisheries.

Madilonga, R.T.; Edokpayi, J.N.; Volenzo, E.T.; Durowoju, O.S.; Odiyo, J.O. (2021). Water Quality Assessment and Evaluation of Human Health Risk in Mutangwi River, Limpopo Province, South Africa. Int. J. Environ. Res. Public Health 2021, 18, 6765.

Millennium Ecosystem Assessment. (2003). Ecosystems and Human Well-being: a Framework for Assessment. Island Press, Washington.

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington.

Mokgoebo, MJ (2019). The use of Water Quality, Aquatic Species Composition and Aquatic Habitat Conditions to assess the River Health Condition of the Nzhelele River, Limpopo Province, South Africa. PhD thesis, University of South Africa.

Monyai, M, Makhado, RA, and Novhe, NO. (2016). Water quality of the Luvuvhu River and its tributaries within the Thulamela Local Municipality, Limpopo Province, South Africa, African Journal of Science, Technology, Innovation and Development, 8 (5-6): 439-445

Nedkov, S. & Burkhard, B. (2012). Flood regulating ecosystem services - Mapping supply and demand, in the Etropole municipality, Bulgaria. Ecol. Indic. **21**, 67–79.

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.

Novitzki, R.P. (1979). Hydrologic characteristics of Wisconsin's Wetlands and their influence on floods, stream flow, and sediment. In Wetland functions and values: the state of our understanding.. Greeson, P. E., Clark, J. R. & Clark, J.E. (Ed.). American Water Resources Association, Minneapolis.

Oberholster, PJ, Ashton, PJ, Fritz, GB and Botha, A-M (2010). First report on the colony-forming freshwater ciliate Ophrydium versatile in an African river. Water SA, 36(3): 315-322

Odiyo, JO and Makungo, R (2012). Water quality problems and management in rural areas of Limpopo Province, South Africa. WIT Transactions on Ecology and The Environment, 164: 135-146

Olivier, J, Venter, JS, and Jonker, CZ (2011). Thermal and chemical characteristics of hot water springs in the northern part of the Limpopo Province, South Africa. Water SA, 37(4): 427-436

Ollis, D.J., Snaddon, C.D., Job, N.M. & Mbona, N. 2013. Classification System

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.

Pfunzo, R. (2017). Agricultural Contribution To Economic Growth and Development in Rural Limpopo Province: a Sam Multiplier Analysis. Stellenbosch University, South Africa.

Phethi, M.D. & Gumbo, J.R. (2019). Assessment of impact of land use change on the wetland in Makhitha village, Limpopo province, South Africa. Jamba J. Disaster Risk Stud. **11**, 1–6.

Phungula, PP (2018). The use of diatoms in assessing water quality in the Nyl and Mogalakwena River system, in the Limpopo, South Africa. Minor MSc dissertation, University of Johannesburg.

Ramaano, A.I. (2021). Potential of ecotourism as a mechanism to buoy community livelihoods: the case of Musina Municipality, Limpopo, South Africa. J. Bus. Socio-economic Dev. **1**, 47–70.

Rowntree, K.M. and Wadeson, R.A. 1999. A hierarchical framework for categorising the geomorphology of river systems, Water Research Commission Report. 497/1/99. WRC, Pretoria.

SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria.

Seanego, KG (2014). Ecological Status of the Sand River after the Discharge of Sewage Effluent from the Polokwane and Seshego Wastewater Treatment Works. MSc Thesis, University of Limpopo.

Seanego, KG and Moyo, NAG (2013). The effect of sewage effluent on the physico-chemical and biological characteristics of the Sand River, Limpopo, South Africa. Physics and Chemistry of the Earth, 66: 75-82

Sekwele, RC (2008). Selected Heavy Metals Concentrations on Selected Samples of Naboom Spruit, Tobias Spruit and The Nyl Floodplain, South Africa. MSc Thesis, University of Limpopo.

South African National Biodiversity Institute (SANBI). 2009. Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

South African National Biodiversity Institute (SANBI). 2018. National Vegetation Map Project (VEGMAP). https://www. http://bgis.sanbi.org/vegmap accessed on 2022/03/01.

South African National Biodiversity Institute. 2016. Botanical Database of Southern Africa (BODATSA) [various species]. doi: to be assigned.

Stats SA. (2020). Census of commercial agriculture, 2017: Financial and production statistics Limpopo. Statistics South Africa.

StepSA. (2018). CSIR MesoZone 2018v1 Dataset. CSIR, http://stepsa.org/socio_econ.html.

Turpie, J. (2018). Environmental and Resource Economics. Ch 15 in Environmental management in South Africa. Juta, Cape Town.

Turpie, J.K., Forsythe, K.J., Knowles, A., Blignaut, J. & Letley, G. (2017). Mapping and valuation of South Africa ' s ecosystem services : A local perspective **27**, 179–192.

Turpie, J.K., Winstanley, T., Cassidy, L., Perche, J., Letley, G. & Costa, A. (2021). Design and Roadmap for the Establishment of a Transboundary Payment for Ecosystem Services Scheme for the Cubango-Okavango River Basin. Report prepared by Anchor Environmental Consultants for the Permanent Cubango-Okavango River Basin Commission (OKACOM).

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.

Vellidis, G., Smith, M.C., Leibowitz, S.G., Ainslie, W.B. & Pruitt, B.A. (2003). Prioritizing wetland restoration for sediment yield reduction: A conceptual model. Environ. Manage. **31**, 301–312.

Venter, JA, Fouché, PSO, and Vlok, W (2012). Current distribution of the southern barred minnow, Opsaridium peringueyi (Pisces: Cyprinidae), in South Africa: Is there reason for concern? African Zoology 45(2): 244–253

WRC. (2015). Water Resources of South Africa of 2012. Pretoria, South Africa: Water Research Commission.

APPENDIX A – GROUNDWATER STATUS QUO ASSESSMENT