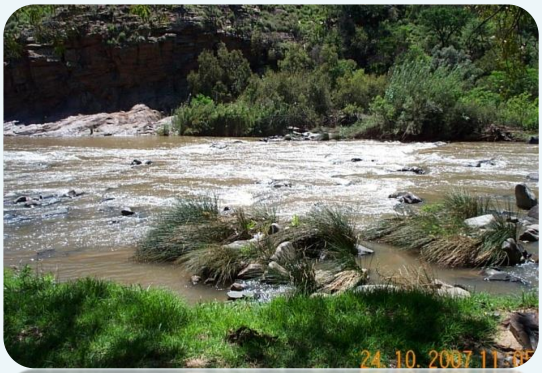

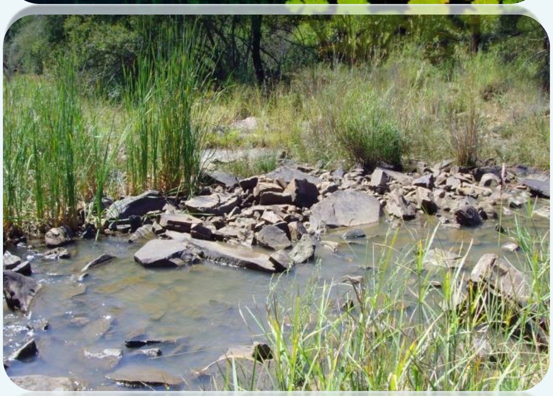

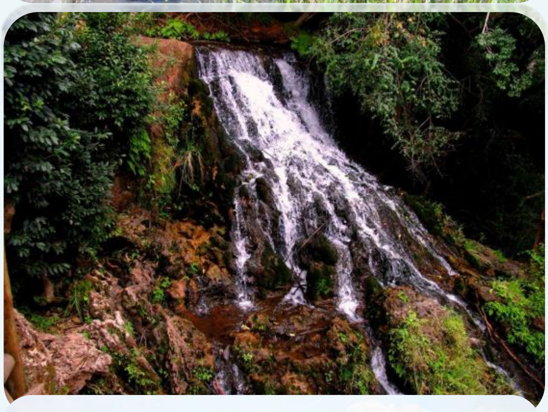

DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE MOKOLO, MATLABAS, CROCODILE (WEST) AND MARICO CATCHMENTS IN THE LIMPOPO NORTH WEST WATER MANAGEMENT AREA (WMA 01)

WP10992

PRELIMINARY RESOURCE UNITS REPORT

REPORT NO.: RDM/WMA01/00/CON/RQO/0316

FINAL

Chief Directorate: Water Ecosystems

SEPTEMBER 2016

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Prepared by:

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DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report.

REPORT INDEX	REPORT NUMBER	REPORT TITLE
1.0	RDM/WMA01/00/CON/RQO/0116	Inception Report
2.0	RDM/WMA01/00/CON/RQO/0216	Information Analysis Report
3.0	**RDM/WMA01/00/CON/RQO/0316**	**Preliminary Resource Units Report**

LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
CD: WE	Chief Directorate: Water Ecosystems
DLMT	Dolomite
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIS	Ecological importance and sensitivity
ENE	East Northeast
EWR	Ecological Water Requirements
FEPAs	Freshwater Ecosystem Priority Areas
IHI	Index of habitat integrity
GMU	Groundwater Management Unit
GWS	Government Water Schemes
HGM	Hydrogeopmorphic
IUA	Integrated Unit of Analysis
IUAs	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
NWA	National Water Act
PES	Present Ecological Sate
RQOs	Resource Quality Objectives
RDM	Resource Directed Measures
RHP	River Health Programme

RUs	Resource Units
SANBI	South African National Biodiversity Institute
WMA	Water Management Area
WMS	Water Management System
WRCS	Water Resource Classification System
WfWetlands	Working for Wetlands
WWTW	Wastewater Treatment Works

EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) has recently commissioned the study "Determination of Resource Quality Objectives (RQOs) in Mokolo, Matlabas, Crocodile (West) and Marico catchments in the Limpopo North West Water Management Area (WMA)". Proposed water resource classes have been completed in these catchment areas and the determination of the RQOs follows on from this process. Establishment of RQOs is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RQOs are defined by the National Water Act as "clear goals relating to the quality of the relevant water resources" (DWAF, 2006).

RQOs are descriptive or quantitative and are the goals defined to protect the water resource and the alignment to the catchment vision and class of the water resource.

As part of the RQO process the first step is to delineate the units of analysis and define Resource Units (RUs). Each integrated unit of analysis (IUA) represents a homogenous catchment area of similar impacts which must be considered in the determination of RQOs. A RU on the other hand is a stretch of river within an IUA that is sufficiently ecologically distinct to warrant its own specification. Groundwater RUs are defined separately and are based on a number of factors.

The IUA delineation of Mokolo, Matlabas, Crocodile (West) and Marico catchments was done as part of the water resource classification process, through which 17 IUAs were delineated. The IUAs delineated form the basis for the RQO determination process. Based on the ecological specifications, ecological water requirements and biophysical nodes defined it is now necessary through the RQO process to delineate key water resources of the Mokolo, Matlabas, Crocodile (West) and Marico catchments into Resource Units (RU) and prioritise the RUs that require RQO development. This report therefore details the preliminary delineation of resource units for and the prioritisation of those requiring RQO development.

In determining the RQOs, it is important to recognise that different water resources will require different levels of protection.

Resource Units Delineation and Prioritisation Approach

The process followed in terms of RU delineation was that described in the RQO Determination Guideline (February 2011). Each IUA represents a homogenous catchment area of similar impacts which must be considered in the determination of RQOs. A RU on the other hand is a stretch of river within an IUA that is sufficiently ecologically distinct or impacted to warrant its own specification. Groundwater priority area are defined separately and are based on a number of factors. Delineation of RUs is required in order to facilitate the effective management of a river set, by breaking down the river into discrete, manageable and ecological homogenous units. The RUs are aligned to the IUA boundaries to prevent overlap between two IUAs.

The following aspects considered for delineation of RUs within the Mokolo, Matlabas, Crocodile (West) and Marico catchments:

- IUA boundaries and sub-quartenary boundaries
- Geomorphological zones and Eco-regions

- EWR sites and location of hydronodes (in terms of the Classification study outputs)
- Ecological condition (based on the EWR and node information)
- PES/EIS desktop assessment of sub-quinary reaches
- Freshwater Ecosystem Priority Areas (FEPAs)
- Operation of the system
- Water quality impacts
- Land use and anthropogenic activities
- Groundwater units
- Expert knowledge of the catchment area and system

A total of 82 RUs were delineated (incorporating rivers, dams, groundwater and wetlands components). The RQO determination procedure proposes RQOs for each resource unit, however this may not always possible due the potentially large number of RUs that could be delineated for a catchment. In order to prioritise and select the most useful RUs for RQO determination, a rationalisation process has therefore been developed as part of the RQO Determination Procedure (DWA, 2011).

The rationalisation process for RU selection and prioritisation is based on a decision support tool that has been developed to guide and support the process. The 'Resource Unit Prioritisation Tool' incorporates a multi criteria decision analysis approach to assess the importance of monitoring each RU as part of management operations to identify high priority RUs.

Based on the priority ratings obtained through application of the RU prioritisation tool, these rankings and weightings were used to select the priority RUs for RQO determination. The evaluation of the RU priority ratings for selection was done at a desktop level and based on the preliminary evaluation process 58 RUs were prioritised (moderate to high rating). The desktop results were presented and discussed with specialists and catchment water resource managers to obtain their input on the rating of the resource units. Based on their local knowledge and understanding of the study area the desktop prioritisation scores were revised, and the RUs selected and prioritised. These results will be presented at the project steering committee meetings in the catchment area to finalise the resource unit prioritisation.

The scores for all criteria are combined into a priority rating which scores the RUs relative to each other. This provides an integrated measure to inform the selection of priority RUs. Based on the preliminary evaluation process 75 RUs were prioritised (moderate to high).

Delineation and Prioritisation Results

- 82 RUs were delineated which incorporates the groundwater priority areas and priority wetlands/wetland clusters;

Based on resource unit prioritisation undertaken:

- 57 RUs were prioritised (which incorporates the groundwater priority areas and priority wetlands/wetland clusters).
- 18 dam RUs were prioritised.

Determination of Resource Quality Objectives in the Mokolo, Matlabas, Crocodile (West) and Marico catchments

Preliminary Resource Units Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

1.1 BACKGROUND

Resource Directed Measures (RDM) is enabled through Chapter 3 of the National Water Act (Act No.36 of 1998) (NWA) which provides for the protection of water resources through the Classification of water resources, determination of Resource Quality Objectives (RQOs) and determination of the Reserve. These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other.

Resource quality objectives have to be determined for a significant water resource as the means to ensure a desired level of protection. The purpose of the RQOs is to provide limits or boundaries (biological, physical and chemical attributes, etc.) which should be met in the receiving water resource in order to ensure protection.

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) has initiated the development of Resource Quality Objectives (RQOs) for the Mokolo, Matlabas, Crocodile (West) and Marico catchments. With the water resources in these catchment area having been classified, RQOs are to be determined as the next step of the protection framework.

1.2 PURPOSE OF THE STUDY

The main objective of the study is to determine Resource Quality Objectives (RQOs) for all significant water resources in the Mokolo, Matlabas, Crocodile (West) and Marico Catchments that must give effect to the Water Resources Classes that have been determined.

A main aim of this study is thus to develop RQOs following the seven step process for determining RQOs (DWA, 2011) which is depicted in Figure 1. Once gazetting has been finalised, implementation, monitoring and review would then follow.

The implementation of the RQO procedure in the Mokolo, Matlabas, Crocodile (West) and Marico catchments will be undertaken using the following study approach:

- An assessment of the catchment areas to understand the status quo with regard to water resources in the catchment and the availability of necessary information and data to support RQO determination. The delineation of the catchments into Resources Units (RUs) based on the integrated unit of analysis (IUA) definition, identified criteria, system understanding and characteristics;
- The application of the RQO procedure (Steps 2 to 7) (Figure 1), *i.e.* determining the RQOs by capturing the water resource class and ecological requirements into measurable management goals, and
- Communication and engagement with stakeholders

The study approach is defined by 5 tasks depicted in Figure 2.

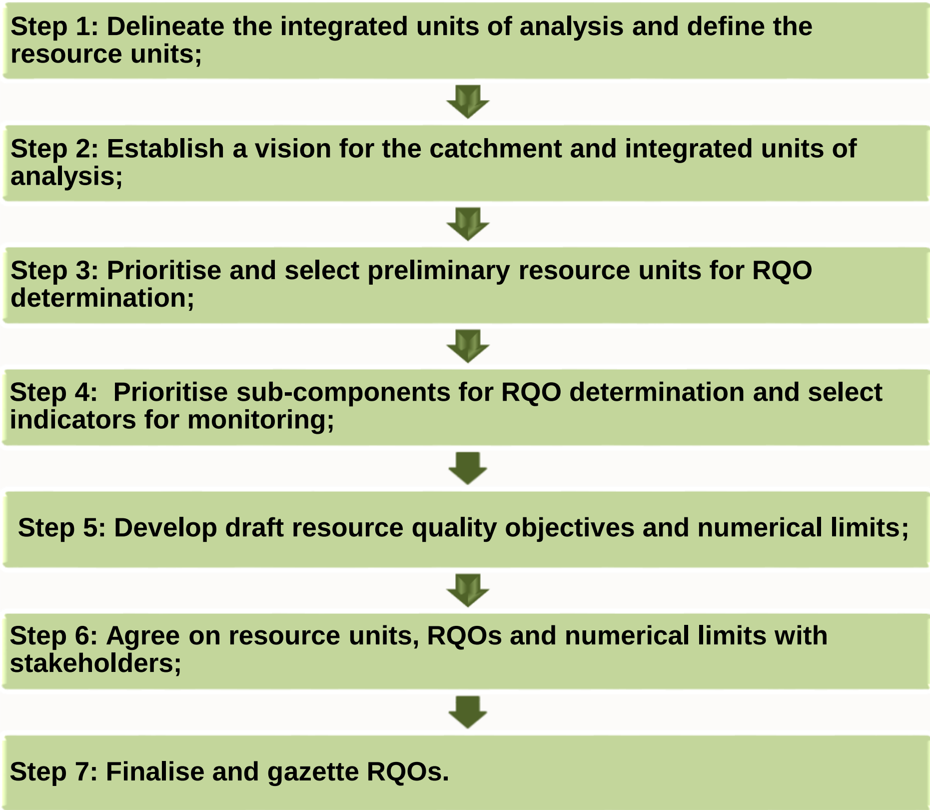

Figure 1: Seven step process for RQO determination

In terms of the RQO determination process outlined above, IUA delineation (Step 1) has been completed as part of the water resource classification study. This study will however define the resource units.

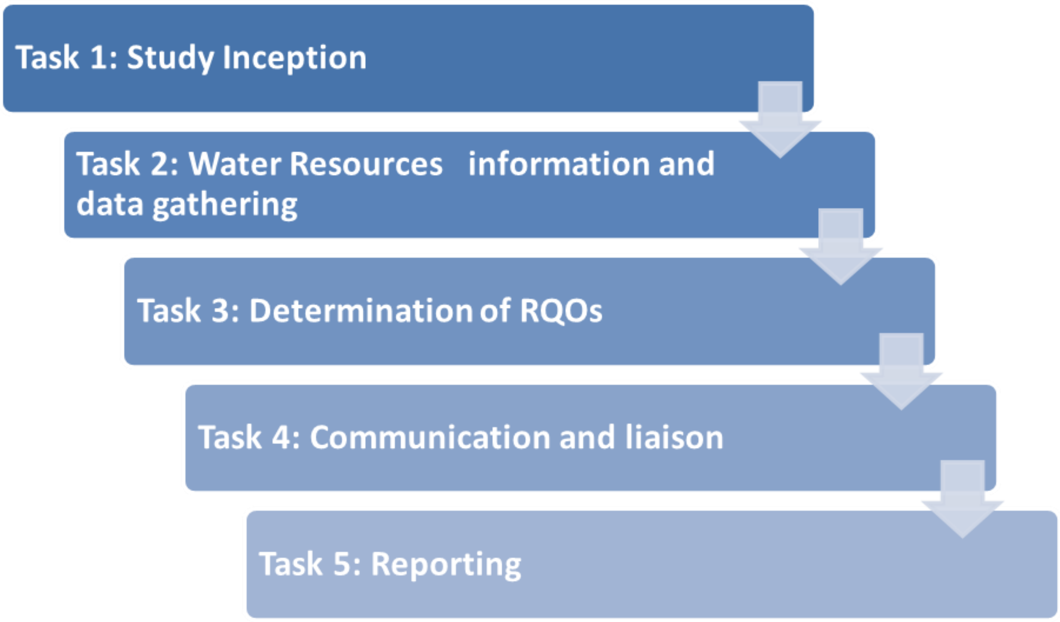

Figure 2: Study tasks

1.3 STUDY AREA

The study area for the RQO Determination study is the Mokolo, Matlabas, Crocodile (West) and Marico Catchments (Figure 3) in the Limpopo North West Water Management Area (WMA). The spatial extent of the area includes tertiary drainage regions A10, A21 to A24, A31, A32, A41, A42 and quaternary drainage region D41A (Table 1).

Table 1:Sub-catchments and related quaternary drainage regions comprising the Mokolo, Matlabas and Crocodile (West) and Marico Catchment areas

Sub-catchment	Catchment Area (km^2)	Quaternary catchments
Upper Crocodile (A21)	6 336	A21 A – L
Elands (A22)	6 221	A22 A – J
Apies/Pienaars (A23)	7 588	A23 A – L
Lower Crocodile (A24)	9 204	A24 A – J;
Marico (A31 and A 32)	12 030	A32 A – E; A31 A – J
Ngotwane (A10)	1 842	A10 A – C
Upper Molopo (D41)	4 300	D41 A
Matlabas (A41)	6 014	A41A – E
Mokolo (A42)	8 387	A42 A – J

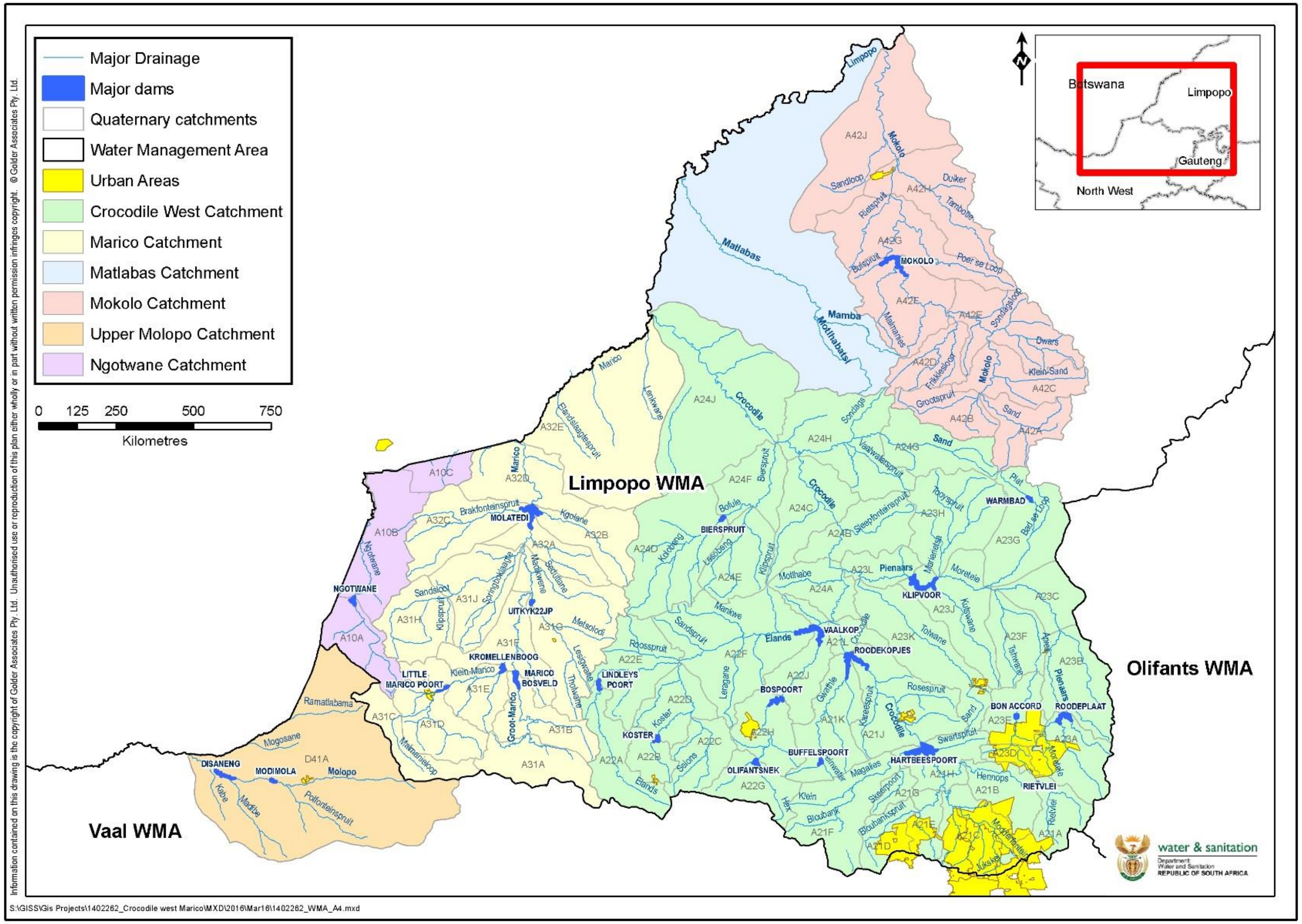

Figure 3: The Study Area - Mokolo, Matlabas, Crocodile (West) and Marico catchments

1.4 THE RESOURCE UNIT DELINEATION AND PRIORITISATION SUB-TASK

The definition of resource units forms part of Step 1 of the RQO determination process, "Delineate Integrated Units of analysis and Define Resource Units", specifically sub-steps 1.5 to 1.7 (as per the Procedures to Develop and Implement Resource Quality Objectives, DWA, March 2011). It is required to facilitate effective management and necessitates the breakdown of a river into discrete manageable units, primarily from an ecological perspective. The resource units are generally ecologically homogenous in nature. The delineation of IUAs and prioritisation of RUs are undertaken as the initial steps of the RQO process. RQOs are then developed per RU within the context of the IUA catchment perspective.

In this study RQOs for rivers, groundwater, dams and wetland resources will be determined. The outcomes of this study will include RQOs for rivers, groundwater, wetlands and dam resources as follows:

- rivers on a RU scale (river RUs),
- priority dam resources on a RU scale,
- priority wetland resources on a RU scale,
- groundwater resources on a groundwater RU scale which is comparable with river RUs, and
- priority groundwater resources on a system specific scale (priority groundwater units).

1.5 PURPOSE OF THE REPORT

This report details the process of delineating and prioritising the resource units for the water resources in Mokolo, Matlabas, Crocodile (West) and Marico catchments. It provides the information used to define the RUs and details the results of the delineation and preliminary prioritised RUs.

These results will be taken through to stakeholders consultation for finalisation of the delineation and prioritised RUs.

2 DELINEATION OF THE INTEGRATED UNITS OF ANALYSIS (IUAS)

The Water Resource Classification (WRC) and the Reserve Determination studies for the Mokolo, Matlabas, Crocodile (West) and Marico catchments have been completed in 2014 and 2009 respectively. Through the classification study the IUAs for the catchment were delineated and the EWR sites and river nodes were specified. These outputs from the classification study form the basis for the RQO determination process, and primarily for the RU definition.

In terms of the classification study, 20 IUAs were delineated (DWA, 2012a). These are listed in Table 2 and shown in Figure 4. The IUAs form the boundaries for RU delineation.

Table 2: IUAs delineated for the Crocodile (West), Marico, Mokolo and Matlabas catchments

IUA No.	Main river system/ IUA name	Quaternary catchments
1	Upper Crocodile/Hennops/Hartebeespoort	A21A, A21B, A21C, A21D, A21E, A21H, A23A, A23B,A23D, A23E
2	Magalies	A21F, A21G
3	Crocodile/Roodekopjes	A21J
4	Hex/Waterkloofspruit/Vaalkop	A21K, A22G, A22H, A22J
5	Elands/Vaalkop	A22A, A22B, A22C, A22D, A22E, A22F
6a	Klein Marico	A31D, A31E
6b	Groot Marico	A31B
7	Kaaloog-se-Loop	A31A
8	Malmaniesloop	A31C
9	Molopo	D41A
10	Dinokana Eye/Ngotwane Dam	A10A
11a	Groot Marico/Molatedi Dam	A31F, A31G, A31H, A31J, A32A, A32B, A32C, A10B
11b	Groot Marico/seasonal tributaries	A10C, A32D, A32E
12	Bierspruit	A24D, A24E, A24F
13	Lower Crocodile	A21L, A24A, A24B, A24C, A24G, A24H, A24J
14	Tolwane/Kulwane/Moretele/Klipvoor	A23C, A23F, A23G, A23H, A23J, A23K, A23L
15	Upper Mokolo	A42A, A42B, A42C, A42D, A42E, A42F
16	Lower Mokolo	A42G, A42H, A42J
17a	Mothlabatsi/Mamba	A41A, A41B
17b	Matlabas	A41C, A41D, A41E

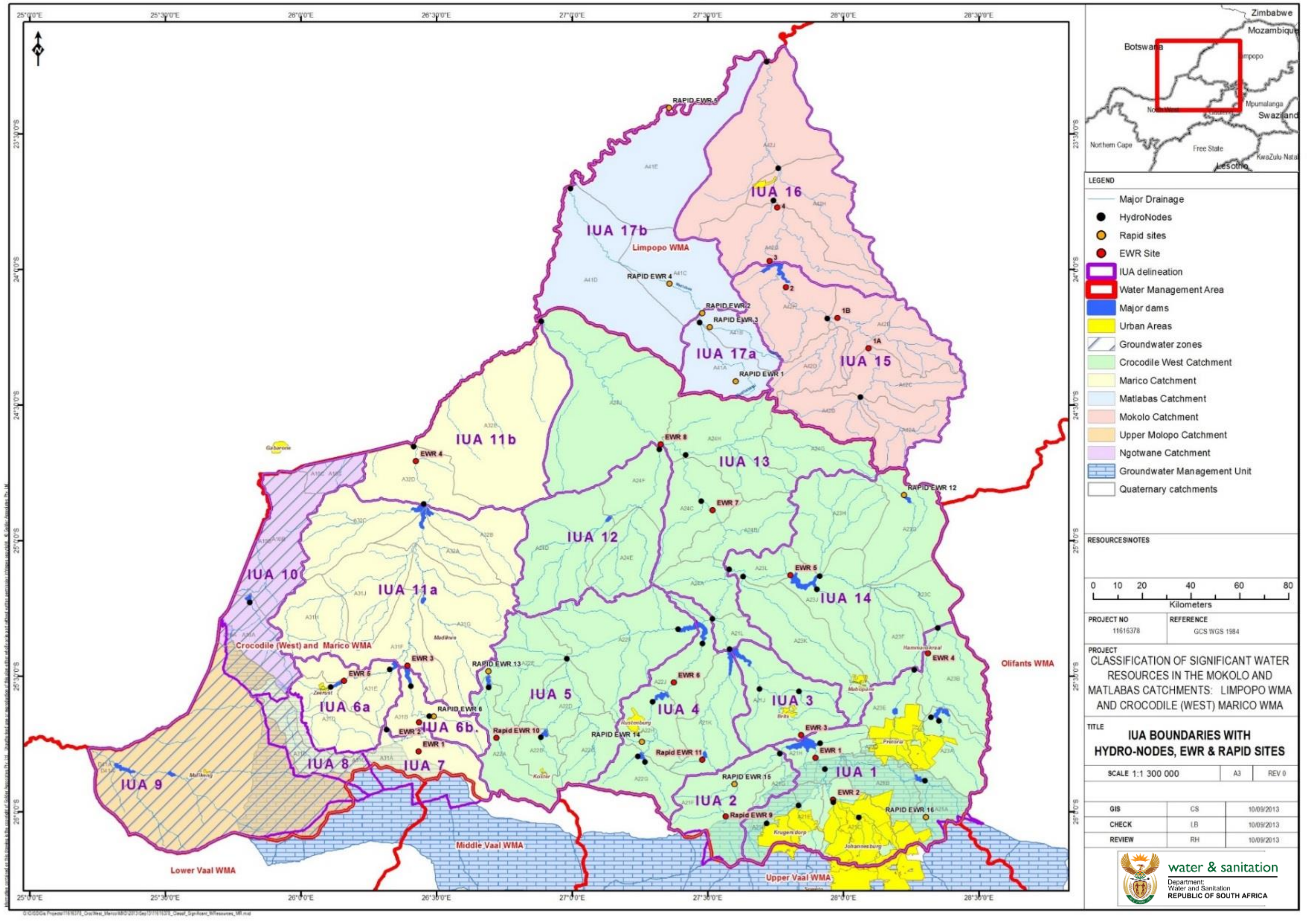

Figure 4: IUAs delineated within Crocodile (West), Marico, Mokolo and Matlabas catchments

3 RESOURCE UNIT DELINEATION: SURFACE WATER

3.1 APPROACH

From an ecological perspective, rivers should be viewed as continuous longitudinal systems. Impacts that occur in upstream reaches are likely to affect downstream processes. As it would not be appropriate to set the same RQOs for the headwaters of a river as for the lowland reaches, RUs are required. The RUs are river reaches that are each significantly ecological different to warrant their own specification of the RQOs and as such the geographic boundaries of each must be clearly delineated (DWAF, 1999, Volume 3).

A RU is a section of a river that frequently has different natural flow patterns, reacts differently to stress according to their sensitivity, and requires individual specifications of the ecological requirements and RQOs appropriate for that reach, as compared to the rest of the river. The delineation of a catchment into RUs is done primarily on a biophysical basis, and where the hydrology, geomorphic characteristics (*i.e.* geomorphic zone), water quality attributes and river size remains relatively similar, a RU can be defined.

In addition management requirements also play a role in the delineation of a RU (DWAF, 1999, Volume 3). The purpose of distinguishing a RU of management requirements is to identify a management unit within which the EWR can be implemented and managed based on one set of identified flow requirements. These management units are based on the principle of homogeneity of impacts in the demarcated RU. This may include the modification of flows in the system due to abstraction, regulation by impoundments and development along the RU and upstream from the RU which may influence the geomorphology and water quality conditions.

The RU delineation process considers the above aspects. Overlaying all the data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process and local knowledge are required for the final delineation of the RUs. The practicalities of dealing with numerous reaches within one study must also be considered to determine a logical and practical suite of RUs.

3.2 RESOURCE UNIT CONSIDERATIONS FOR DELINEATION

Spatial data from the water resource classification study defining the IUAs and hydronodes was reviewed and served as the departure point for the delineation of the resource units. The EWR sites and the hydronodes were reviewed and their relevance and rationale for inclusion was assessed.

Each IUA was then delineated into smaller units based on quaternary catchment boundaries. Sub-quaternary analysis and assessment was also undertaken where required. However the delineation based on quaternary catchment boundaries was preferred as it relates to the unit of management of the water resources in the catchment from a regulation, authorisation and management point of view. The quaternary catchment level delineation will facilitate the implementation and application of the RQOs determined. Where present the RQOs will be linked to the EWR sites and hydronodes which will serve as the monitoring site for compliance assessment. These reaches will be specified at the sub-quaternary level to support the monitoring programmes to be established.

The resource unit delineation was done based on the assessment of the following considerations and components:

- IUA boundaries, quaternary and sub-quaternary boundaries: This formed the basis of delineation (alignment to the water resource classification), and of relevance from a management and implementation.
- EWR sites and location of biophysical nodes (in terms of the Classification study outputs): Relevant from an ecological point of view (EWR sites) and important in meeting the classification ecological categories specified at the nodes. The nodes are of relevance in setting water quality and flow related resource quality objectives.
- Water resource management classes set: Considered to determine the level of protection required within an IUA.
- PES/EIS desktop assessment of sub-quinary reaches: To determine the reaches that require higher protection and areas that are degraded and need to be improved within an IUA.
- Ecological condition (based on the EWR and node information): Understanding of ecological condition and ensuring implementation of the Reserve
- Protected and conservation areas: Areas that are of importance from a biodiversity and conservation point of view (different to the higher impacted areas). Would need RQOs that support the conservation status.
- Operation of the system: How the water resources in the system area regulated and managed from a system point of view. This relates more importantly to regulation of the dams, and their influence of the river surface water flow, transfers, strategic water resources, etc.
- Water quality impacts: The water quality status/condition of the resources influences the delineation of the resource units in terms of where specific RQOs would be required. Highly impacted, poor water quality areas would need RQOs and similarly areas of good water quality would require protection in line with the water resource management classes and ecological condition.
- Land use and anthropogenic activities: the activities within the IUAs, were considered – the nature, intensity, scale, type and extent of impact. This influenced the delineation of resource units in terms of the management required and the RQOs that would be required to ensure the water resources are sustainably used.
- User dependence: The reliance of users on the water resources for domestic water supply.
- Groundwater units: the priority groundwater resources and their importance to the system and users.
- Wetlands: The priority wetland areas and systems and their importance from their value, support to the ecosystem and services they provide, and to the users; and
- Expert knowledge of the catchment area and system.

The following sections provides some detail on the background information related to land cover, ecological information, water infrastructure and freshwater water ecosystem areas which also informed the delineation of resource units.

3.2.1 Land cover

Land cover and land use information of the Mokolo, Matlabas, Crocodile (West) and Marico catchments is used to determine homogeneity of impacts and used in the decision-making regarding delineation of the RUs. The land cover of the Mokolo, Matlabas, Crocodile (West) and Marico catchments is dominated by cultivated lands, degraded areas, mining, natural grassland, plantations, urban/built up areas and water bodies (see Figure 5).

3.2.2 Ecological information

As RU definition is to a large extent based on the ecological condition and characteristics of the water resource, it is important to understand the ecological requirements and specifications of the surface water resources in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. The ecological condition of the 20 IUAs as classified in terms of the Water Resource Classification study for the study area is summarised below.

The Mokolo, Matlabas, Crocodile (West) and Marico catchments includes 33 EWR sites (intermediate and rapid) and 65 nodes. The summary table of the eco-classification and the management classes per IUA are also included in Table 3 (DWA, 2013).

Table 3: Summary of Eco-classification and the IUA Management Classes in the study area

IUA	No	Quat	Hydro node	EI	ES	PES	REC	Recommended Class
1 Upper Crocodile/ Hennops/ Hartebeespoort	HN1	A21A	Rietspruit (source) to Rietvlei Dam (CROC_EWR16)	Low	Low	C	C	III
	HN2	A21B	Sesmylspruit with its' tributaries to confluence with Hennops	Mod	Mod	E		
	HN3	A21C	Modderfonteinspruit to confluence with Jukskei	Mod	Mod	E	D	
	HN4		Klein Jukskei at confluence with Jukske	Mod	Mod	E	D	
	HN5		Jukskei River at CROC_ EWR2	Mod	Mod	E	D	
	HN6	A21D	Bloubankspruit and tributaries (outlet of quaternary/confluence with Crocodile)	Mod	Mod	D		
	HN7	A21A, B, H	Hennops (source) to confluence with Crocodile	Mod	Mod	D		
	HN8	A21H	Swartspruit to Hartbeespoort Dam	Mod	Mod	D		
	HN9	A21E, H	Crocodile (source) to CROC_EWR1	Mod	Mod	D	D	

IUA	No	Quat	Hydro node	EI	ES	PES	REC	Recommended Class
	HN10	A21H, J	Crocodile at Hartbeespoort Dam, outlet of IUA1	High	High	C/D		
	HN11	A23A	Pienaars(source) and including Moreletaspruit and Edendalespruit to outlet of Roodeplaat Dam	Low	Low	E		
	HN12	A23B	Pienaars from Roodeplaat Dam to outlet of quaternary catchment (outlet of IUA1) (CROC_EWR4)	High	High	C	C	
	HN13	A23B	Boekenhoutspruit to confluence with Pienaars	High	High	C		
	HN14	A23D	Skinnerspruit (source) to confluence with Apies	Low	Low	E		
	HN15	A23D, E	Apies (source) to Bon Accord Dam, below the dam at outlet of IUA1	Low	Low	F		
2 Magalies	HN16	A21F	Magalies below Maloney's Eye at CROC_EWR9	Very high	Very high	B	B	II
	HN17 HN18	A21G, F	Magalies (CROC_EWR15)	Low	Low	C/D	C/D	
			Skeerpoort at outlet of IUA2	Low	Low	C/D		
3 Crocodile/ Roodekopjes	HN19	A21J	Rosespruit at confluence with Crocodile	High	High	C/D		III
	HN20		Crocodile from Hartbeespoort Dam to upstream Roodekopjes Dam, outlet of IUA3	Mod	Mod	D		
4 Hex/ Waterkloof-spruit/ Vaalkop	HN21	A21K	Sterkstroom (source) to Buffelspoort Dam (CROC_EWR11)	High	High	C	C	II
	HN22		Sterkstroom from Buffelskloof Dam to Roodekopjes Dam, outlet of IUA4	High	High	C		
	HN23	A22G	Hex (source) to Olifantsnek Dam	Mod	High	C		
	HN24	A22H	Waterkloofspruit (CROC_EWR14) to confluence with Hex	Low	Low	B/C	B/C	
	HN25		Hex from Olifantsnek Dam to Bospoort Dam	Mod	Mod	D		
	HN26	A22J	Hex from Bospoort Dam to Vaalkop Dam (CROC_EWR6)	Mod	Mod	D	D	
	HN27		Elands from Vaalkop Dam to confluence with Crocodile, outlet of IUA4	Mod	Mod	D		

IUA	No	Quat	Hydro node	EI	ES	PES	REC	Recommended Class
5 Elands/Vaalkop	HN28	A22A	Elands (source) to Swartruggens Dam (CROC_EWR10)	High	High	C	B/C	II
	HN29		Elands from Swartruggens Dam to Lindleypoort Dam	Mod	High	C		
	HN30	A22B	Koster (source) to Koster Dam	Mod	High	C		
	HN31	A22C, A22D	Selons to confluence with Elands	Mod	High	C		
	HN32	A22E, A22F	Elands from Lindleypoort Dam (CROC_EWR13) to Vaalkop Dam, outlet of IUA5	Low	Low	C	C	
6a Klein Marico	HN64	A31D	Malmaniesloop to confluence with Klein Marico	High	High	C	C	II
			Klein Marico and tributaries upstream of Zeerust					
	HN35	A31D	Klein Marico from Zeerust to Klein Maricopoort Dam	High	High	C		
			Klein Mario from Klein Maricopoort Dam to Kromellemboog Dam (MAR_EWR5), outlet of IUA6a					
	HN65	A31E		High	High	C		
	HN36	A31E		Mod	Mod	C		
6b Groot Marico	HN33	A31B	Polkadraaispruit to confluence with Marico (MAR_EWR6)	Mod	Mod	B/C	B	II
	HN34		Marico from MAR_EWR2 to N4 road at town	Very High	Very High	B		
	HN63		Marico from N4 road to Marico-Bosveld Dam, outlet of IUA6b	Very High	Very High	B	B	
7 Kaaloog-se-Loop	HN37	A31A	Kaaloog-se-Loop (MAR_EWR1) to concluence with Groot Marico	Very High	Very High	B	B	I
	HN38	A31A	Vanstraatenvlei and tributaries at confluence with Kaaloog-se-Loop, outlet of IUA7	High	High	B		
8 Malmaniesloop	-	A31C	Groundwater	-	-	-	-	I
9 Molopo	HN66	D41A	Molopo at outlet of wetland	-	-	-		II
	HN67		Molopo at Modimola	Low	Low	E		
	HN39		Molopo at outlet of IUA9	Low	Low	E		

IUA	No	Quat	Hydro node	EI	ES	PES	REC	Recommended Class
11a Groot Marico/ Molatedi Dam	HN40	A31F, G, A32A	Marico from Marico Bosveld and Kromelmboog Dam to Molatedi Dam (MAR_EWR3), outlet of IUA11a	High	High	C/D	C/D	III
11b Groot Marico/ seasonal tributaries	HN41	A32D, E	Marico from Molatedi Dam to confluence with Crocodile (MAR_EWR4), outlet of IUA11b	High	High	C	C	II
12 Bierspruit	HN42	A24D, E, F	Bierspruit to confluence with Crocodile River, outlet of IUA12	Mod	Mod	D		III
13 Lower Crocodile	HN43	A24G, A24H	Sand to confluence with Crocodile	Mod	Mod	C		III
	HN44	A21L, A24A-C, / A24H	Crocodile from Roodekopjes Dam (CROC_EWR7) to proposed Mokolo transfer (CROC_EWR8)	Mod	Mod	D	D	
	HN45	A24J	Crocodile from CROC_EWR8 to confluence with Limpopo, outlet of IUA13	Mod	Mod	C	C	
14 Tolwane/ Kulwane/ Moretele/ Klipvoor	HN46	A23G	Platspruit (source, CROC_EWR12) to confluence with Pienaars	Mod	Mod	B/C	B/C	III
	-	A23C, A23F	Wetland at Pienaars & Apies confluence and inflow to Klipvoor Dam	Mod	Mod	C		
	HN47	A23H	Karee/Rietspruit to confluence with Pienaars	Mod	Mod	C		
	HN48	A23J / A23J, A23L	Moretele (Pienaars) to confluence with Crocodile (CROC_EWR5), outlet of IUA14	High	High	D	C	
	HN49	A23K	Tolwane to confluence with Moretele	High	High	D		
15 Upper Mokolo	HN50	A42A	Sand (source) to confluence with Grootspruit	Mod	Mod	C		II
	HN51	A42B	Grootspruit (source) to confluence with Sand	Mod	Mod	C		
	HN52	A42C	Mokolo to confluence with Dwars (MOK_EWR1a)	High	High	C/D	B/C	
	HN53	A42D, A42E	Mokolo to confluence with Sterkstroom (MOK_EWR1b)	High	High	B/C	B	

IUA	No	Quat	Hydro node	EI	ES	PES	REC	Recommended Class
	HN54	A42D	Sterkstroom (source) to confluence with Mokolo, including Dwars	High	High	B/C		
	HN55	A42F	Mokolo from Sterkstroom to Mokolo Dam (MOK_EWR2), outlet of IUA15	Very high	Very high	B/C	B	
16 Lower Mokolo	HN56	A42G	Rietspruit (source) to Mokolo confluence	Mod	Mod	B/C	B	II
	HN57		Mokolo below dam (MOK_EWR3) to Rietspruit confluence (MOK_EWR4)	Very High	Very High	B/C		
	HN58	A42H, A42J	Mokolo from MOK_EWR4 to confluence with Limpopo, outlet of IUA16.	Very High	Very High	C	B	
17a Mothlabatsi/ Mamba	HN59	A41A	Mothlabatsi to confluence with Mamba	Very High	Very High	B	A	I
	HN60	A41B	Mamba to confluence with Mothlabatsi, outlet of IUA17a	Mod	Mod	B/C	B/C	
17b Matlabas	HN61	A41C	Matlabas from Mamba confluence to MAT_EWR2	High	High	C	B/C	II
	HN62	A41C, D	Matlabas from MAT_EWR2 to confluence with Limpopo, outlet of IUA17b	Mod	Mod	B	B	

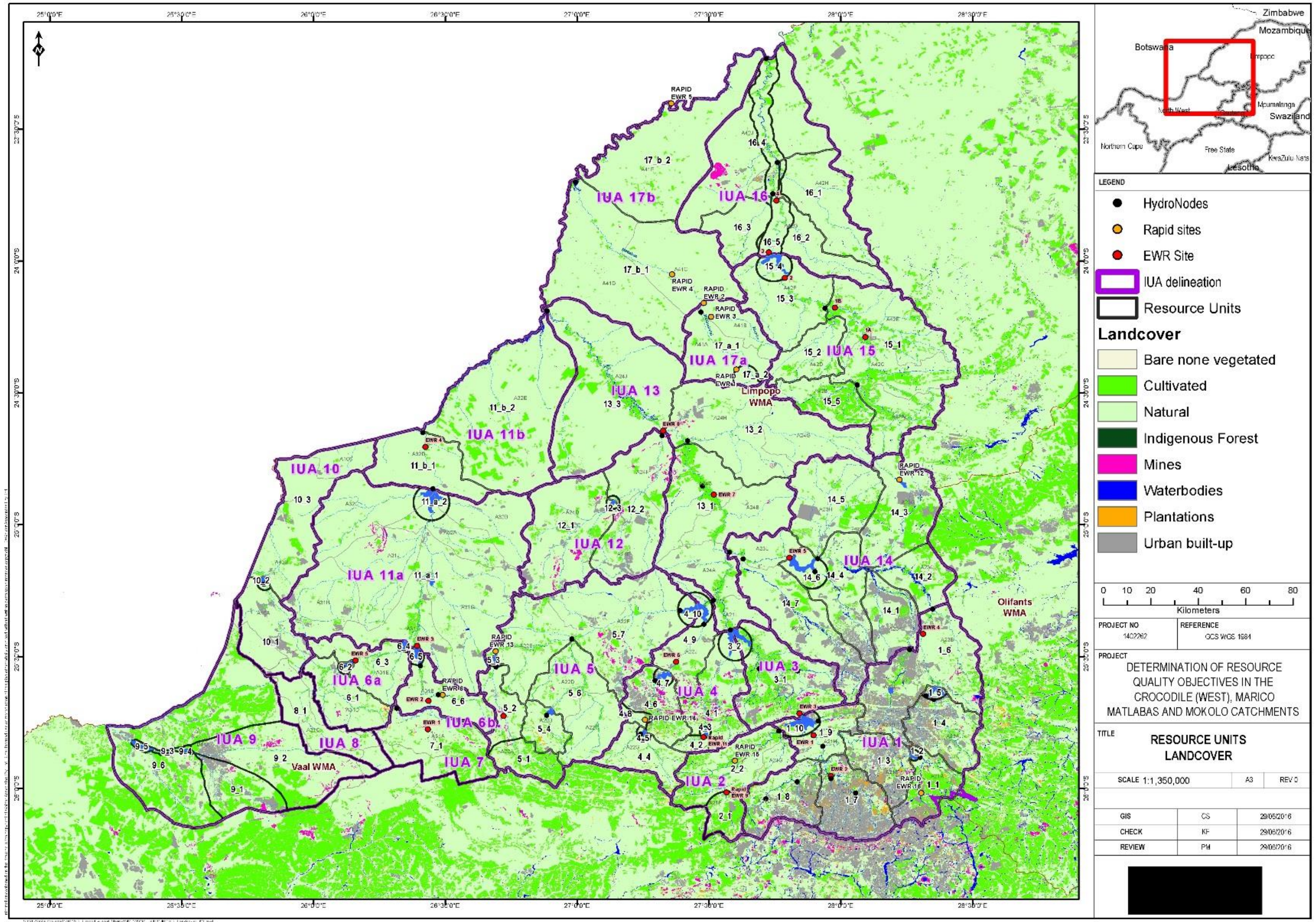

Figure 5: Land cover and land use information of the Crocodile (West), Marico, Mokolo and Matlabas catchments

3.2.3 EWR sites

A number of Reserve studies were undertaken at various levels of detail. The most significant were the intermediate studies initiated in 2009 and completed in 2012 for the Crocodile West/Marico WMA and during 2009 to 2011 for the Mokolo catchment. The intermediate study did not include the Matlabas catchment.

Additional Rapid III Reserve determination studies were undertaken in the Crocodile West/Marico catchments during the water resource classification study to enhance the existing information and to enable the extrapolation of EWRs to all the identified hydro nodes.

Four EWR sites were also identified in the Matlabas catchment on which Rapid Reserve studies were undertaken to provide the necessary information for the WRCS.

All EWR all sites (Intermediate and additional Rapid sites) are listed in Table 4 and Table 5 below.

The Intermediate Crocodile West/Marico Reserve was updated and approved of 08 August 2013.

Table 4: Information on preliminary Reserve studies in the catchments of the study area

EWR site	River	Quaternary catchment	PES	EIS	REC	nMAR(1) (10^6m^3)	%EWR	Level
CROCODILE WEST								
EWR 1	Crocodile: Upstream of the Hartbeespoort Dam	A21H	*D*	Moderate	D	231.05	24.07	Intermediate
EWR 2	Jukskei: Heron Bridge School	A21C	*E*	Moderate	D	139.9	24.87	Intermediate
EWR 3	Crocodile: Downstream of Hartbeespoort Dam in Mount Amanzi	A21J	*C/D*	High	C/D	143.3	21.7	Intermediate
EWR 4	Pienaars: Downstream of Roodeplaat Dam	A23B	*C*	High	C	28.2	30.81	Intermediate
EWR 5	Pienaars/Moretele: Downstream of the Klipvoor Dam in Borakalalo National Park	A23J	*D*	High	D	113.0	11.82	Intermediate
EWR 6	Hex: Upstream of Vaalkop Dam	A22J	*D*	Moderate	D	26.9	14.96	Intermediate
EWR 7	Crocodile: Upstream of the confluence with the Bierspruit	A24C	*D*	Moderate	D	463.4	9.14	Intermediate

EWR site	River	Quaternary catchment	PES	EIS	REC	nMAR(1) ($10^6 m^3$)	%EWR	Level
EWR 8	Crocodile: Downstream of the confluence with the Bierspruit in Ben Alberts Nature Reserve	A24H	*C*	Moderate	C	559.9	13.78	Intermediate
Rapid EWR 9	Magalies: Downstream of Malony's Eye	A21F	*B*	Very high	B	14.7	45.58	Rapid 3
Rapid EWR 10	Elands: Upstream Swartruggens Dam	A22A	*C*	High	B/C	10.1	30.48	Rapid 3
Rapid EWR 11	Sterkstroom: Upstream Buffelspoort Dam	A21K	*C*	High	C	13.96	28.41	Rapid 3
MARICO								
EWR 1	Kaaloog-se-Loop: Below gorge	A31A	*B*	Very high	B	10.539	76.32	Intermediate
EWR 2	Groot Marico: Upstream confluence with Sterkstroom	A31B	*B*	Very high	B	42.08	50.26	Intermediate
EWR 3	Groot Marico: Downstream Marico Bosveld Dam	A31F	*C/D*	High	C/D	65.083	23.62	Intermediate
EWR 4	Groot Marico: Downstream Tswasa Weir	A32D	*C*	High	C	153.251	7.96	Intermediate
EWR 5	Klein Marico downstream Klein Maricopoort Dam	A31E	*C*	Moderate	C	39.42	4.67	Rapid 3
EFR M8	Molopo: Wetland	D41A	*C*	-	-	-	-	-
MOKOLO								
EWR 1a	Mokolo: Vaalwater	A42C	*C/D*	High	B/C	84.84	22.6	Intermediate
EWR 1b	Mokolo: Tobacco	A42E	*B/C*	High	B	135.03	17.6	Intermediate
EWR 2	Mokolo: Ka'ingo	A42F	*B/C*	Very high	B	196.2	19.8	Intermediate
EWR 3	Mokolo: Gorge	A42G	*B/C*	Very high	B	214.5	12.5	Intermediate
EWR 4	Mokolo: Malalatau	A42G	*C*	Very high	B	253.3	16.5	Intermediate
EWR 5	Mokolo: Tambotie floodplain	A42G	*D*	-	-	-	-	-

1) nMAR – Natural Mean Annual Runoff is based on the updated hydrology from the DWA 2010and 2011 studies

Table 5: EWR sites of additional rapids undertaken

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Eco-region level 2	MAR ($10^6 m^3$)
CROCODILE WEST							
EWR 12	A23G	Buffelspruit	Rapid III	-24.8304	28.2224	8.01	3.144
EWR 13	A22E	Elands	Rapid III	-25.48108	26.69039	7.03	18.77
EWR 14	A22H	Waterkloof-spruit	Rapid III	-25.48108	26.69039	8.05	5.469*
EWR 15	A21F	Magalies	Rapid III	-25.89690	27.59820	7.04	21.89
EWR 16	A21A	Rietvlei	Rapid III	-26.01885	28.30442	11.01	4.788
MARICO							
EWR 6	A31B	Polkadraai-spruit	Rapid III	-25.64697	26.48928	7.04	9.866
MATLABAS							
EWR 1	A41A	Matlabas ZynKloof	Rapid III	-24.41203	27.60324	7.04	5.23
EWR 2	A41B	Matlabas Haarlem East (A4H004)	Rapid II	-24.160139	27.4797111	1.03	32.80
EWR 3	A41B	Mamba River Bridge	Rapid II	-24.2127	27.50718	1.02	9.54
EWR 4	A41C	Matlabas Phofu	Rapid I	-24.05159	27.35922	1.02	35.58

3.2.4 Freshwater Ecosystem Priority Areas

The Freshwater Ecosystem Priority Areas (FEPAs) identified through the National Freshwater Ecosystem Priority Areas Project of the Water Research Commission (WRC, 2011) within the Mokolo, Matlabas, Crocodile (West) and Marico catchments were considered and assessed for RU delineation. FEPAs have been identified as those areas that are important for sustaining the integrity and continued functioning of their related ecosystems. The FEPAs of importance as identified in the Middle WMA are shown in Figure 6 (WRC, 2011). FEPAs are present in the Marico, Malmaniesloop, Upper Crocodile, Elands, Mokolo and upper Matlabas catchment areas.

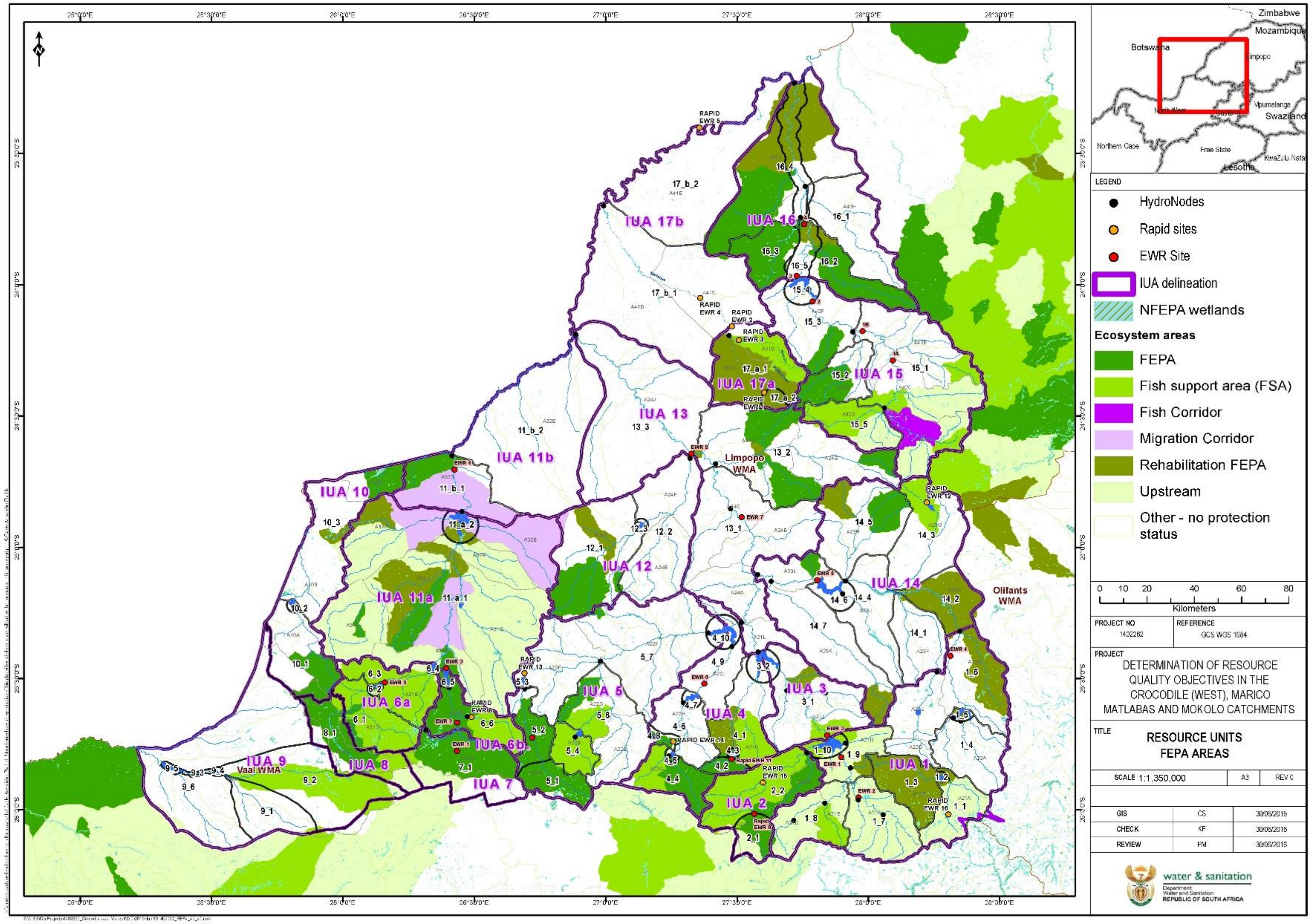

Figure 6: The FEPAs of importance and protected areas within the Crocodile (West), Marico, Matlabas and Mokolo Catchments

3.2.5 Water Infrastructure

3.2.5.1 Crocodile (West) and Marico

Major bulk water supply systems

A complex water infrastructure network exists, with most of the water requirements supplied by two major water boards (Rand Water and Magalies Water) which source water from the Vaal WMA and the Crocodile (West) River catchment. Most of the urban water requirements are supplied from surface water. Tshwane Metropolitan Municipality, Bela Bela and Thabazimbi Local Municipalities use groundwater in addition to surface water.

Dams

The following major dams exist in the Crocodile (West) River catchment:

- Hartbeespoort, Roodekopjes, Buffelspoort, Rietvlei, Roodeplaat, Klipvoor, Bon Accord, Leeukraal, Bischoffs, New Warmbaths, Old Warmbaths, Nooitgedacht, Meintjes, Vaalkop, Bospoort, Olifantsnek, Lindleyspoort, Kosterrivier, Mankwe (Houwater), Sun City, Rockwell, Swartruggens and Bierspruit.

The Crocodile River system is regulated by 9 major dams:

- Rietvlei, Hartbeespoort and Roodekopjes in the Upper Crocodile catchment;
- Roodeplaat and Klipvoor dams in the Apies/Pienaar catchment, and
- Olifantshoek, Bospoort, Lindleyspoort and Vaalkop in the Elands River catchment.

No major dams occur in the Lower Crocodile catchment area.

There are some 3 800 minor impoundments in the Crocodile (West) River catchment. (irrigation/municipal/recreation dams):

- 1 150 with a total storage capacity of ±19 million m^3 are in the Upper Crocodile sub-catchment,
- 688 with a total storage capacity of ±14 million m^3 are in the Elands sub-catchment,
- 856 with a total storage capacity of ±11 million m^3 are in the Apies-Pienaars sub-catchment; and
- 460 with a total storage capacity of ±12 million m^3 are in the Lower Crocodile sub-catchment. M

Wastewater treatment works

There are currently 32 wastewater treatment works (WWTW) operational in the Crocodile (West) River catchment. The largest WWTW in South Africa, Johannesburg Northern Works, is located in the Crocodile catchment discharging an average 400Mℓ/d to the Jukskei River.

Main irrigation related infrastructure

The Hartbeespoort, Buffelspoort and Middelkraal Government Water Schemes (GWS) as well as the Magalies, Zeekoeihoek, Kromdraai, Sterkwater and Buffelshoek Irrigation Boards are in the Upper Crocodile sub-catchment. The Lindleyspoort GWS as well as Koster River, Olifantsnek, Modderfontein and Glyklip IBs are in the Elands sub-catchment. The Pienaars

GWS as well as the Bon Accord and Warmbad Irrigation Boards are in the Apies-Pienaars sub-catchment and the Crocodile West River Irrigation Board is in the Lower Crocodile sub-catchment.

Rand Water imports water from the Upper Vaal WMA to the Crocodile (West) River catchment for urban, industrial and mining use. Water is also imported to Cullinan from the Olifants River catchment for urban use and for use on the Premier Diamond mine. Magalies Water exports water to supply the requirements of Modimolle (previously known as Nylstroom).

There are several inter-quaternary transfers within the Crocodile (West) River catchment. Most of these transfers form part of the Magalies Water supply system, supplying water to urban areas, mines and industries. A number of effluent transfers within the Crocodile (West) River catchment are also present.

3.2.5.2 Marico catchment

The natural mean annual runoff (MAR) of the Marico River catchment is approximately 126 million m^3/a. The available surface water resource is mainly from the Marico Bosveld and the Molatedi dams. The Marico Bosveld Dam in the upper catchment and the Molatedi Dam further downstream are the two major storage dams that regulate flow in the Marico River. There are other dams in the catchment such as the Klein Maricopoort and Sehujwane Dams, from which water is mainly used for irrigation along the Marico River. The main surface water impoundments of the Marico catchment are indicated in Table 6. There are no other economical sites available for the construction of dams in this sub-area (DWAF, 2004).

Table 6: Major dams in the Marico catchment

Catchment	River	Dam	Purpose
A31B	Groot Marico	Marico Bosveld	Irrigation
A31D	Klein Marico	Klein Maricopoort	Irrigation
A31E	Klein Marico	Kromellenboog	Irrigation
A31G	Tholwane	Madikwe	Domestic
A31H	Sandsloot	Sehujwane	Domestic
A32A,B,C	Groot Marico	Molatedi dam	Irrigation/Domestic
A31G	Tholwane	Pella	Domestic

The Marico Bosveld Dam situated in the upper catchment of the Groot Marico River (A31B) supplies irrigators downstream in A31.

There are a number of important rural settlements and irrigation developments in the Marico catchment, with Zeerust, Groot Marico and Madikwe being the main areas. The Marico River catchment borders on Botswana in the north and water is transferred from the Molatedi Dam to Gaborone. There is commercial agriculture downstream of the Marico Bosveld Dam and downstream of the Molatedi Dam.

The TSWASA scheme, which consists of the Molatedi Dam and associated infrastructure, was constructed to supply water to the former homeland of Bophuthatswana, South Africa and the Government of Botswana. An agreement known as the TSWASA agreement was signed in 1988. Its purpose was to supply water to the parties as follows (DWAF, 2004):

- 7.1 million m^3 /a to Gaborone for primary purposes;
- 5.0 million m^3 /a for irrigation purposes in the former Homeland of Bophuthatswana; and
- 10.6 million m^3/a for irrigation purposes in the then Republic of South Africa.

The above volumes are slightly higher than the firm yield of Molatedi Dam of 21 million m^3/a. However, the dam is operated at a higher risk, which is acceptable for irrigation purposes and hence there is potential for the Molatedi Dam to not be able to supply the demands with a 100% assurance (DWAF, 2004).

Zeerust the main urban centre in the Marico River catchment obtains most of its water supply from groundwater although the Klein Maricopoort River supplements its water supply. The rural towns of Madikwe and surrounding villages obtain their water requirements from the Madikwe Dam on the Thulane River. Some of the rural villages further downstream obtain their water from the Pella Dam. These water resources are fully utilised. There is potential for groundwater development to meet additional rural water supplies. The rural villages in the western portion of the catchment obtain their water from the Sehujwane Dam (DWAF, 2004).

Apart from water required for irrigation, other requirements include water mainly for domestic use and stockwatering. The urban water requirements are for the main towns of Zeerust, Groot Marico and Madikwe. Return flow is not being directly utilised but it contributes to the yields of the dams in the catchment. The Marico River catchment has no commercial afforestation and there is no water used for strategic uses.

Return flows from wastewater treatment works in Zeerust and return flows from the mines around Zeerust as well as irrigation in the Marico catchments is estimated at approximately 6 million m^3/a. Irrigation is the major contributor to the return flows in the Marico River catchment.

In terms of the Internal Strategic Perspective (ISP) for the catchment there are potential risks of supply failure from the Sehujwane, Marico Bosveld, Madikwe and Molatedi dams because the demands on the dams are much higher than the available yield. The Kromellenboog Dam is also being operated in combination with Marico Bosveld Dam and is also over utilised. The current operating rules for all the dams in the catchment which supply the irrigation scheme in the downstream catchment A31F, need to be reviewed (DWAF, 2004).

3.2.5.3 Mokolo catchment

The Mokolo River rises on the northern escarpment of the Wolkberg Mountains and flows almost due north to the Limpopo River. The surface water resources of the Mokolo catchment are substantial while groundwater is also used. The catchment is mostly rural in nature with only two significant towns, Vaalwater in the south and Lephalale in the north. The numerous small farm dams in the catchment, the run-of river and Mokolo Dam contribute to a large surface water resource estimated at 77 million m^3/a after allowing for the Ecological Reserve. The Mokolo Dam was constructed to provide water to the power station and coal mines located near Lephalale. The dam has a full supply capacity of approximately 146 million m^3. The natural MAR at the dam site is estimated at 240 million m^3/a.

The small capacity of the dam, when considered against the growth potential of Lephalale, means that there is limited capacity to manage water releases for environmental purposes. The downstream river is therefore dependant on flood flows that overspill the dam, and irregular water releases supplied to downstream irrigation agriculture.

However, in recent years, the downstream river has become heavily infested with reeds (*Phragmites mauritianus*), and irrigation releases have been increasingly hard to manage. The reeds not only consume large volumes of water, but also restrict flow through narrow encroached channels, delaying the delivery of released water to the lower reaches of the river.

The inability to deliver water effectively to the lower river is thought to impact adversely on water temperatures and ecological cues that could disrupt breeding cycles of aquatic fauna due to the unseasonal nature of the releases. The Mokolo Irrigation Board has, through consultation with DWAF and Limpopo Environmental Affairs, embarked on a regular aerial spraying program of the reeds using a herbicide. While the spraying appears to have a significant impact on the reeds, the effects of decaying weeds on water quality and the cumulative impacts of the herbicide on aquatic fauna, and other flora, have yet to be determined.

The current groundwater resource is estimated at 11 million m^3/a and this is used to supply irrigation and domestic rural use.

The town of Lephalale has three small domestic wastewater treatment works of < 5Mℓ/d capacity and Vaalwater has one. ESKOM also runs a wastewater treatment works in Lephalale and the mines in the catchment all have small wastewater treatment works.

3.2.5.4 Matlabas catchment

The Matlabas catchment is a largely undeveloped catchment with limited water resources and water use. There are no significant dams in this catchment and a significant portion of the water use is from groundwater due to the low assurance of the run-of-river yields. Due to the highly erratic surface water flow, the yield from surface water resources is negligible, while there are ample groundwater resources which are underutilised.

The largest water use in the Matlabas catchment is irrigation, but even this is very limited and estimated at only 4 million m^3/a, half of which is sourced from groundwater. There are limited rural requirements, estimated as 2 million m^3/a, which are supplied from groundwater.

3.2.6 Groundwater (Hydrogeology)

3.2.6.1 Geological Background

The geology as published by the Council for Geoscience on 1:250 000 scale maps for the study area is shown in Figure 7, in relation to delineated IUAs. Major fault zones are also indicated as increased groundwater yield potential is generally present at these structures. The groundwater resource potential of the major faults is often not recognized due to limited focused geohydrological investigations to date.

The Limpopo Mobile Belt is present in the northern sections of IUA16 and IUA17b which comprise of gneissic, granites, granulites, serpentenites, metapelites and horneblende gneisses, which have undergone high grade granulite metamorphism. The Beit Bridge Complex consists of metaquartzite, calcsilicate, amphibolite, meta-pelite and pink hornblende gneisses and represents part of the Greenstone Belts. These Greenstone Belts are infolded mainly into grey granitic gneisses which dominate the early Archaean terranes.

To the south of the Limpopo Mobile Belt the area is underlain by Waterberg Group sandstones which cover most of IUA 15, IUA 17a and southern portion of IUA 16, consisting of a wide variety of different lithologies.

Karoo Super Group rocks consisting of shale, shaley sandstone conglomerate with coal in places, occur in the central portions of IUA16 and IUA17b.

North of the Magaliesberg the geology is largely dominated by the Bushveld Complex, a massive layered igneous complex. The lower portion of the intrusive complex comprises of ultramafic rocks known as the Rustenburg Layered Suite, which is overlain by acidic rocks that form the Rashoop Granophyre Suite and Leboa Granite. The Rustenburg Layered Suite is rich in minerals and a number of mines have been developed. Platinum, chrome and vanadium mining in particular are taking place at a large scale. The Rashoop Granophyres and Leboa Granite represent weathered and fractured aquifers which often contain excessive fluoride in groundwater from geological origin, rendering the water unsuitable for human consumption.

Dolomite formations of the Malmanie Subgroup occur in four IUAs situated on the southern boundary of the study area. In the Upper Crocodile sub-catchment, dolomite formations are found in the Rietvlei Dam catchment at the confluence of the Tolwane and Pienaars rivers as well as the origin of the Apies River (Pretoria Fountains) in the Apies/Pienaars sub-catchment. Further west to the (north and west of Mogale City) large dolomite compartments occurs and is used for irrigation*, i.e.* the Tarlton area towards the Maloney's Eye, *viz*. the Steenkoppies Compartment). Dolomite formations also occur in the south-western parts of the Marico catchment in the Lichtenburg-Itsoseng area and further north towards Lobatsi (Botswana).

The dolomite formations are compartmentalised by intrusive dykes and represent dolomite compartment units with unique water bearing characteristic (good quality and significant yield potential, however, vulnerable to pollution and over utilization.

The Lower Crocodile River in catchment A24J traverses and is incised into an alluvial flood plain underlain by mainly basement complex granites, termed the Makoppa Granite Dome. The total reach of the river is some 92 km. Hobbs (1986) reports that the alluvial aquifer is in hydraulic connection with the river, which recharges the aquifer during flow events. The alluvial aquifer is partially underlain by highly productive secondary aquifers, associated with highly fractured granite bedrock.

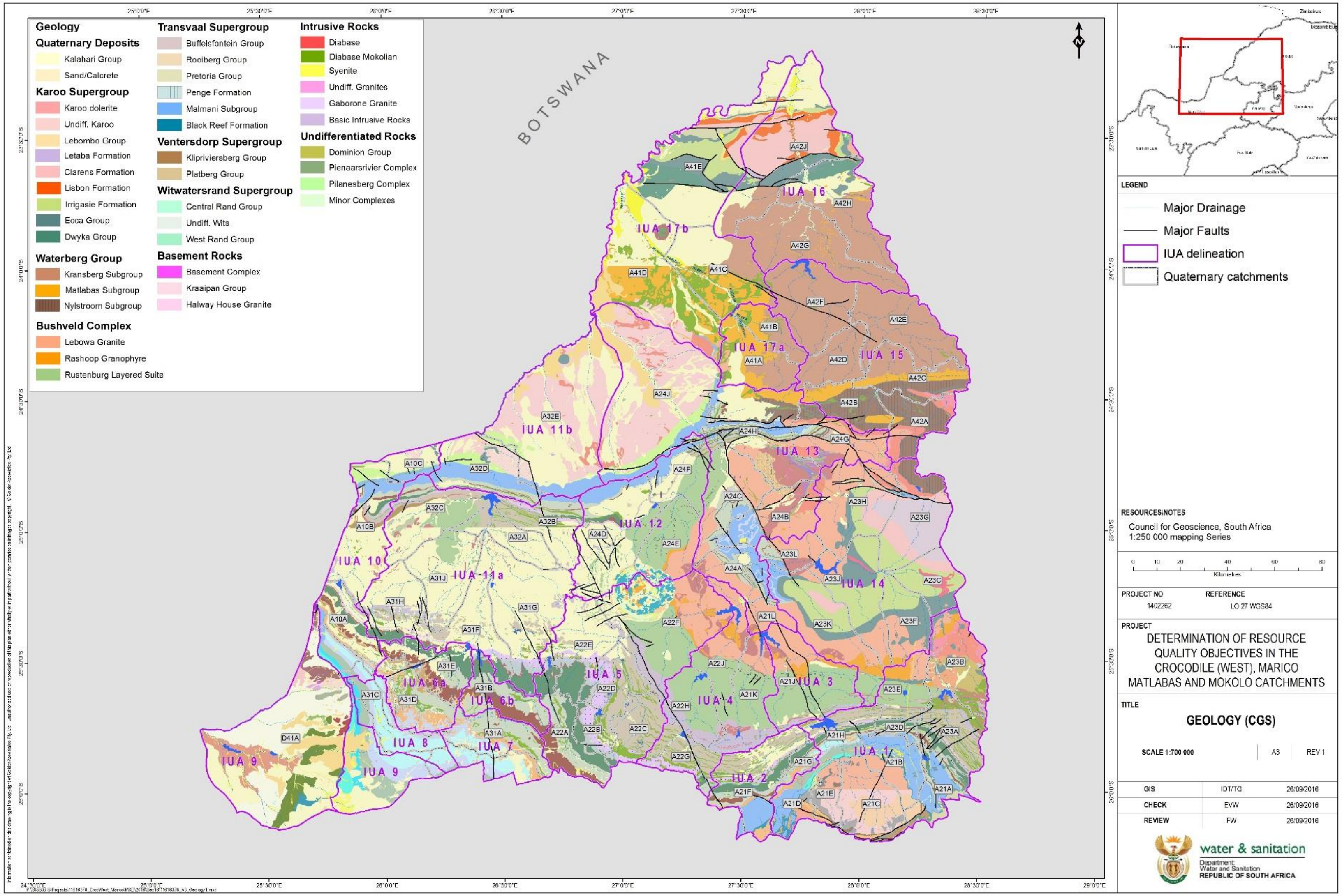

Figure 7: Illustration of the primary and secondary geological features in the study area

The valley of the Crocodile River, upstream of Thabazimbi in catchments A24H, A24C and A24B, contains extensive alluvial deposits for approximate 80 km in length - termed the Crocodile River Valley Aquifer. The area is known for intensive irrigation which relies heavily on both surface and groundwater resources.

The rest of the catchment consists mainly of sedimentary rocks. The quartzitic Magaliesberg forms prominent topographic features (west – east running ridges due to tectonic effects pertaining from the northern Bushveld Igneous Complex intrusion).

3.2.6.2 Aquifer types

Aquifer systems in South Africa are described in terms of their hydrogeological characteristics (rock types), *i.e*.

- Intergranular (referenced as primary aquifers, alluvial aquifers are limited to the main river stems and thick (>50 m) regional semi-consolidated formations such as the Kalahari Group sediments);
- Fractured (referenced as secondary aquifers, typical fractured (broken) hard rock granitoids/gneissoids, banded ironstone, orthoquartzitic sandstones; massive basalt/andesitic lava's, rhyolite/felsite extrusive rocks, competent metamorphic rocks such as quartzites, granulite and marble and intrusive rocks such as dolerite, diabase, norite and gabbro);
- Karst (mainly continental dolomite formations where deep leaching has produced karst/cavernous systems); and
- Intergranular and Fractured (typical combination of a deep weathered rock such as granite/granite-gneiss, sandstone, soft rocks such as shales, mudrock and tillite, and incompetent metamorphic rocks such as phyllite and slate).

The second classification criteria for aquifer systems is based on the Borehole Yield Classification criteria*, i.e.*

Borehole Yield Class (l/s)	Aquifer Rating
0 to 0.5 l/s	Insignificant
>0.5 to 2.0 l/s	Minor
>2.0 to 5.0 l/s	Moderate
>5.0 l/s	Significant

With relevance to the study area, the aquifer types and borehole yield classes (median l/s) are illustrated in Figure 8.

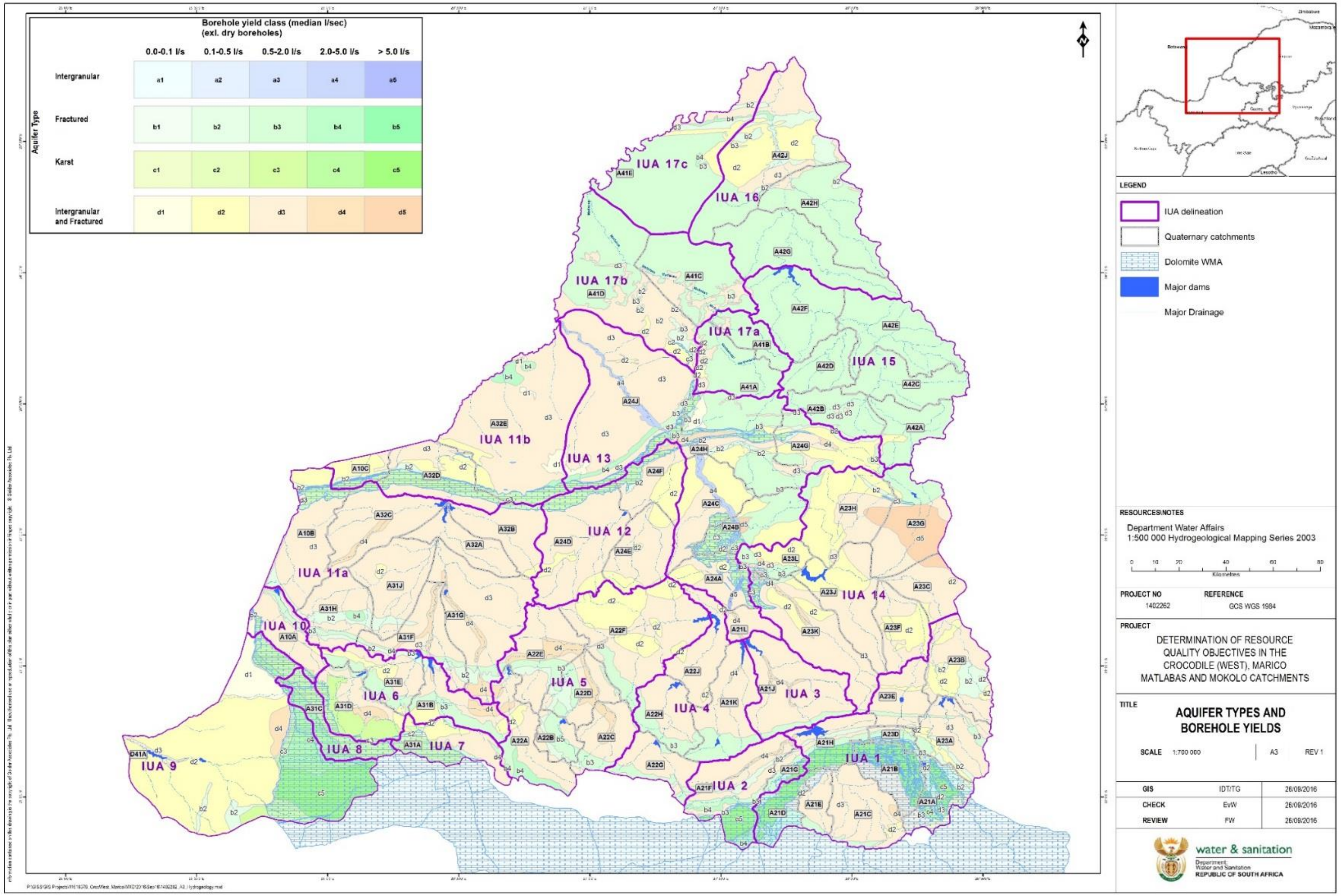

Figure 8: Illustration of the Aquifer Types and Borehole Yield Classification in the study area

Intergranular

Alluvial aquifers consist of unconsolidated or partially cemented rock fragments and are mostly found underneath and/or adjacent to surface drainage channels in valleys and flat lying flood plain areas. Intergranular (alluvial) aquifers are in most cases directly recharged by flood events in the river channel and are in equilibrium with the river stages. They are recharged during periods of high stream-flows as well as during the rainfall season. It is an important local, aquifer and could exists in equilibrium with surface water, adjacent secondary groundwater systems, and ecosystems along the surface water sources, *i.e*. wetlands.

- Crocodile West: These are situated along the main stem of the Crocodile River are important in terms of impacting the local surface water system due to return flows where irrigations and /or industrial activities occurs.. This is included in the surface water quality criteria, however, where significant groundwater is abstracted from the river valley alluvium aquifers, the impact of the surface flows becomes an important aspect to the controlled. Moderate to significant yielding alluvial aquifers occur along the main river channels of (i) the Crocodile River from below the Roodekoppies Dam down to its confluence with the upper Limpopo River and specific the following quaternary catchments along the main drainage channel (*viz*. A24A, –B, –C, –H and –J). Aquifer yields are in the order of 2.0-5.0l/s to the surrounding intergranular and fractured aquifers of minor to insignificant ratings (viz. < 2.0 l/s). Significant alluvium deposits were mapped along the lower main stem (*i.e*. between Thabazimbi and confluence of the Marico River, *viz*. start of the Limpopo River) of the Crocodile River in IUA11b reaching thicknesses of up to 40 m. These alluvium aquifers in combination with underlying weathered bedrock (a weathered and fractured aquifer type) form a significant alluvial aquifer system, and in combination with the Crocodile River's surface water component, represents a significant water resource in IUA11b.

  Further to the west, similar aquifers are present along the main stem drainages in the following quaternary catchments, A22C, –D and –E (as illustrated if Figure 9). These systems are classified as moderate rating (*i.e*. 2.0 to 5.0 l/s).

- Marico: In the head waters regions of the Marico River catchment, moderate aquifer ratings have been mapped in conjunction with natural drainages, *i.e*. quaternary catchments A31G, –F, and A32C. A moderate yield rating has been mapped along these drainages. Marico: Aquifer systems adjacent to the main stem of the Madikwene (A31G – Madikwene) and the Klein-Groot Marico (A31F, adjacent to the Marico Bosveld Dam drainage systems are classified as intergranular and fractured (2.0-5.0l/s).

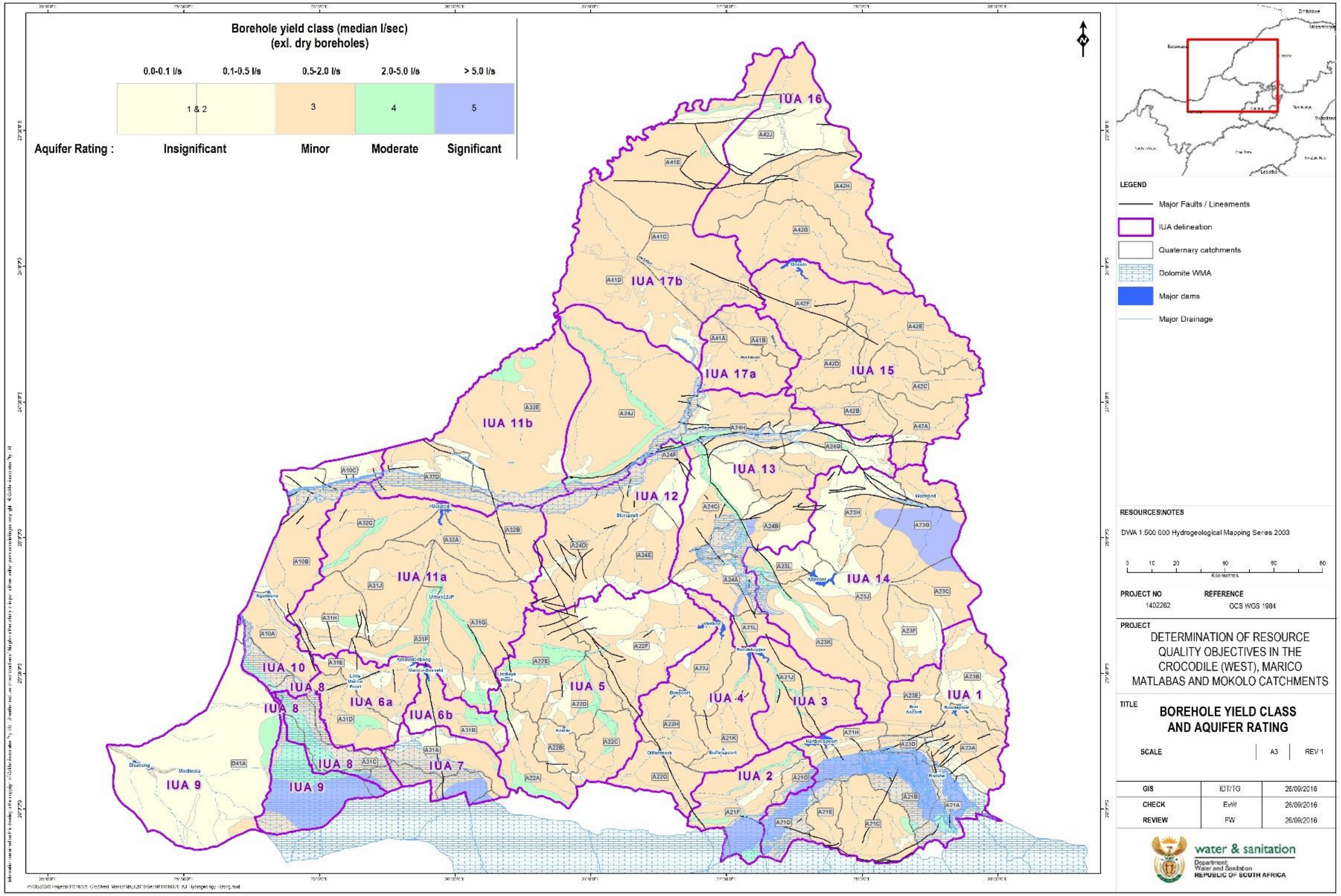

Figure 9: Illustrating Aquifer Ratings and Borehole Yield Class

- Elands River upstream of the Vaalkop Dam QC (A22F): Aquifer systems underlying and adjacent to the upper stems of the drainage system *viz*. the Roosspruit (A22E) and Koster (A22D) are classified as intergranular and fractured aquifer systems and consist of alluvial deposits underlain by fractured rocks of the Transvaal Supergroup. Borehole yield classes in these systems are one rating order higher than the surrounding fractured and weathered aquifer class (viz. 0.5-2.0 l/s versus 2.0-5.0l/s);
- Limpopo (Matlabas and Mokolo): Although alluvial deposits have been mapped along these rivers, the thickness and flow status of the river systems do not support significant intergranular aquifer systems. Borehole yield classification and aquifer ratings, are based on the potential of the surrounding intergranular & fractured and fractured, hard rock systems (as discussed below), *i.e*. Minor to Insignificant (<2.0 l/s).

The water quality status of intergranular aquifer are highly influenced by the local land use activities, the quality in the adjacent river channel (could be impacted by upstream water uses), and the water quality of the underlying/adjacent regional aquifer systems. The overall groundwater quality in the intergranular aquifer systems are in the Marginal water quality class (70 to 300 mS/m). The result of anthropogenic pollution (probably poor water treatment and heavy fertilizer feeding) has resulted in elevated nitrate (NO_3 as N) concentration (>10 mg/l) along the lower reaches of the Crocodile West (Thabazimbi to Limpopo River confluence) and the Matlabas (UIA13 and –17b), as indicated in Figure 10.

Fractured Hard Rock Aquifer Systems.

These aquifer systems are the most typical systems in the region and consist of rock formations from a wide grouping of sedimentary, igneous, and metamorphic origin.

- The Waterberg Group (mainly in the Matlabas and Mokolo catchments): aquifer is predominantly of a fractured and weathered type potentially connected to alluvial deposits occurring along the Mokolo River. The main groundwater targets are associated with fractured dyke contacts and fault zones. The Waterberg formation is associated with steep topography and shows generally poor capability to produce huge amounts of groundwater. Recharge to the aquifer, often discharged on the steep slopes as interflow, and provides baseflow to the local surface water drainages. A weathered zone aquifer is found only where local deep weathering occurs and provides groundwater storage that feeds the underlying fractured aquifer.

  Yields varies from Minor to Insignificant and water quality (EC) varies from Good (~70 mS/m) to Marginal (~300 mS/m) with elevated nitrate NO_3 (as N) and fluoride (*viz*. IUA_17b).

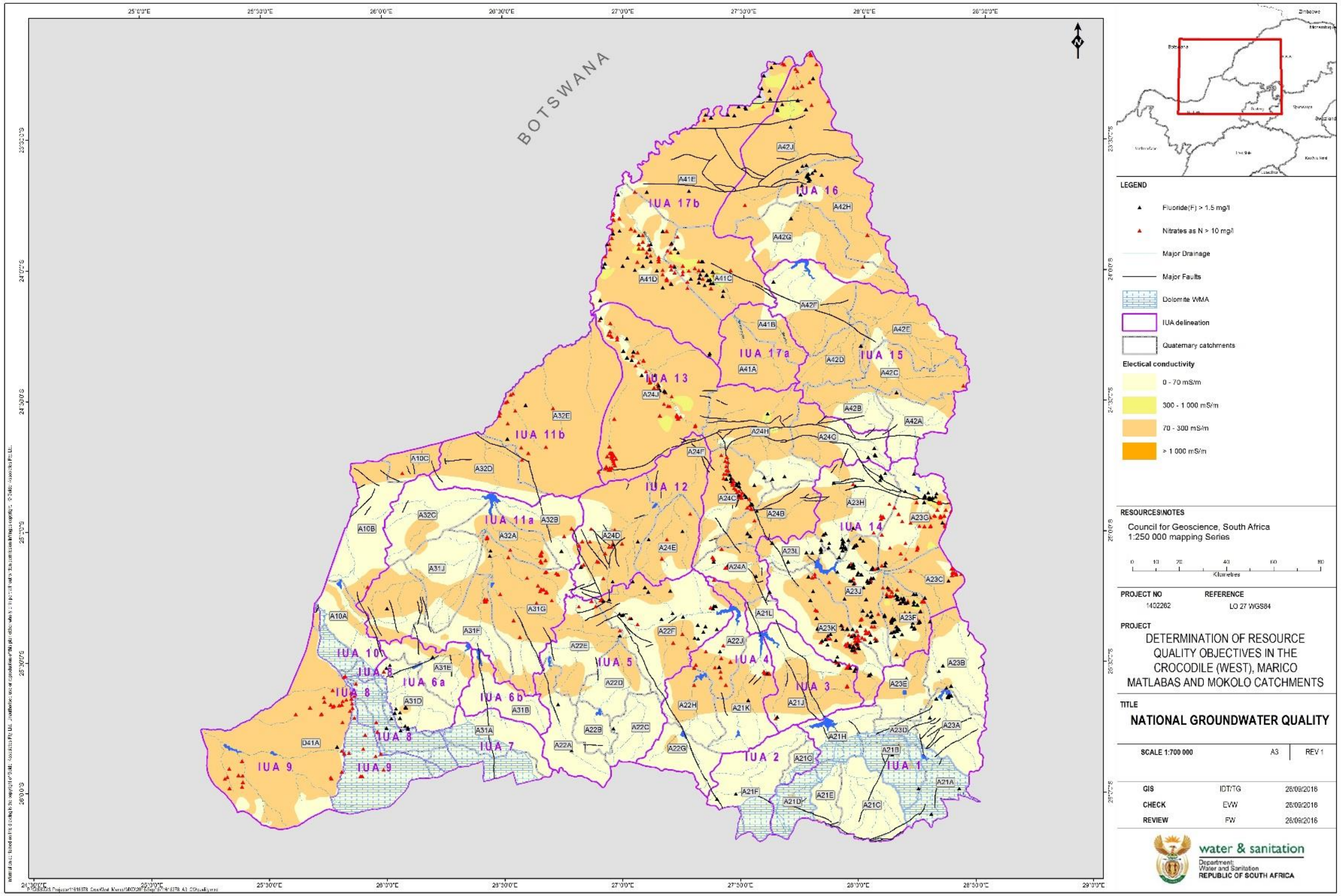

Figure 10: Illustration of the groundwater quality based on the geohydrological mapping programme

Other geological groupings that falls under this aquifer type classification, are as follows:

- The Karoo Supergroup: aquifer is predominantly of a fractured nature comprising of fractured consisting of mudrock, sandstone and coal seems, mudstones and siltstones, capped by Clarens sandstone/siltstone formations – in the central parts of IUA 16 and 17b (A42J and A41E respectively). The aquifer rating is a minor (*viz*. <2.0 l/s) with water quality in the Good to Marginal classes (*i.e*. 70 to 300 mS/m);
- The Transvaal Supergroup: (partly, predominantly meta-arenaceous quartzitic aquifers of the Timeball Hill and Magaliesburg formations with limited weathered zones, but significant deep fracturing due to the younger Bushveld Igneous Complex (emplacement) – Ideal to Marginal water quality (<300 mS/m) but Minor aquifer yield rating (<2.0 l/s) in the head waters catchments of the Marico and southern quaternary catchments of the Crocodile West, *i.e*. A31(A, –B, –D and –E), A22(A, – G, and –H), A21(A, –F, –G, –H, -J, and –K), and A23(A and –D).
- The Witwatersrand Supergroup (limited exposure in IUA_1 only, mostly subequal shale and quartzite in quaternary catchments A21D and –E).
- The Basement Rock Formations granitoids of the Makoppa Dome (IUA_11b) and Halfway House Granite complexes (A21C and A21C) with minor yield ratings (0.5 to 2.0 l/s) and marginal to fresh to marginal water quality respectively; and
- Intrusive Rock Formations (complexes): Glenover Carbonatite (A41D) with Ideal to Marginal water quality (<300 mS/m) and Minor yield rating (<2.0 l/s). The Rashoop granophyre in the southern part of quaternary catchment A24H is part of the Bushveld Igneous Complex and has a Minor aquifer rating (<2.0 l/s) with Ideal water quality (<70 mS/m).

Intergranular and Fractured Aquifers:

These aquifer systems represent a combination of an upper horizon of weathered/broken rock and a deeper, underlying zone of jointed/fractured rocks in most cases the same formation composition. In drainage channels, these aquifer systems are high productive and a unique surface-groundwater interaction system exists:

- Basement aquifers that comprise of deeper fractured (*i.e*. secondary) aquifers overlain by a weathered horizon of variable thickness. Thick, weathered aquifer zones are expected in areas where the bedrock has been subjected to intense fracturing. The existence of diabase and dolerite dykes forms poor groundwater targets due to the lack of weathering on the margins of these dykes with the basement rocks (gneiss), especially below the static water level. The most noticeable aquifer within the basement rocks are the East northeast (ENE) trending zones of shearing, faulting and brecciation and are usually covered with Quaternary deposits contributing to the aquifer’s storage potential;
- The Karoo Supergroup: aquifer is predominantly of a fractured and weathered nature comprising of fractured rocks with a spasmodic porous matrix. These aquifer systems occur on the eastern side of the study area, A23H, –J, and –K, and groundwater resources and especially the development thereof, are limited due to the low recharge to these aquifers – Minor to Insignificant Aquifer Rating (<2.0 l/s);

Most of the other geological groupings that falls under this aquifer type classification, are as follows:

- The Bushveld Igneous Complex: crystalline hard rock formations/aquifers (Nebo/Lebowa Granite and Pyramid Gabrro-Norite) with limited weathered zones, but local deeper fracturing. Minor aquifer yield rating (<2.0 l/s) with water quality variations between 70 and 300 mS/m (Good to Marginal Class). Predominantly present in IUA14 (parts of A23F, –H, –J, –K, and –L, and –J), IUA13 (parts of A24C, and A24H), IUA11A (lower parts of A31J, –G, and A32A, –B, and –C), IUA12 (A24D, –E, and –F) IUA5 (A22F), IUA4 (A22H, –J, and –K), IUA3 (A21J);

- The Transvaal Supergroup: (partly, predominantly meta-argillaceous Silverton shale and Hekpoort extrusive lavas, Smelterskop shale/arenite/andesite and Rooiberg felsites with Ideal to Marginal water quality (<70 to 300 mS/m) with Minor aquifer yield rating (<2.0 l/s) in head waters regions of IUA 11a (A31H, –F, and G), IUA5 (parts of A22A, –B, –C, and –D), IUA4 (A22G), IUA2 (A21F, and parts of A21G), IUA1 (parts of A21H, head water parts of A23A, and head water parts of A23E);
- The Ventersdorp Supergroup (not extensively present, extrusion type deposits with well-developed local weathered zones, but otherwise a competent, crystalline hard rock type aquifer) – Insignificant yield classification (<0.5 l/s), and Good to Marginal water quality (*i.e*. 70 to 300 mS/m) range:
- The Basement Rock Formations: granitoids of the Makoppa Dome (IUA_11b) and Halfway House Granite complexes (A21C and A21C) with minor yield ratings (0.5 to 2.0 l/s) and marginal to fresh water quality respectively (*i.e*. <300 mS/m). The Mount Dowe and Alldays Gneiss occurs in the most northern parts of IUA16 and IUA17b, quaternary catchments A42J and A41E respectively, a Minor aquifer rating (<2.0 l/s) with Good to Marginal water quality (70 to 300 mS/m). Elevated nitrates (NO3-N, >10 mg/l) and fluorides (F) are abundant in this basement rock area.
- Intrusive Rock Formations (complexes): Goudini Complex (A31J) with Insignificant yield rating (<0.5 l/s), Ideal water quality (<70 mS/m), Pilanesberg Complex (A22F, A24E and A24D) with Insignificant yield rating (<0.5 l/s) and Ideal to Marginal water quality (<300 mS/m), Nooitgedacht and Kruidfontein Carbonatite (A24A) with Insignificant yield rating (<0.5 l/s) and Good to Marginal water quality (<300 mS/m).

Karst Aquifers:

A special grouping of aquifer systems characterised in terms of hydrogeological properties including significantly higher recharge rates, hydraulic parameters and subsequently, it's potential as a sustainable aquifer system. In addition, this aquifer systems vulnerability rating towards pollution and ground stability is high. Flushing of a dolomite aquifer system is more realistic than in the other aquifer systems, and is merely based on a significant dilution process, normally driven by the high recharge rates associated with dolomite water areas. Other specific features are as follows:

- Associated with the Malmanie Subgroup dolomite formations in the southern parts of the Crocodile (West) and Marico catchments, are highly productive, especially in chert rich horizons with extensive karst zones where sustainable borehole yields between 5 and 20 l/s are common. High yielding production boreholes with abstraction rates > 40 l/s for 24 hours per day are in use for domestic and irrigation water supply.
- A large number of intrusive dykes, with low to impervious hydraulic conductivity, compartmentalize the dolomite aquifer which may be partially hydraulically linked with surrounding compartment units. Several dolomite springs occur where the dolomite water discharges as surface flow and support downstream dolomite compartment units and/or surface water/wetland systems.

- Groundwater gradients are highly variable, typical of the compartmentalizing effect of diabase/dolerite dykes on the local/regional flow patterns in dolomite aquifers. Within dolomite compartments bounded by dykes, groundwater gradients are generally very low indicating high aquifer transmissivity. Pending the topographic relief and the hydraulic conductivity of dykes, very steep (several metres) groundwater gradients (or steps) are observed across dyke boundaries. In areas with low topographic relief, the potential boundary effect of some dykes may presently not be evident from groundwater piezometric levels.

The high yielding dolomite compartments are used extensively for domestic (Pretoria, Centurion, Tarlton, Mafikeng and Zeerust areas) and irrigation water supplies. Spring flows from dolomite compartments have mainly been secured for bulk municipal supply purposes. These flows have been diverted into pipelines, thereby limiting or curtailing their contribution to the original receiving surface water catchments. Due to high water supply demands, natural flows (dolomite eyes, or springs) from these dolomite compartments have been augmented by abstraction boreholes in the vicinity of the eyes, which subsequently lowered the water table resulting in total capturing of the natural spring flows, *i.e*. the Grootfontein Eye supplying Mahikeng in IUA9 (D41A).

More detailed discussion of the characteristics of the various dolomite water areas in the study area is discussed under Section 5.2.

Geological Contact Aquifers:

The study area is significantly intersected (criss-crossed) by secondary geological features consisting of dykes (diabase, syenite, and pre/post Karoo Dolerite), faulting (*viz*. dip faulting), and breccia zones (silicified).

Although not specifically classified under the national geohydrological aquifer classification system, geological contacts (i.e. fracture zones, fault zones, and various dyke intrusions), plays a significant role in the occurrences of groundwater (specifically the actual borehole yield status). Borehole yields of these contact type aquifers, are normally an order of magnitude higher than the surrounding aquifer system (intergranular & fractured and fractured types). Dolerite dykes, and specifically the Jurassic Karoo dolerite dykes play an important role in local borehole yields due to the high permeabilities of the dyke/host rock contact zone. These high yields, however, is still depends on the storativity of the adjacent host rock formation, *i.e*. a dolerite-shale contact aquifer might not have a similar sustainable yield classification than a dolerite-sandstone type combination. In many cases, dyke/sill-like intrusives may act as groundwater flow boundary systems – which in the case of the dolomite water areas, forms the compartment boundaries where the dolomite eyes occur.

3.2.6.3 Registered Groundwater Use

The main water user sectors of groundwater in the catchments are:

- Mokolo: Mining (dewatering of opencast pits for coal mining), municipal water supply (Vaalwater and other smaller towns/villages), rural domestic, livestock farming/nature reserves and commercial irrigation farming;
- Matlabas: Local, village water supply (*i.e*. Steenbokpan), rural domestic, small scale irrigation and livestock farming;
- Crocodile West: Urban domestic (Pretoria/Centurion: extensive groundwater abstractions from dolomite compartment units, part of surface water - groundwater conjunctive use), non-urban/rural domestic (conjunctive supplies: Thabazimbi, Bela Bela and Rustenburg rural sectors,

most other rural villages and communities supply augmented from piped surface water supplies), mining related (limited mine dewatering on platinum mines), irrigation (significant uses along the lower stem of the catchment, *viz*. A24J quaternary catchment, the western Springbok Flats and the Maloney's Eye-Skeerpoort River), extensive irrigation from dolomite compartment units (Tarlton, Maloney's Eye catchment, Bapsfontein-upper Rietvlei system), and livestock/dry land farming support.

- Marico: non-urban/rural domestic (sole supplies: Dinokana and Zeerust, conjunctive supplies: Swartruggens, Groot Marico, Pella, Madikwe and Koster supported by piped, local surface water supplies), bulk water supplies from dolomite compartment units (Molopo Eye and Grootfontein for Mahikeng), extensive groundwater irrigation schemes (Grootfontein and Groot Pan dolomite compartment units), recreational (Molopo Eye), mining related (local mine dewatering on alluvial aquifers for diamond mining and limestone/cement factories) and extensive livestock water supplies on private and rural farming land; and
- Upper Molopo: Urban domestic (Mafikeng and Itsoseng), extensive irrigation schemes from dolomite aquifer systems (Lichtenburg-Itsoseng dolomite compartment units) and extensive livestock/dry land farming support.

The status of groundwater use registrations is yet not sufficiently audited; thus the information supplied in the WARMS dataset required more detailed assessment before realistic calculations of quaternary groundwater use figures should be endeavored.

3.2.7 Wetlands

The description of the wetlands and wetland systems within the Mokolo, Matlabas, Crocodile (West) and Marico Catchments per IUA is provided in the sections below.

3.2.7.1 IUA1: Upper Crocodile/Hennops/Hartbeespoort

Based on the current conditions, an understanding of the geomorphology, drainage patterns, and soils in the remaining relatively undisturbed open space areas of this IUA, five wetland types are encountered, namely pans, hillslope seepage wetlands, unchannelled valley bottom wetlands, channelled valley bottom wetlands and floodplains. Large parts of this IUA have been converted from grasslands to accommodate industrial and housing estates. This has taken place at the expense of grasslands and their associated hillslope seepage wetlands and secondarily on previously unchannelled valley bottom wetlands. Many historically unchannelled valley bottom systems have become channelled as a result of post-development changes in hydrology. Increased surface runoff as a result of the development of the catchments of many of these systems has resulted in erosion and the development of headcuts and channelling in most of these systems in the urban environment.

Pans are also fairly well represented in the IUA, mainly towards the south-east with approximately 24 occurring between Midrand and Kempton Park. Pans are recognized as being important for biodiversity support and more recently their links to other wetland systems in relation to landscape hydrology have also been highlighted. Pans are also unique in terms of their individual biogeochemical attributes. The pans in the Midrand and Kempton Park area are considered important, mainly from a biodiversity perspective as they support related bird and amphibian populations. Those that still have some of their catchments intact or that still have associated hillslope seepage wetlands such as Bullfrog pan in Glen Austin are thought to support some of the last remaining populations of the Giant bullfrog (Pyxicephalus adspersus) on the Highveld. The remaining pans and their associated hillslope seepage wetlands are thus regarded as critical habitat for these populations. The wetlands including the pans in this area are all threatened by impacts from urbanization. Wetland habitat loss continues as urbanization expands and the hydrology of the related systems and catchments change due largely to stormwater management or lack thereof.

The Rietvlei wetland system is situated immediately upstream of the Rietvlei Dam within the Rietvlei Dam Nature Reserve. The wetland is a peatland.

Historically the Rietvlei wetlands were heavily eroded and desiccated, having been drained for cultivation and peat mining before the area was proclaimed a nature reserve. In recent years, the dam has become overloaded with nutrients and other pollutants, as its highly urbanized catchment has received increasing volumes of treated domestic sewage and industrial effluent. Partly in response to this situation, and recognising that the wetlands were degraded, Working for Wetlands (WfW) formed a partnership with the Tshwane municipality in 2000 to rehabilitate the wetlands upstream of the dam. Monitoring results tend to show that there has been some improvement of the quality of water flowing into the dam.

Another important wetland that occurs within the urban setting in this IUA is the Colbyn Valley wetland. It is approximately 15 ha in extent and is situated on shales of the Silverton Formation.This wetland with its associated peat is a scarce wetland type in the Pretoria region and as such has an intrinsic conservation value. In terms of species composition, diversity and abundance however, the Colbyn Valley wetland is not unique in the region (Grundling and Marneweck, 1999). The uniqueness value is therefore a result of the peat resource it contains. Since the peat has developed in response to specific physical and biological conditions, it can be argued that factors such as the hydrological regime, slope and low energy environment which have created conditions favourable for the accumulation of peat are in their own right rare features in the area. Peat therefore is the product of the features which make this type of wetland scarce or rare in the region. The system has been impacted as a result of adjacent land-use and hydrological changes and is considered to be largely modified with a PES of D. The EIS on the other hand is regarded as High to Very High due to the uniqueness of the system in the region.

A number of floodplain wetlands also occur in the region, including the Apies River floodplain which has been canalised and straightened in the urban areas. This has resulted in higher flows which in turn have also altered channel and bed shape in the floodplain area lower down in the system. Urban runoff, sewage spills and litter from settlements impact heavily on water quality and the functional integrity of the river. Most of the riparian vegetation has been cleared due to high levels of development and where this remains, it is generally associated with steep banks and terraces that are scoured. Alien vegetation encroachment is high in some areas with mulberries, jacaranda, seringa and sesbania being some of the more common species. Across much of this area, watercourses are not afforded the opportunity of self-adjustment to accommodate changes to the imposed hydrology because of encroachment of buildings and other infrastructure such as parking lots and roads. This severely limits opportunities to effectively manage the wetlands.

3.2.7.2 IUA 2: Magalies Catchment Area

Maloney's Eye, the source of the Magalies River, a tributary of the Skeerpoort River upstream of Hartebeespoort Dam, is a unique dolomitic eye in the upper Crocodile West system and should be regarded as a priority system. Any forms of mining activities or other developments which could negatively impact the upper reaches of Maloney's Eye are considered incompatible with the local spatial development plan and would potentially threaten the ecological integrity of the river and the EIS of the associated eye and wetlands along its course. Wetlands are mostly confined to the banks of the Magalies River and hillslopes adjacent to the river.

The general water quality in the wetland systems is very good and can be considered to be close to natural in most areas, particularly in the upper watershed. In the upper reaches of the Magalies River, water is predominantly alkaline due to the local geological and biological processes and the overall integrity of many of the systems in the watershed can be considered to have a PES that is unmodified or natural (A) or largely natural (B). The EIS of the wetlands associated with the river and around the eye would be regarded as high to very high. The surrogate PES analysis of the mapped wetlands shows PES categories of D for many of the larger systems in the IUA mainly due to agricultural impacts associated with cultivation.

3.2.7.3 IUA 3: Crocodile/Roodekopjes Catchment

Apart from the Langberg, the topography is relatively flat, and in places the heavy vertic soils preclude subsurface seepage which is generally integral to wetland formation. Wetlands are therefore mostly associated with incised drainage lines and streams and low lying depressions, and are widely dispersed.

Water does not have the opportunity to infiltrate the soil and accumulate for long enough periods to impart hydromorphic characteristics to the soil profile. It is also likely that any hydromorphy is masked by magnesium oxides and organic matter in the dark soils. This explains the relative scarcity of wetlands in this landscape. It is likely that there is subsurface movement of water laterally across the landscape at depth through the interface between the soil and parent material.

3.2.7.4 IUA 4: Hex/Waterkloofspruit/Vaalkop Catchment

A number of wetland types occur in this IUA, with most containing clear wetland hydromorphic characteristics. In particular depression wetlands and channelled and unchannelled valley bottom systems are quite common. Many of the unchannelled wetlands, driven mostly by diffuse inputs from relatively flat, large, inward-draining catchments, are undergoing channel incision, often as a result of road crossings or other impacts that result in the concentration of flow. In parts of this IUA there are coarse-grained, sandy, shallow soils within a gently undulating topography, attributes which are conducive to the formation of valley bottom and seepage wetland systems. Unchannelled valley bottom wetlands in these areas are mostly dominated by temporary and seasonal wetland zones, and driven predominantly by subsurface seepage of water through the shallow, sandy catchment soils.

Typical unchannelled systems with perennial watercourses dominated by *Phragmites australis* and a well-established riparian fringe are also found in this IUA. An important wetland in this IUA is the Waterval Valley mire (peatland) in the Kgaswane Nature Reserve which has been subject to rehabilitation as part of WfW programme.

3.2.7.5 IUA 5: Elands/Vaalkop

Based on an understanding of the geomorphology, drainage patterns, and soils in this IUA, four wetland types occur, namely pans, hillslope seepage wetlands, unchannelled valley bottom wetlands and channelled valley bottom wetlands.

A large pan complex occurs to the south of Koster (a complex of approximately 24 pans). A number of hillslope seepage and valley-bottom wetlands are also associated with these pans. This combination of an extensive network of pans, hillslope seepages and valley-bottom systems, and also that they are unaffected by urbanization and not found elsewhere in any of the other IUAs in such a cluster in this study, renders this an important water resource in the study area. It is likely that populations of the Giant bullfrog may occur or be found in the pans in this IUA.

The pans appear to be mainly fresh (low salinity systems) and dominated by grasses and sedges. These pans are all associated with hillslope seepage wetlands and probably receive water from both surface runoff and lateral seepage via a perched aquifer. The possibility exists that these pans could contribute towards the local aquifer that supports other wetland systems, particularly the valley bottom systems in the area. These pans and their associated hillslope seepage wetlands represent good examples of specific types of wetlands which occur in the Highveld region, an area not well represented outside of IUA1 in this study area. They are therefore an important feature contributing towards the maintenance of the the ecological diversity of the region. Threats are mainly from agricultural activities including agricultural pollutants such as fertilizers, pesticides and herbicides. Road crossings also intersect the pans and disrupt the movement of water. Runoff water from roads also contributes towards the silt load that is built up in these pans. Current potential effects on the integrity of pans and associated hillsope seepage wetlands include cultivation, accumulation of pesticide residues, direct impacts from ploughing, and road related impacts. While the pans in particular have a high to very high EIS, the PES categories are mostly D due to the related agricultural impacts.

3.2.7.6 IUA 6a: Klein Marico Catchment

Given the available information and due to the topography and soil type, there do not appear to be many wetlands in this IUA. Where wetlands occur, they are mostly associated with drainage lines and streams and low lying depressions and are widely dispersed. Based on examination of the aerial imagery, it appears that the South African National Biodiversity Institute (SANBI) probability map and Freshwater Ecosystem Priority Area (FEPA) wetland coverage exaggerates the wetland extent and distribution in the south central section of this IUA and as such this representation is probably not accurate.

3.2.7.7 IUA 7: Kaaloog-Se- Loop

This IUA includes two ecoregions, namely Highveld and Western Bankenveld. Agriculture is an important sector in this IUA with conservation in the form of game farming also occurring. Five wetland types occur, namely hillslope seepage wetlands, unchannelled and channelled valley bottom wetlands, dolomitic eyes and a tufa waterfall. Seepage wetlands are common in the upper reaches of the Bokkraal and the Ribbokfontein se loop. Channelled valley bottom wetlands are the most common system in this IUA and in the upper reaches of the Marico River these form broad wetlands in some reaches. Impacts on these wetlands occur mainly in the form of invading exotic vegetation (Grey poplar, Seringa, Wild Senna, Wattle, and Giant Reed), agricultural activities, road crossings and small farm dams.

Unchannelled valley bottom wetlands also occur in this IUA with a good example being the upper reaches of the Rietspruit.

A special feature of this IUA is the tufa waterfall at Bokkraal and a second at Kuilfontein. This is a waterfall composed of limestone or calcium carbonate formed by the precipitation of carbonate minerals. It is a very rare type of waterfall in South Africa and as such can be considered as having a very high EIS.

Also found in this IUA is the dolomitic eye (Kaaloog or Marico eye) at the source of the Kaaloog-se-loop (headwaters of the Marico River). As with the other eyes in the region, it comprises a peat wetland system fed by groundwater originating from fractures in the underlying dolomite. The system has a PES of B/C as a result of surrounding agricultural influences but the EIS is considered very high.

3.2.7.8 IUA 8: Malmaniesloop

An important wetland dominates this IUA, namely the system associated with the Malmanie River which runs south to north across the IUA. Dolomite forms the main watershed of the Malmanie River in the central portion of this IUA. The source of the Malmanie River is the Malmanie eye which comprises a wetland system fed by groundwater originating from fractures in the underlying dolomite. Being perennial, the wetland system associated with, and downstream of, the eye forms peat. This peatland forms part of the Highveld peat ecoregion.

Peatlands associated with the dolomites in the Malmanie as well as Molopo and Marico Rivers in particular comprise unique ecosystems characterised by a high degree of endemicity (species which are found only there). The results from both morphological and genetic studies of the fish species showed that the indigenous cichlid populations inhabiting these dolomitic wetlands are unique, with a number of populations having differentiated to the extent where they may be considered as separate species (DEA&T, 1995).

Dolomitic eyes and their associated peatlands are regarded as sensitive systems. Most of these systems are also important water supply sources and thus the associated ecosystems have been impacted by water abstraction. They are also threatened by groundwater contamination from agriculture, industry and mining, habitat transformation and invasions by alien species (particularly exotic plants e.g. poplars and fish species e.g. black bass) and some have been mined for peat.

These groundwater dependent ecosystems are facing increasing pressure from pollution and consumptive uses for agriculture and commercial developments. Seepage areas can occur along the margin of these wetlands with the presence of both seasonally and temporary wet zones. A characteristic deposit of white sulphur reducing bacteria often also occurs in the substrate of the eyes. Typical riparian species associated with rocky habitat also occur around the eyes with terrestrial habitat immediately adjacent to the wetland area.

3.2.7.9 IUA 9: Molopo

A number of important wetlands occur in this IUA. These include the dolomitic eyes and peatlands associated with the two arms of the upper Molopo River which run east to west across the IUA. Again dolomite forms the main watershed of the Molopo River to the east of this IUA. Each of the arms of the Molopo River have peatlands and eyes at their source. The main Molopo eye feeds the arm to the north. The southern arm is referred to as the Droë Moloporivier. The PES category of this arm is C/D, mainly due to agricultural impacts whereas that of the main northern arm ranges from A/B to C/D. The EIS of both these arms is considered very high. This is mainly due to the unique biodiversity associated with these systems as well as the fact that the wetlands represent a rare type of wetland in South Africa which is also unique to this particular region.

One cyprinid species in particular, Barbus cf. brevipinnis (a type of ghieliemientjie) is endemic to the Molopo and is currently under high risk of extinction due to loss of habitat as a result of reduced flows to the wetland area. The Molopo eye is also an important water supply source and thus the associated ecosystems and downstream wetland have been impacted by water abstraction. As with all the dolomitic peatlands in the region, it too is threatened by groundwater abstraction, contamination from agriculture, industry and mining, habitat transformation and invasions by alien species (particularly exotic plants e.g. poplars and fish species e.g. black bass). Tourism development has also contributed towards the loss of natural habitat on the periphery of the eye. Working for Wetlands (WfWetlands) started doing rehabilitation work in the Molopo catchment in 2001 including in the headwaters. It has long been recognized that an integrated management strategy is required for conserving or maintaining these unique wetland systems.

The Mareetsane wetland near Mahikeng also provides important ecosystem services for people, livestock and wildlife, including water supply and livelihoods support. It is on the Mareetsane River, which flows into the Molopo River. WfWetlands has been undertaking wetland rehabilitation work on this system. These projects were undertaken in partnership with the Local Municipality and Tribal Authority.

To the south is the Bodibe peatland along the Potfonteinspruit on. As a result of a drop in groundwater levels in the dolomite, the peatland at the eye of the Bodibe system has dried and the peat started to burn. The system has been burning for a few years and this has not only resulted in the loss of the peatland, but also poses a health and safety hazard for people and livestock living adjacent to the peatland. Working for Wetlands has done some work at the eye, mainly trying to prevent the fire from spreading west by creating a soil barrier across the system. This has not been successful and the system continues to burn. As a result of the degradation of the system, the PES category is D/E. The system would have had a high to very high EIS but as a result of the desiccation, its biodiversity value has deteriorated.

Another feature of this IUA is an abundance of small pans. Inundation of these is characteristically ephemeral. Some of the pans can stand dry for years between temporary flooding (DWA, 2010). Water loss from pans is largely due to evaporation. Although the pans are not inundated for long periods at a time, they are still a good example of a specific type of wetland which occurs in this region.

Threats are mainly from agricultural activities including agricultural pollutants such as fertilizers, pesticides and herbicides. Road crossings intersect pans and disrupt hydrological movement of water. Runoff water from roads also contributes towards the silt load built-up in these pans. Pans in general have received little attention and this also applies to the systems associated with this IUA. No information could be found in the literature review relating to these systems and so very little is known about their hydrology or biogeochemistry. Further studies would be required on these systems to get a better understanding of their role and ecological importance in the region.

3.2.7.10 IUA 9: Dinokana Eye/Ngotwane Dam

There are not many wetlands in this IUA but two important systems do occur, namely the Dinokana eye and associated wetland and the Ngotwana wetland. Both these wetlands provide important ecosystem services for people, livestock and wildlife, including water supply and livelihoods support. These wetlands are also the type localities of various animals, plants and fish. The PES category of the former D/E, mainly due to the impacts associated with the surrounding settlements and land degradation. The PES category of the latter ranges from A/B to C/D mainly as the area upstream is severely eroded due to overgrazing. The EIS of both these systems is considered to be high to very high. This is mainly due to the unique biodiversity associated with these systems as well as the fact that the wetlands, albeit that they are quite different, each represent a particular type of wetland in which is also unique to this particular region.

3.2.7.11 IUA 11a: Groot Marico/Molatedi Dam

Given the available information and due to the topography and soil type, and apart from pans, there do not appear to be many wetlands in this IUA. Where wetlands occur, they appear to be mostly associated with drainage lines and streams and low lying depressions and are widely dispersed. Based on examination of the aerial imagery, it appears that the SANBI probability map and FEPA wetland coverage exaggerates the wetland extent and distribution around the dam in the north of the IUA. As such this representation is probably not accurate in this area.

3.2.7.12 IUA 11b: Groot Marico/Seasonal Tributaries

Given the available information and due to the topography and soil type, and apart from a few pans and the system along the lower Marico River, not many wetlands are indicated on the available databases for this IUA. Two fairly large wetland systems were however identified from the aerial imagery of the area. These include the lower section of the Lengope la Kgamanyane River just before the confluence with the Marico River and what appears to be an extensive floodplain-type system associated the Lenkwane River at and upstream of the confluence of the Marico River. Additional work would be required at a more detailed scale to accurately map the extent of these systems.

From consideration of the FEPA maps as well as available aerial imagery, there is also an extensive riparian zone associated with the Marico River.

Floodplain wetland features also occur along the Marico River. Sections of the Marico River and its associated riparian zone as well as well as these wetland features are indicated as a wetland FEPAs. Pans also occur in this IUA.

3.2.7.13 IUA 12: Bierspruit

Given the available information and due to the topography and soil type, there do not appear to be many wetlands in this IUA. It is likely that hillslope seepages would occur on the granites as this would be expected due to the sandy nature of these soils. Shallow groundwater movement would be a key driver of these systems. As these systems are sometimes difficult to detect, even in the field, identifying signatures remotely is even more difficult.

3.2.7.14 IUA 13: Lower Crocodile

The dominant land use in IUA 13 (which comprises of the lower reaches of the Crocodile River) is largely natural, but irrigation along the Crocodile River main stem is an important contributor to local GDP. Some granite mining is found in the IUA. Again, given the available information and due to the topography and soil type, there do not appear to be many wetlands in this IUA apart from pans. Where wetlands occur, they appear to be mostly associated with drainage lines and streams and low lying depressions and are widely dispersed. As with IUA 12, it is likely that hillslope seepages would occur on the granites as this would be expected due to the sandy nature of these soils. Sections of the Crocodile River and its associated off-channel wetlands and floodplain are indicated as wetland FEPAs. Further work would be required at a more detailed scale to more accurately map the extent of wetlands in the IUA.

3.2.7.15 IUA 14: Tolwane/Kulwane/Moretele/Klipvoor

Based on the current conditions, an understanding of the geomorphology, drainage patterns, and soils in this IUA, four wetland types have been identified. These are pans or depressions, hillslope seepage wetlands, unchannelled valley bottom wetlands, channelled valley bottom wetlands and floodplains.

The largest and probably one of the most important systems in this IUA is the Moretele or Pienaars River floodplain. Together with the Apies River floodplain which is also in this IUA and which flows into the Moretele, this combined system forms the second largest floodplain in the Bushveld Ecoregion. It also represents the southern-most natural distribution of Wild Rice (Oryza longistaminata) in Africa. The floodplain is used extensively by the surrounding communities for fishing and grazing and is also regarded as an important birding area, with the floodplain and surrounding area supporting 362 of the 461 species recorded in the North West Province. The wetland also includes traditionally sacred sites which have high cultural significance.

The PES is indicated as C/D to D/E, mainly due to the changes in the systems as a result of the modification of flow due to urban development upstream and sewage as well as agricultural return flows. The EIS is considered to be very high.

The wetlands within the Borakalalo National Park are also considered of high conservation value, despite being heavily degraded. They have also been the focus of WfWetlands work over the past few years. Borakalalo forms the western end of the Moretele floodplain. The Tswaing Crator and its associated pan or depression wetland also fall within this IUA.

3.2.7.16 IUA 15: Upper Mokolo

This IUA comprises the watershed and upper catchment of the Mokolo River. This area is characterized by steep mountain slopes of the Waterberg with sandy nutrient poor soils, rocky plateaus and mixed broad leaved savanna bushveld. The wetland systems typically found include hillslope seepage wetlands, sheetrock wetlands and channeled and unchanneled valley-bottom systems. Water quality is typically good, and the streams are flanked by narrow riparian zones with the larger dominant tree typically being the Waterberry (Syzygium cordatum) and water pear (Syzygium guineense). Valley-bottom wetlands typically comprise a mixture of tall emergent plants such as the common reed Phragmites australis and the grass Miscanthus junceus and shorter grass-sedge meadows dominated by Leersia hexandra and Red vlei grass (Ischaemum fasciculatum). The main ecosystem services supplied by these systems include flood attenuation, water quality enhancement, streamflow augmentation and biodiversity maintenance.

Extensive wetland systems occur in the Sand River catchment (southern-most watershed of the Mokolo River). They form important habitat for Blue cranes and are thus of high importance from a conservation and biodiversity perspective. Land use in the area is mostly agricultural and as a result many of the wetland systems have been degraded. WfWetlands targeted the area for wetland rehabilitation and to date a number of projects have been implemented. The Thaba Metsi wetland was also targeted as part of this work. In addition to these wetlands, the riparian and instream habitats of the Sterkstroom, Taaibosspruit and Rietspruit are also considered important ecologically. These are also some of the remaining rivers in the catchment that still support flow dependent fish species (River Health Programme, 2006). At the catchment scale the wetlands in IUA 15 are expected to provide valuable ecosystem services, most notably streamflow augmentation, but also biodiversity support, and, due to their largely unchannelled, diffuse-flow nature, flood attenuation, sediment trapping and water quality improvement functions (DWA, 2010).

The land use in the catchment is game farming, and it can be considered to be largely pristine in parts, consisting of mixed broad-leafed woodland. Other parts of the IUA are however heavily impacted by agricultural practices, particularly in the areas where the topography is not so steep. In the agricultural areas, the PES of the wetlands is usually in a category C/D while in the nature reserves and game farms this improves to A/B. Extensive desktop mapping was undertaken in this IUA and the wetland map derived is considered to be reasonable accurate at that level.

3.2.7.17 IUA 16: Lower Mokolo

Downstream of the Mokolo Dam the Mokolo River enters the Limpopo plain. Here colluvial processes dominate and the river and associated riparian and wetland habitats are controlled by the deposition, transport and erosion of sediment. Here the alluvial (river process driven) aquifer supports an extensive riparian forest fringe and instream biota. The riparian zone in particular, which includes large specimens of the Nyala berry (Xanthocercis zambesiaca), Waterberry (Syzygium cordatum) and the Tamboti (Spirostachys africana), is dependent on this shallow alluvial aquifer system. The lower reaches also support Leadwood trees (Combretum imberbe). The pools and backwater floodplains associated with the lower Mokolo River provide valuable refugia for river and wetland biota during dry periods and thus play a valuable biodiversity support role. The floodplains also provide high quality grazing for the farms located along these areas and sediment trapping and flood attenuation during high flow periods (DWA, 2010)

In the vicinity of Lephalale, the river is extensively used for sand mining. This together with the regulated flows from the Mokolo Dam upstream has affected the structure of the river along this reach with resulting alterations to the flow regime and pattern. There is also evidence suggesting that the resulting changes have not only affected the distribution and abundance of reedbeds in the system, but also the alluvial aquifer which in turn is impacting on the instream and riparian ecosystem. The reduction in flows and large floods due to upstream dams and abstraction is expected to have reduced the recharge of the river-associated wetlands (ox-bows and backwater pools) along the lower section of the Mokolo River (DWA, 2010).

The Tambotie River which flows through D'Nyala Nature Reserve and joins the Mokolo River near to Lephalale, is also regarded as an important system. The floodplain of the Tambotie River supports an extensive population of Tamboti (Spirostachys Africana) and Leadwood trees (Combretum imberbe). Water abstraction and the droughts experienced in the 1980's and early 1990's impacted on the system and with the drying out of the alluvial aquifer during this time, many of the Leadwood trees died. This floodplain system is nevertheless considered to have high ecological importance and sensitivity and is a key wetland in the region.

3.2.7.18 IUA 17a: Mothlabatsi/Mamba

The Matlabas River flows through the Marakele National Park. The park is characterized by the Waterberg Moist Bushveld vegetation type (veld type 12), mixed Bushveld (veld type 18) and the Sweet Bushveld (veld type 17). The Sweet Bushveld is mostly found along the banks of the Matlabas River and forms an important winter refuge area for game particularly during limiting periods at the end of the dry season.

Given the available information not many wetlands have been mapped in this IUA. While there are expected to be many smaller wetlands associated with the drainage lines in the Waterberg in particular, these cannot easily be identified using remote mapping techniques. There however do not appear to be many large wetlands in this IUA. Where wetlands occur, they appear to be mostly associated with drainage lines and streams and are widely dispersed. Some riparian wetlands can be seen on the aerial imagery in sections of the Motlhabatsi and Mamba Rivers.

3.2.7.19 IUA 17b: Matlabas

Given the available information and due to the topography and soil type, there do not appear to be many other wetlands in this IUA. Where wetlands occur, they appear to be mostly associated with drainage lines and streams and low lying depressions and are widely dispersed.

A fairly large wetland system is indicated on the 1:50 000 topographic maps associated with the lower Matlabas River. There is also an extensive wetland system associated with a section of the Aslaagte River which is a tributary of the Matlabas River. From consideration of the FEPA maps as well as available aerial imagery, there is also an extensive riparian zone associated with the Limpopo River. Floodplain wetland features such as cut-off meanders associated with the paleo-channel of the Limpopo River also occur. The Limpopo River and its associated riparian zone as well as well as these wetland features are regarded as important systems (wetland FEPAs) and further work is recommended to more accurately map and assess these systems and features, particularly considering the proposed future coal mining activities in this IUA and the potential impact thereof on this system and these wetland features which lie at the lower-end of the catchment. Similarly, and in addition to considering the wetlands and riparian features along the Limpopo River, additional work would be required at a more detailed scale to accurately map the extent of the wetlands in this IUA.

There is also very little information available on the pans in this IUA and further work on these systems is also recommended, particularly given that many are indicated as wetland FEPAs. Pans in general are recognised as being important for biodiversity support. Understanding how they may be linked to other drainage features will also be important, particularly considering the proposed future coal mining activities in this IUA and the potential impact thereof on these systems as well.

4 RESOURCE UNIT DELINEATION RESULTS

Based on the consideration and integration of the aspects discussed above, as well as using expert knowledge based on discussions with specialists and catchment water resource managers, 82 RUs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments have been delineated. The RUs are shown in Figure 11 below and are listed and described in Table 7.

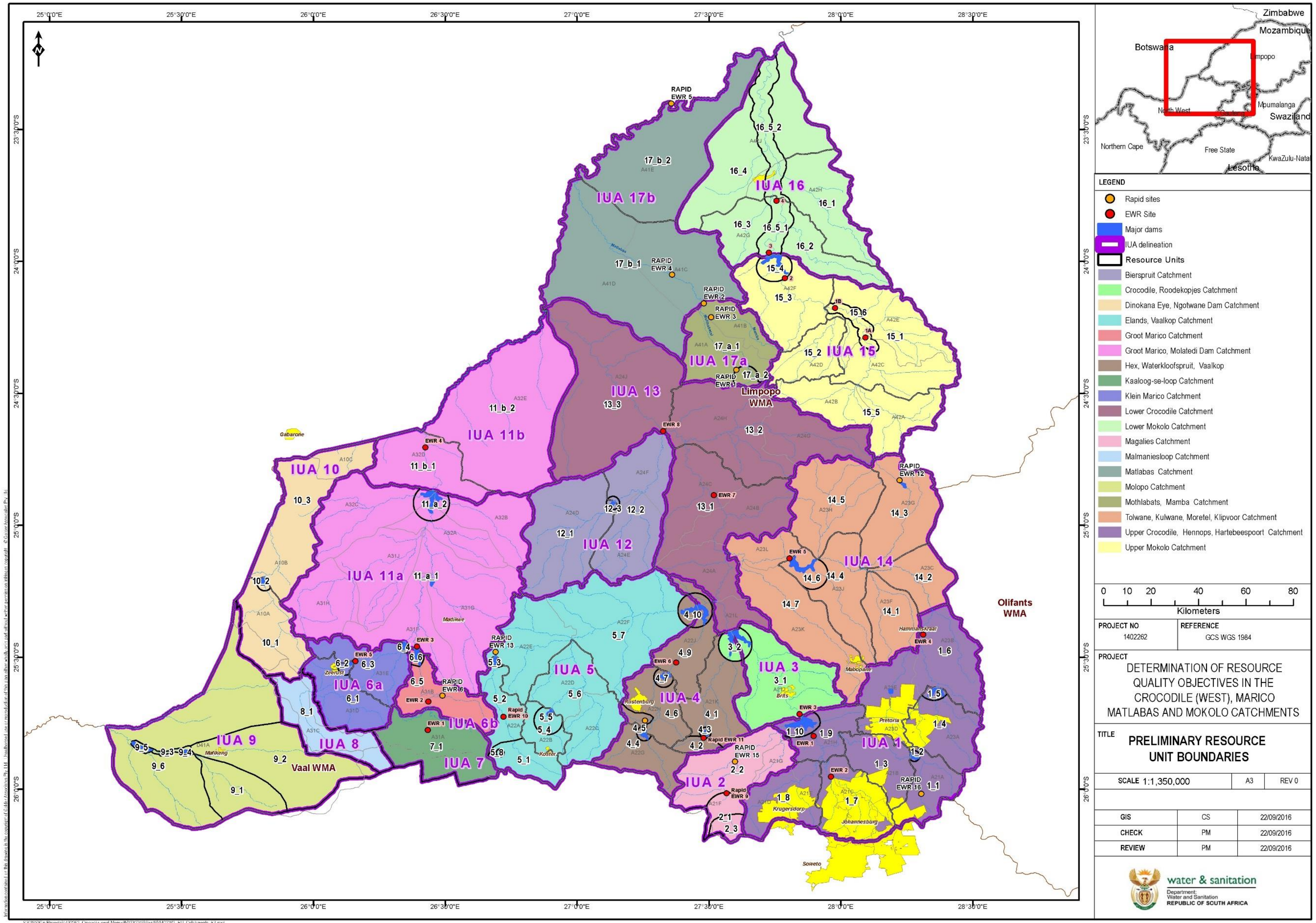

Figure 11: Delineated Resource Units

Table 7: Description of Resources Unit delineation in the Mokolo, Matlabas, Crocodile (West) and Marico catchments

IUA1	**Upper Crocodile/Hennops/Hartebeespoort**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
1_1	Upper Hennops and Rietvlei Rivers to inflow to Rietvlei Dam	A21A	CROC_EWR 16 HN 1	This is a threatened system. The headwaters require protection owing to the upstream economic activities and downstream water abstraction for water service provision (human health). Some wetland FEPAs. Some pans, peatlands and valley bottom wetlands present. The Rietvlei Nature Reserve is located at the bottom of this unit, which is a rehabilitation FEPA and an important protected area. PES D/E. Groundwater: This unit includes the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Contains the Centurion dolomite aquifer system where large volumes of water is abstracted, ground stability is a concern for large infrastructure such as the Gautrain constructions. The aquifer is highly impacted by irrigation and pollution. RQOs for quality and quantity required. Ground stability problems is a concern.
1_2	Rietvlei Dam	A21A		This dam supplies Tshwane with raw water. This is a threatened system with water quality impacts. The dam is located within the Rietvlei Nature reserve, which is a rehabilitation FEPAs, wetland FEPA and an important protected area. The Rietvlei wetland system is situated immediately upstream of the Rietvlei Dam within the Rietvlei Dam Nature Reserve. The wetland is a peatland. Water quality and flow monitoring data is available.
1_3	Hennops River from outflow Rietvlei Dam to the A21B catchment	A21B	HN2	This system is degraded owing to upstream waste water treatment works (WWTW). Rehabilitation FEPA are present. *Barbus rappax* (Southern Papermouth) is still present in the system. Some hillslope seepage wetlands present with high botanical diversity. This unit includes the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Contains the Centurion dolomite aquifer system where large volumes of water is abstracted, ground stability is a concern for large infrastructure such as the Gautrain constructions. The aquifer is highly impacted by irrigation and pollution. RQOs for quality and quantity required.

RU Number	Delineation Description	Quaternary Catchment	Hydronodes (HN)/ EWR sites	Rationale/Consideration
1_4	Upper Pienaars River, Edendalespruit and Moretlele Rivers to Roodeplaat Dam	A23A	HN11	This system supports the supply of water to Roodeplaat Dam. Rare fish species noted in this area. FEPA wetlands are present. The system is overall degraded with a PES D/E. Water quality, flow monitoring and a node are present. Colbyn Valley wetland (peatlands) present.
1_5	Roodeplaat Dam	A23A		This dam is eutrophic with algal blooms impacting the taste of the water. The dam is responsible for the supply of raw water. It is a conservation area.
1_6	Upper and middle reaches of Apies River, Skinnerspruit, Pienaars River from outflow Roodeplaat Dam to Boekenhoutpruit confluence, Roodeplaatspruit, Boekenhoutspruit	A23B, A23D, A23E	Croc_EWR 4 HN13, HN14, HN15	This is at the outlet of the Roodeplaat Dam. The Pienaars River downstream of the dam provides for the colonization of several fish species no longer found in other tributaries and the system is thus important for fish movement, especially with Roodeplaat Dam upstream and Klipvoor Dam downstream. The Boekenhoutspruit is a rehabilitation FEPA. The upper parts of the catchment are impacted by urbanization, irrigation, WWTWs. The Ecological Importance and Sensitivity (EIS) is high. EWR site 4 is present and includes three nodes.
1_7	Jukskei, Klein Jukskei, Modderfonteinspruit	A21C	Croc_EWR2 HN3 and HN4	This RU includes the headwaters of Jukskei. There are several WWTWs located both upstream and downstream of these systems which includes the transfers for Mokolo (Lephalale). The systems are highly impacted from nutrient input thus threatening the biotic integrity of the systems. PES is an E category.
1_8	Upper reaches of Crocodile River and Bloubank Spruit	A21D, A21E	HN6	This is the headwaters of the Crocodile River. Tourism activities is high. The serious threat to the system is mining and the acid mine decant from the western basin. The Crocodile River is a FEPA fish support area (nature reserve). The Tweelopiespruit flows into the Bloubankspruit and forms part of the Krugersdorp Game Reserve and the Cradle of Humankind World Heritage Site. Groundwater: Dolomite aquifer systems, heavily impacted by historic mine dewatering and discharges of acid mine drainage (AMD) into Tweelopiespruit and further downstream. RQOs will be required in terms of quality. Ground stability problems are a concern.
1_9	Crocodile River from Jukskei confluence to inflow Hartebeespoort Dam, Swartspruit	A21H	Croc_EWR 1 HN7	This river reach includes planned transfers of wastewater discharges to the Mokolo catchment. The system is highly impacted from upstream activities (WWTW, urban activities, discharges etc.). There are wetland FEPAs in the

				vicinity of the EWR 1 site, HN8. Groundwater: Upstream part of unit (southern portion of quaternary catchment) is the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Contains the Centurion dolomite aquifer system where large volumes of water is abstracted, ground stability is a concern for large infrastructure such as the Gautrain constructions.
1_10	Hartebeespoort Dam	A21H	HN8, HN10	The dam is located at the outlet of IUA1. Planned water transfer to Mokolo (future). The dam is highly impacted upon and continues to be threatened from upstream activities and primarily from a nutrient perspective with significant eutrophication. The dam is used for water supply coupled with recreation and livelihoods. Threatened by upstream activities.
IUA2	**Magalies**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
2_1	Maloneys Eye	South eastern portion of A21F	Croc_EWR9	Regarded as a priority system. Areas associated with the eye have been identified as irreplaceable and the eye important for tourism. This IUA is in a Class II with a very high EIS. Upper part of the Steenkoppies dolomite compartment unit (DCU) - very high volumes for irrigation in the Tarlton area. RQOs (quality and quantity) extremely important for Maloneys Eye.
2_2	Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers	A21F, A21G	EWR 9, HN16, HN15, HN17 Rapids	The primary economic activities include tourism and agriculture. This IUA contains the Magaliesburg conservation area and the Cradle of Humankind World Heritage Site. This IUA is a Class II. These rivers pose as a fish support area (i.e. *Barbus motebensis). Magalies River downstream of Maloneys Eye dependent on dolomitic outflows (constand high baseflows) and not similar to other tributaries. Hillsope sepage wetlands with high botanical diversity.* Groundwater: Discharges from upper reaches Steenkoppies DCU. RQOs should address a sustainable discharge. Interaction between surface and groundwater systems.
2_3	Surface water area linked to Maloney's Eye (catchment area)	A21F		The surface water streams are not reporting to the eye which is impacting on quality and quantity at the eye. Quantity (abstractions) and flow of the surface water needs to be managed. Area is impacted by mining and sewage effluent discharges.

IUA3	**Crocodile/Roodekopjes**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
3_1	Crocodile River from outflow Hartebeespoort Dam to inflow Roodekopjes Dam, Rosespruit, Ramogatla and Kareespruit	A21J	Croc_EWR 3, HN19 and HN20	The water resources are in a degraded state owing to the changes in the flow regime as a result of the Hartebeestpoort Dam just upstream of this IUA and agriculture being a primary activity. Unnamed tributary has a B category PES. Water transfer to Mokolo catchment through the reach. Wetland FEPAs are present within this IUA. Sensitive fish species (AJON) are expected to occur within this reach and flow dependent species (CPRE and BMAR).
3_2	Roodekopjes Dam	A21J		Dam is a source of domestic water supply. Impacted by surrounding activities. Nutrient enrichment of dam due to return flows from upstream catchment. Water to be transferred to the Mokolo catchment.
IUA4	**Hex/Waterkloofspruit/Vaalkop**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
4_1	Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe	A21K middle and lower catchment below dam	Croc_EWR11	Some irrigation is present in the upper reaches of the system. The EIS is high due to the presence of the vulnerable *Barbus motebensis* (Marico Barb) and high abundance of the unique *Amphilius uranoscopus* (Common Mountain Catfish) and *B. motebensis* upstream in the catchment. Wetland FEPAs and FEPA fish support area are within this IUA and it is partly a protected area. Class II water resource class. Forms part of the Magaliesberg Biosphere Reserve (MBR).
4_2	Upper reaches of Sterkstroom to inflow Bueffelspoort Dam , Kleinwater	A21K upper catchment to dam	EWR rapid III site	The EIS is high due to the presence of the vulnerable *B. motebensis* and high abundance of the unique *A. uranoscopus* and *B. motebensis* upstream in the catchment. Wetland FEPAs, river FEPAs and FEPA fish support area are within this IUA and it is partly a protected area. Class II water resource class. Forms part of the Magaliesberg Biosphere Reserve (MBR).
4_3	Buffelspoort Dam	A21K		Irrigation Dam and the dam is classed as a nature reserve.
4_4	Upper Hex River to Olifantsnek Dam, Rooikloofspruit	A22G	HN23	This area is located within a nature reserve with limited land use and thus is protected with high tourism value. Rooikloofspruit (Waterkloofspruit). This system has river FEPAs and the Hex river is a fish support FEPA. Forms part of the Magaliesberg Biosphere Reserve (MBR).

4_5	Olifantsnek Dam	A22G		Supports irrigation, recreation
4_6	Hex River outflow Olifantsnek Dam to inflow Bospoort Dam, Sandspruit	A22H	HN25	The water resources of the Hex River have been degraded due to the Olifanstsnek, Bospoort and Vaalkop Dams situated on the river. Rustenburg and extensive mining and agriculture in the middle reaches of the catchment further impacts on the water resources, both quality and quantity. Forms part of the Magaliesberg Biosphere Reserve (MBR).
4_7	Bospoort Dam	A22H		Supports irrigation and recreational activity. Poor water quality in the dam.
4_8	Water Kloofspruit tributary catchment	A22H	Rapid EWR 14	This catchment is within the Nature Reserve with a PES of a B/C. River FEPAs, wetland FEPAs are present and further wetland priority areas are present (Waterval valley bottom mire - peatlands). Protected area. Flow dependent fish species present (BMOT). Forms part of the Magaliesberg Biosphere Reserve (MBR).
4_9	Hex River outflow Bospoort Dam to inflow Vaalkop Dam	A22J	Croc_EWR 6, HN27	The water resources of the Hex River have been degraded due to the Olifantsnek, Bospoort and Vaalkop Dams situated on the river. Rustenburg and extensive mining and agriculture in the middle reaches of the catchment further impacts on the water resources, both quality and quantity.
4_10	Vaalkop Dam	A22J		Nature Reserve, supports fishing, recreation and releases are made for irrigation.
IUA5	**Elands/Vaalkop**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
5_1	Upper reaches of Elands to Swartruggens Dam	A22A south eastern portion	EWR site Rapid 10	The presence of the vulnerable *B. motebensis* within the upper reaches of the Elands River contributes to a high EIS for the upper reaches. This reach also serves as a refugia as the downstream catchment and river has been degraded. The wetlands are important and the rivers are FEPAs. There is some dry land farming and slate mining.
5_2	Elands river downstream Swartruggens Dam to Lindleyspoort Dam	A22A	HN29	This reach of the Elands River is located below dam. The reach is impacted upon by the WWTW and urban activities.

5_3	Lindleyspoort Dam	A22A		The dam is surrounded by agriculture and subsistence farming and thus primarily supports irrigation water users and some domestic use and provides flow regulating capacity. The upstream impacts include WWTW. Dam supports mainly irrigation activities. This dam forms part of the Lindleyspoort Government Water Scheme.
5_4	Upper Koster River to Koster Dam	A22B	HN30	The upper Koster River is a fish support area. Activities namely cultivation and plantations occur along the reach. PES=C.
5_5	Koster Dam	A22B		The main use of this dam is for water supply to the town of Koster and irrigation purposes.
5_6	Selons River, Kodoespruit, Dwarsspruit, lower Koster River	A22C, A22D	HN31	A small portion of the Selons River is protected. Cultivation (limited irrigation) activities occurs.
5_7	Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana	A22E, A22F	EWR13 (Rapid site) HN32	The Mankwe tributary is protected in the Plianesburg National Park. These rivers are however surrounded by mining on Leragane (impacted).
5_8	Swartruggens Dam	A22A south eastern portion		The dam is located upstream from the town of Swartruggens. The dam provides water supply to the town (all domestic supply).
IUA6a	**Klein Marico**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
6_1	Upper Klein Marico to inflow Klein Maricopoort dam, Rhenosterfonteinspruit, Malmanieloop, Kareespruit	A31D	HN35	Klein Marico Eye fed by groundwater. This reach is a Class II and located within the Madikwe game reserve near the town of Zeerust (urban). Impacts on Kareespruit from WWTW, irrigation and over abstraction. PPHI populations present. There are some flow issues for macroinvertebrates. BMOT and BMAT are on the expected list for this reach. Groundwater: Significantly impacted by bulk groundwater abstractions for municipal supplies; thus quantity and due to agricultural activities quality may become an issue in future.
6_2	Klein Maricopoort dam	A31D		Mainly used for irrigation. Protect dam as it supports downstream habitat availability for biota. Fish refugia. Recreational activities present at the dam.

6_3	Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit	A31E	MAR_EWR 5	Impacts include irrigation and over abstraction. Poor water quality. Poor fish diversity. Wilgeboomspruit is a small seasonal stream.
6_4	Kromellenboog Dam	A31E		Mainly used for irrigation. General habitat for birds.
IUA6b	**Groot Marico**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
6_5	Groot Marico, Polkadraaispruit	A31B	MAR_EWR 2 MAR_EWR 6 (Rapid site) HN33, HN34	Isolated occurrences to BMOT, AURA, CPRE and AMOS in the Polkadraaispruit, locality of aquatic invertebrate lampyridae as well as a large number of inverts and fish sensitive to water quality changes. In terms of the Groot Marico, AURA, CPRE and to a certain degree BMOT occurs within the Groot Marico. It sits within a Class II, PES B/C, FEPA rivers and wetlands and it is a fish support area. The area surrounding the dam is protected. There is mine prospecting activities in the area and some settlements forming part of the town of Marico, agricultural activities present.
6_6	Marico Bosveld Dam	A31B	HN63	The Marico Bosveld Dam is situated at the outlet of this IUA. Some recreational activities (local angling). Irrigation downstream. Site is located within the Marico Bosveld nature reserve. Dam habitat functions for fish refugia.
IUA7	**Kaaloog-se-loop**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
7_1	Marico Eye, Kaaloog-se-Loop, Bokkraal-se-Loop, Ribbokfontein-se-Loop	A31A	MAR_EWR1 site HN37, HN38	The EIS is very high owing to the presence of the rare and endangered AURA, CPRE, BMOT and the very high taxon richness of inverts (>45) due to good quality. Habitat needs to be protected. The area is a Class I with very high protection/conservation due to the dolomitic eyes and associated fauna and flora. Therefore the need for protection in this area is high as there is a threat from over abstraction. The area includes FEPA rivers. Wetlands (pans and valley bottom) are priority. Tufa waterfall (unique feature) is present. Groundwater: Large abstractions for mining, agriculture and municipal supplies - current problems with high groundwater level recession rates in the Lichtenburg Area.

IUA8	**Malmaniesloop**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
8_1	Malmanie Eye, Dolomites	A31C		An important wetland dominates this IUA (systems associated with the Malmanie River). There are peatlands. This area has FEPA rivers and protected areas. Groundwater class II. This IUA 8 is mainly groundwater related around Molopo Eye. Huge impact on groundwater sustainability occurs due to growing demand for municipal and irrigation needs; and localised quality impacts due to mining activities.
IUA9	**Molopo**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
9_1	Bodibe Eye	D41A (Polfonteins pruit and Lotlhakane tributary catchment area)		Groundwater resources and wetlands are priority (pans and valleybottom wetlands). The Bodibe Eye is a peatland and important for water supply and biodiversity support. High groundwater abstraction in the area is resulting in a decrease in groundwater which has further resulted in spontaneous combustion underground and the peatland oxidised and been burning for several years now, resulting in a loss of the peatland. This poses a health and safety hazard for people and livestock. The area is high in dolomite and impacts include urban and settlement activities and cement mining. Serious depletion of groundwater levels in this area (~25m) due to over-utilisation. Large eyes (springs) already impacted and dry. No sensitive fish or inverts.
9_2	Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Modimola dam	D41A	HN66	This IUA 9 is mainly groundwater related around Molopo Eye. The area has FEPA rivers and is a fish support area. The eye is important as it is inhabited by the unique PPHI. According to a study Malawian Cichlids have been introduced. Impacts include a cement factory and urban development (Mafikeng). Groundwater resources and wetlands are priority (unchannelled valleybottom wetlands and peatlands). The Molopo eye is a peatland and important for water supply and biodiversity support. Grootfontein aquifer not productive anymore, and all Mahikeng's water is sourced from Molopo's Eye.

RU Number	Delineation Description	Quaternary Catchment	Hydronodes (HN)/ EWR sites	Rationale/Consideration
9_3	Molopo River mainstem only from Modimola Dam to Disaneng Dam	D41A (main stem)	HN67	Highly impact from urban settlement in Mahikeng which has resulted in a PES E. Serious problem with water pollution in Mahikeng and catchment of the Modimole Dam (WWTWs).
9_4	Modimola Dam	D41A		Mainly used for domestic water supply (WWTW upstream). Poor water quality. Habitat supporting birds.
9_5	Disaneng Dam	D41A		Mainly used for irrigation purposes.
9_6	All remaining tributaries - Madibe, Kabe, Mogosane	D41A	HN39	Scattered settlements present.
IUA10	**Dinokana Eye/Ngotwane Dam**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
10_1	Upper Ngotwane, Dinokana Eye	A10A		This IUA is mainly groundwater related to the Dinokana Eye. Two important wetland systems occur namely the Dinokana eye and Ngotwana wetland (high biodiversity wetland in semi-arid climate with its source in Botswana) which both supply water for livelihood support for people, livestock and wildlife. AJON occurs within the upper Ngotwane. Groundwater priority area. Groundwater related subsistence use. Water balance in this area is a concern as this is a sole-aquifer system for Dinokana and Zeerust.
10_2	Ngotwane Dam	A10A		Limited irrigation and supports downstream domestic water supply.
10_3	Ngotwane River outflow Ngotwane Dam to drainage boundary	A10A		Limited activity. No flow dependent species.
IUA11a	**Groot Marico/Molatedi Dam**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
11a_1	Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, all tributaries: Elandslaagtespruit, Lengope le Kgamanyane, Lenkwane	A31G, A31H, A31F, A31J, A32A, A32B, A32C	MAR_EWR 3 HN40	The Groot Marico has a high EIS owing to the reach which forms a natural refugia with a number of perennial pools.
11a_2	Molatedi dam	A32A, A32B, A32C		International obligations with Botswana and releases to downstream irrigators. Dam habitat must be maintained for fish refugia and mammals. Some recreational activities

IUA11b	**Groot Marico/Molatedi Dam**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
11b_1	Groot Marico mainstem, Rasweu, Maselaje rivers	A32D	MAR_EWR 4	Impacts are primarily as a result of the Molatedi Dam upstream and the release pattern from the Tswasa Weir for irrigation purposes. Tributaries are mostly dry. Flow dependent fish species occur (BMAR, LMOL and SZAM). Riparian zone is heavily grazed. High sedimentation following rainfall events due to heavy erosion and overgrazing. Riparian zone and flood plain wetlands present.
11b_2	Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane	A32E		Game farms present. Conservation areas
IUA12	**Bierspruit**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
12_1	Wilgespruit, Motlhabe, Bofule, Kolobeng, Magoditshane	A24D		The water quality is degraded due to mining activities, town development and irrigation in the catchment. River FEPA are located in the upper reaches near Kolobeng. Area is very important from an ecotourism point pf view (includes the Pilansberg National Park)
12_2	Bierspruit oultfloe Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng	A24E, A24F	HN42	The water quality is degraded due to platinum mining, town development, irrigation and cultivation.
12_3	Bierspruit Dam	A24D		Supports irrigation, Nature reserve area
IUA13	**Lower Crocodile**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
13_1	Crocodile River outflow Roodekopjes Dam to upstream Sand River confluence, Sleepfonteinspruit, Klipspruit tributaries	A21L, A24A, A24B, A24C	CROC_EWR_7 CROC_EWR_8	Activities mainly include irrigation use and return flows. The area further has large hunting and private conservation areas. Flow dependent fish species (LMOL, CPRE) are present. Groundwater: Abstraction/discharges from/to irrigation on alluvium aquifer system along the Crocodile River.

13_2	Sand River to confluence with the Crocodile River to Bierspruit confluence, Sondags, Vaalwaterspruit and Monyagole tributaries	A24G, A24H	HN43	Activities mainly include irrigation use and impacts from return flows. The area further has large hunting and private conservation areas. Moderate and sensitive fish species (CPAR). Groundwater: Abstraction/discharges from/to irrigation on alluvium aquifer system along the Crocodile River.
13_3	Lower Crocodile from Bierspruit confluence to the Botswana border (Limpopo River)	A24J	HN45	Activities mainly include irrigation use and return flows. The area further has large hunting and private conservation areas. Sensitive fish species present (CPAR, LMOL). During good flow, crocodiles move close to CROC_ EWR site 8.
IUA14	**Tolwane/Kulwane/Moretele/Klipvoor**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
14_1	Apies River, Tshwane tributary	A23F		Rehabiliation FEPAs present. Subsistence irrigation undertaken. Water quality issues are prevalent. Wetland systems are important (Apies River floodplain is present).
14_2	Pienaars River from Boekenshout confluence to Apies River confluence	A23C		The EIS is high due to the presence of the unique *B. rappax* fish species whom are intolerant to poor water quality and flow changes are also present namely *Chiloglanis pretoriae*, *Labeobarbus marequensis*, *Labeo cylindricus* and *L. molybdinus*). Sensitive invertebrates also reside in these reaches. There are rehabilitation FEPAs in the upper reaches of the Dinokeng Game Reserve. Irrigation activities occur downstream. Wetland priority area. Moretele floodplain present with high biodiversity and important bird habitat. Important resource for the adjacent community.
14_3	Plat River	A23G	CROC_EWR 12	The area is a fish support area within a nature reserve. Fish species (CTHE) occurs within the Plat River (upper reaches). It requires certain flows and water qualities. Isolated group within the upper part. As soon as the river flows into the bushveld basin, the river dries out and CTHE does not occur. The important Plat river floodplain occurs.
14_4	Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam	A23J		Water quality impacts are primarily a result of urbanization, specifically deterioration in water quality due to WWTWs discharges. The present state of the Moretele River is in a D category owing to the releases from the dams and water quality impacts mentioned above. Moretele floodplain present with high biodiversity and important bird habitat. Important resource for the adjacent community. Tswaing crator (unique endorhic wetland system). Top minnow fish species present which also occur within wetland systems.
14_5	Rietspruit and all tributaries	A23H	HN47	No sensitive fish species.

14_6	Klipvoor Dam	A23J		Borakalola Nature Reserve. Fish refugia. Confirmed crocodile population within the dam. Good birdlife. Dam is high in algae.
14_7	Pienaars River from Klipvoor Dam to Crocodile Riverconfluence, Tolwane tributary	A23K, A23L	CROC_EWR 5, HN48 and HN49	The rivers are impacted by urban development and cultivation. The Tolwane river is significantly impacted. No flow dependent fish species. However, owing to the enrichment in the dam and flow release, the LMAR occur within the river below the dam due to the flow increase from the dam releases. They have introduced artificial fly fishing downstream of the dam due to the LMAR. Therefore consistent flow management from the dam is vital in order to retain the population of LMAR. The fish cannot migrate as the dam functions as a migration barrier for the fish. An additional unique fish species is LROS.
IUA15	**Upper Mokolo**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
15_1	Moloko River in A42C, Sand River and Klein Sand, Brakspruit, Sondagsloop, Heuningspruit, Dwars, Jim se loop tributaries	A42C, A42E		The area is important as it plays a role as a corridor for fish (FEPA rivers). Important fish include CPRE, AURA and AMOS (flow dependent and water quality dependent fish species). The main impact on the water resource is irrigation. Extensive wetland systems occur in the Sand River catchment which form important habitat for Blue Cranes. Important valley bottom and hillslope wetlands present forming part of the Waterberg system (unique combination of flora and faunal associations)
15_2	Sterkstroom, Frikkies-se -loop	A42D, A42E	HN53,HN54	Game farming, High EIS, PES is a B category.
15_3	Mokolo River in A42F to inflow Mokolo Dam, Taaibosspruit, Malmanies and Bulspruit tributaries	A42F	MOK_EWR2 Rapid site	The main impact on the water resources include agriculture and abstraction weirs. Rare and endangered mammals occur within the nature reserve contributing to the present state of a B/C, as well as unique fish and invertebrate species.
15_4	Mokolo Dam	A42F		This dam is located within a nature reserve and it's a protected area. It supplies Matimba power station and Lephalale (town)
15_5	Grootspruit and Sandspruit tributaries (Mokolo headwater catchment)	A42A, A42B	HN50,HN51	Impacts include agriculture. Extensive wetland systems occur in the area coupled with the area being a fish support area. Important habitat for Blue Cranes (which have been identified within the Sand River catchment). No rheophilic species occur within these reaches. Small barbs during the wet season will occur. Migration corridor for birds. Wetland systems are important (valley bottom and hillslope seepage wetlands present forming

				part of the Waterberg system (unique combination of flora and faunal associations)
15_6	Mokolo River from Dwars river to confluence with Sterkstroom, Klein Vaalwaterspruit, Brakspruit	A42E	MOK_EWR1a and MOK_EWR1b (rapid sites)	The area is important as it plays a role as a corridor for fish.
IUA16	**Lower Mokolo**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
16_1	Tambotie river catchment	A42H (major portion - eastern)		This catchment falls within a protected area and nature reserve and thus has a Present State of a B. It further includes game farms and high in tourism. Tolerant fish species and aquatic macroinvertebrates occur.
16_2	Poer se Loop catchment	A42G		This catchment falls within a protected area and nature reserve and thus has a Present State of a B. It further includes game farms and high in tourism. Upper part of the river gets flow opposed to the lower section which becomes dry during dry seasons.
16_3	Rietspruit catchment	A42G (south western portion)		This catchment falls within a protected area and nature reserve. There are FEPA rivers, and some protected areas at the headwaters. The EIS is very high due to the presence of rare and endangered biota and fish species whom are intolerant to water quality changes.
16_4	Sandloop	A42J and remaining portion of A42H		Impacts on this system include coal mining, the power stations, coal bed methane extraction as well as agriculture. Serious impacts of local groundwater resources due to dewatering and future acid mine drainage discharges.
16_5_1	Mokolo mainstem - Mokolo from below EWR3 to the Tamboti confluence	A42G, H along mainstem	MOK_EWR3 MOK_EWR4	Important vegetation namely Syzygium cordatm (Water Berry) and Schotia brachypetala (huilboerboon) which continues in the rocky areas. Major sand mining is occurring within the Mokolo mainstem catchment. Furthermore high density anthocercis zambesiaca (Nyala tree) are present. These are good indicators of groundwater and thus assume that the large specimens are very dependent on groundwater. Downstream of the dam there a number of unique wetland pans. These pans are most of the time not filled up by flow from the river but rather by water flowing from the surrounding ridge of low hills along the river during heavy rainfall periods. Some are quite sizeable and provided habitat for water birds. Mokolo River floodplain present.

16_5_2	Mokolo mainstem - from Tamboti confluence to Limpopo.	A42J along mainstem	HN57	Abstraction activities is high in this mainstem with sand mining being a considerable issue in the Lepahlale area. Flow dependent fish occur (BMAR, LMOL). Owing to the floodplain, there are oxbow lakes. There are very large Faidherbia albida (Ana trees). Impact of landuse on groundwater needs to be considered to ensure resource sustainability. Tamboti River floodplain present
IUA17a	**Mothlabatsi/Mamba**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
17a_1	Mothlabatsi, Mamba Rivers	A41A, A41B	Rapid sites EWR 2 and EWR 3	The Matlabas River is within a Class I and flows through the Marakele Nature Reserve (protected area) owing to the present state of a B. The system is a fish support area with limited impacts. Flow dependent fish species (AURA) in Matlabas Zynkloof. Isolated population of CTHE. Rapid sites EWR 2 and EWR 3 are present. B. Waterburg (secret fish) has been noted to occur in the Mamba.
17a_2	Headwaters Mothlabatsi (peatlands)	A41A (south eastern)	EWR 1 (Rapid site)	The headwaters of the Mothlabatsi is located here. IUA is in a Class II and is a fish support area and within a protected area. Large wetlands occur within this IUA. There is the Matlabas peatland/mire and valleybottom wetlands present.
IUA17b	**Matlabas**			
RU Number	**Delineation Description**	**Quaternary Catchment**	**Hydronodes (HN)/ EWR sites**	**Rationale/Consideration**
17b_1	Matlabas	A41D, A41C	MAT_EWR 2 (Rapid site)	The primary land use is conservation and game farming. However, this IUA has been earmarked for future coal mining developments. FEPA wetlands are present and the rapid site EWR 4 is located. Migratory corridor to the Limpopo for the bird species. Valleybottom wetlands present in lower Matlabas River and includes Aslaagte.
17b_2	Catchment area including Steenbokpan	A41E		A large wetland system is indicated on the maps associated with the lower Matlabas River. The Steenbokpan area has been earmarked for future coal mining in this IUA. When the lower sections of the Matlabas at the confluence with the Limpopo is in flood, forms a large floodplain. Important floodplain features. Large oxbows linked to the Limpop River which flow once flooded.

5 RESOURCE UNIT PRIORITISATION

While the RQO determination procedure proposes RQOs for each resource unit, this may not always possible due the potentially large number of RUs that could be delineated for a catchment. A rationalisation process has therefore been developed as part of the RQO Determination Procedure (DWA, 2011) in order to prioritise and select the most useful RUs for RQO determination. The prioritisation of resource units forms Step 3 of the RQO determination process (Figure 12), and has been defined specifically prioritise and select RUs that are then taken through stakeholder consultation process to confirm priority.

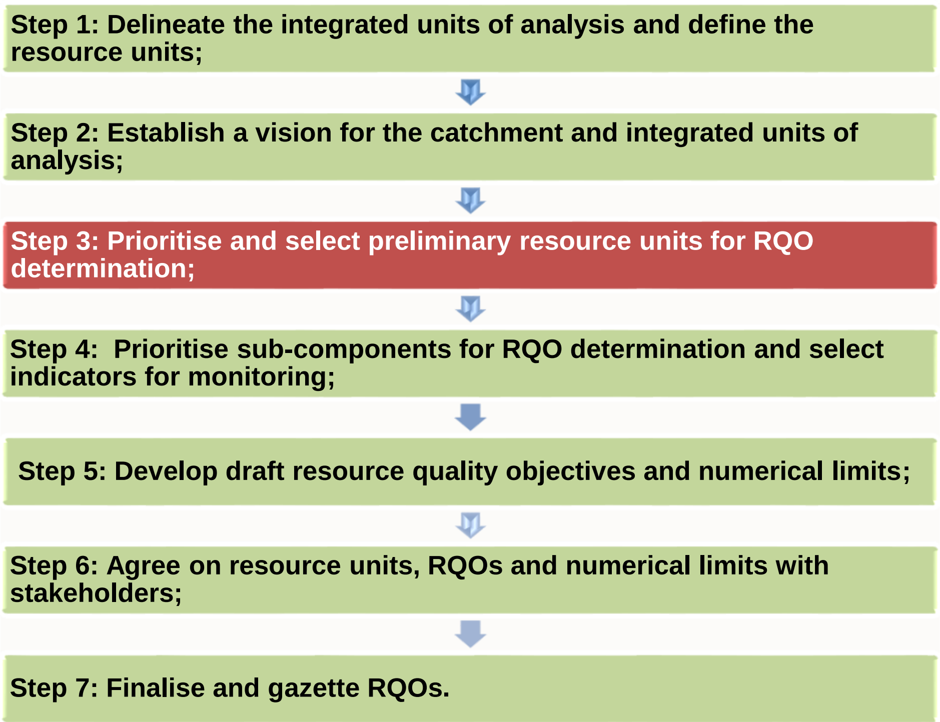

Figure 12: RQO Determination Process

The rationalisation process for RU selection and prioritisation is based on a decision support tool that has been developed to guide and support the process. The 'Resource Unit Prioritisation Tool' incorporates a multi criteria decision analyses approach to assess the importance of monitoring each RU as part of management operations to identify important RUs.

The criteria assessed per RU include:

- Position of RUs within an IUA;
- Importance of the RU to users;
- Threat posed to water resource quality for users;
- Threat posed to water resource quality for the environment;
- Ecological considerations;

- Practical Constraints, and
- Management Considerations.

Standardised rankings and weightings are proposed for each of the seven criteria above used in the prioritisation process by application of the tool. The RU Prioritisation Tool consists of a simple scoring system where a score of 0, 0.5 or 1 is assigned to the criteria to assess conformance to the guidelines supporting criterion. The rating scores then through ranking, relative weighting and multiplication allows for the relative prioritisation of RUs to be determined, by producing a prioritisation score – the priority rating of the RU (DWA, 2011). The priority rating scores the RUs relative to each other and considers the summary scores for the criteria This provides an integrated measure to inform the selection of RUs. However these values maybe altered if strong motivation exists and may be adjusted to suite the current context. The process also requires that a rationale is provided for the selection of priority RUs as in some cases low and moderate rated RUs may be selected over higher rated ones (DWA, 2011).

This tool maybe applied using desktop information however local knowledge and good understanding of the catchment is required to obtain the desired results.

5.1 RESOURCE UNIT PRIORITISATION BASED ON ASSESSMENT CRITERIA

As described above the Resource Unit Prioritisation Tool incorporates seven criteria that are scored, ranked, weighted, rated and assessed. The criteria assessed to prioritise the RUs are described in Table 8 below.

Table 8: Criteria of the Resource Unit Prioritisation Tool (DWA, 2011)

Criterion	Description and Reasoning	Sub-criteria rated (0: low, 0.5: moderate or 1:high) per criterion per RU
Position of RU within IUA	This is the first criterion that is considered within the RU Prioritisation Tool. Resource Units on large main stem rivers at the downstream end of the IUAs are located at the edge of socio-economic zones where user requirements are likely to differ. Such Resource Units also aggregate the upstream impacts from the entire IUA and thus enable the assessment of management performance at meeting objectives (including the gazetted IUA Class) for the upstream catchment. These RU thus receive high prioritisation in the Tool. It is important to note that estuaries will always be prioritised in this way (DWA, 2011).	• Resource Units located on large main stem river at the downstream end of the IUA (IUA outlet node)
Assessment of the importance of each Resource Unit to users	This is the second criterion assessed and considers both current and future use. The tool assesses a number of sub-criteria relevant to different user considerations.	• Resource units which provide important cultural services to society • Resource units which are important in supporting livelihoods of significant vulnerable communities

Criterion	Description and Reasoning	Sub-criteria rated (0: low, 0.5: moderate or 1:high) per criterion per RU
		• Resource units which are important in meeting strategic requirements and international obligations • Resource units that provide supporting and regulating services • Resource units most important in supporting activities contributing to the economy (GDP & job creation) in the catchment (e.g. commercial agriculture, industrial abstractions and bulk abstractions by water authorities)
Level of threat posed to the water resource quality for users	This assessment considers the risk of the water resources to the users. Resource units which are threatened or are likely to be threatened by current or future activities should be monitored (most likely to be impacted by high risk activities)	• Level of threat posed to users
Ecological importance	This criterion is assessed to identify resource units that are important from an ecological perspective. A range of attributes relative to the water resource are considered.	• Ecological Importance and Sensitivity Categories (EIS) • Present Ecological State (PES) and Nested Ecological category (NEC) • National Freshwater Ecosystem Priority Areas • Priority habitats/species identified in provincial conservation plans
Threat posed to the water resource quality for the environment	This criterion is assessed to identify RUs which are threatened or are likely to be threatened by current or future activities that should be monitored due to the risk posed to the ecological elements of the water resource. This considers those RUs most likely to be impacted by high risk activities.	• Level of threat posed to the ecological components of the resource unit
Management considerations	This criterion requires the assessment of RUs where management actions should be prioritised. This applies to RUs or reaches where it is necessary to monitor the effectiveness of measures implemented to improve status quo.	• Resource Units with PES lower than a D category or lower than the accepted gazetted category (NEC)
Practical considerations	In addition to the above practical considerations are also considered to if RQOs can be determined and monitored.	• Availability of EWR site data or other monitoring data (RHP, DWA gauging weirs) located within reach • Accessibility of resource units for monitoring • Safety risk associated with monitoring resource unit

The Resource Unit Prioritisation Tool was applied at a desktop level to the RUs delineated in the Mokolo, Matlabas, Crocodile (West) and Marico catchments for the seven criteria described above. The desktop results were presented and discussed with specialists and catchment water resource managers to obtain their input on the rating of the resource units. Based on their local knowledge and understanding of the study area the desktop prioritisation scores were revised, and the RUs selected and prioritised. These results will be presented at the project steering committee meetings in the catchment area to finalise the resource unit prioritisation. The results of the prioritisation rating process are included in Appendix A and presented in Figure 13 and Figure 14. The overall prioritisation rating score per RU for the Crocodile (West), Marico, Mokolo and Matlabas catchments are listed below in Table 9. The resource units rated as high and moderate have been prioritised for RQO development.

Table 9: Prioritisation Rating per RU for the Crocodile (West) catchment, Marico catchment and Mokolo and Matlabas catchments (Rating: 0.1-0.4 Low; 0.5-0.7 Moderate; 0.8 – 10 High)

IUA1	Upper Crocodile/Hennops/Hartebeespoort			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
1_1	Upper Hennops and Rietvlei Rivers to inflow to Rietvlei Dam	A21A	0.9	High
1_2	Rietvlei Dam	A21A	0.9	High
1_3	Hennops River from outflow Rietvlei Dam to the A21B catchment	A21B	0.5	Moderate
1_4	Upper Pienaars River, Edendalespruit and Moretlele Rivers to Roodeplaat Dam	A23A	0.7	Moderate
1_5	Roodeplaat Dam	A23A	0.5	Moderate
1_6	Upper and middle reaches of Apies River, Skinnerspruit, Pienaars River from outflow Roodeplaat Dam to Boekenhoutpruit confluence, Roodeplaatspruit, Boekenhoutspruit	A23B, A23D, A23E	0.8	High
1_7	Jukskei, Klein Jukskei, Modderfonteinspruit	A21C	1.0	High
1_8	Upper reaches of Crocodile River and Bloubank Spruit	A21D, A21E	0.9	High
1_9	Crocodile River from Jukskei confluence to inflow Hartebeespoort Dam, Swartspruit	A21H	1.0	High
1_10	Hartebeespoort Dam	A21H	0.9	High
IUA2	**Magalies**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
2_1	Maloneys Eye	South eastern portion of A21F	0.8	High
2_2	Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers	A21F, A21G	1.0	High
2_3	Surface water area linked to Maloney's Eye (catchment area)	A21F	0.8	High

IUA3	Crocodile/Roodekopjes			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
3_1	Crocodile River from outflow Hartebeespoort Dam to inflow Roodekopjes Dam, Rosespruit, Ramogatla and Kareespruit	A21J	1.0	High
3_2	Roodekopjes Dam	A21J	0.6	Moderate
IUA4	**Hex/Waterkloofspruit/Vaalkop**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
4_1	Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe	A21K middle and lower catchment below dam	0.5	Moderate
4_3	Buffelspoort Dam	A21K	0.5	Moderate
4_2	Upper reaches of Sterkstroom to inflow Bueffelspoort Dam , Kleinwater	A21K upper catchment to dam	0.7	Moderate
4_4	Upper Hex River to Olifantsnek Dam, Rooikloofspruit	A22G	0.5	Moderate
4_5	Olifantsnek Dam	A22G	0.5	Moderate
4_6	Hex River outflow Olifantsnek Dam to inflow Bospoort Dam, Sandspruit	A22H	1.0	High
4_7	Bospoort Dam	A22H	0.5	Moderate
4_8	Water Kloofspruit tributary catchment	A22H	0.5	Moderate
4_9	Hex River outflow Bospoort Dam to inflow Vaalkop Dam	A22J	1.0	High
4_10	Vaalkop Dam	A22J	0.6	Moderate
IUA5	**Elands/Vaalkop**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
5_1	Upper reaches of Elands to Swartruggens Dam	A22A south eastern portion	0.8	High
5_2	Elands river downstream Swartruggens Dam to Lindleyspoort Dam	A22A	0.9	High
5_3	Lindleyspoort Dam	A22A	0.6	Moderate
5_4	Upper Koster River to Koster Dam	A22B	0.5	Moderate
5_5	Koster Dam	A22B	0.1	Low
5_6	Selons River, Kodoespruit, Dwarsspruit, lower Koster River	A22C, A22D	0.5	Moderate
5_7	Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana	A22E, A22F	1.0	High
5.8	Swartruggens Dam	A22A	0.8	High

IUA6a	Klein Marico			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
6_1	Upper Klein Marico to inflow Klein Maricopoort dam, Rhenosterfonteinspruit, Malmanieloop, Kareespruit	A31D	0.8	High
6_2	Klein Maricopoort dam	A31D	0.6	Moderate
6_3	Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit	A31E	1.0	High
6_4	Kromellenboog Dam	A31E	0.6	Moderate
IUA6b	**Groot Marico**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
6_5	Groot Marico, Polkadraaispruit	A31B	1.0	High
6_6	Marico Bosveld Dam	A31B	0.7	Moderate
IUA7	**Kaaloog-se-loop**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
7_1	Marico Eye, Kaaloog-se-Loop, Bokkraal-se-Loop, Ribbokfontein-se-Loop	A31A	1.0	High
IUA8	**Malmaniesloop**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
8_1	Malmanie Eye, Dolomites	A31C	1.0	High
IUA9	**Molopo**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
9_1	Bodibe Eye	D41A (Polfonteinspruit and Lotlhakane tributary catchment area)	1.0	0High
9_2	Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Modimola dam	D41A	0.9	High
9_3	Molopo River mainstem only from Modimola Dam to Disaneng Dam	D41A (mainstem)	1.0	High
9_4	Modimola Dam	D41A	0.5	Moderate
9_5	Disaneng Dam	D41A	0.5	Moderate
9_6	All remaining tributaries - Madibe, Kabe, Mogosane	D41A	0.1	Low
IUA10	**Dinokana Eye/Ngotwane Dam**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score e**	**Priority based on rating score**
10_1	Upper Ngotwane, Dinokane Eye	A10A	0.8	High
10_2	Ngotwane Dam	A10A	1.0	High
10_3	Ngotwane River outflow Ngotwane Dam to drainage boundary	A10A	0.4	Low

IUA11a	**Groot Marico/Molatedi Dam**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
11a_1	Rasweu, Maselaje rivers	A32D	1.0	High
11a_2	Molatedi dam	A32E	0.7	Moderate
IUA11b	**Groot Marico/Molatedi Dam**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
11b_1	Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, all tributaries	A31G, A31H, A31F, A31J, A32A, A32B, A32C	1.0	High
11b_2	Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane	A32A, A32B, A32C	0.5	Moderate
IUA12	**Bierspruit**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
12_1	Wilgespruit, Bofule, Kolobeng, Magoditshane	A24D	0.9	High
12_2	Bierspruit oultfloe Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng	A24E, A24F	1.0	High
12_3	Bierspruit Dam	A24D	0.4	Low
IUA13	**Lower Crocodile**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
13_1	Crocodile River outflow Roodekopjes Dam to upstream Sand River confuence, Motlhabe, Sleepfonteinspruit, Klipspruit tributaries	A21L, A24A, A24B, A24C	1.0	High
13_2	Sand River to confluence with the Crocodile River to Bierspruit confluence, Sondags, Vaalwaterspruit and Monyagole tributaries	A24G, A24H	1.0	High
13_3	Lower Crocodile from Bierspruit confluence to the Botswana border (Limpopo River)	A24J	1.0	High
IUA14	**Tolwane/Kulwane/Moretele/Klipvoor**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
14_1	Apies River, Tshwane tributary	A23F	0.7	Moderate
14_2	Pienaars River from Boekenshout confluence to Apies River confluence	A23C	0.9	High
14_3	Plat River	A23G	0.5	Moderate
14_4	Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam	A23J	1.0	High
14_5	Rietspruit and all tributaries	A23H	0.3	Low
14_6	Klipvoor Dam	A23J	0.4	Low

14_7	Pienaars River from Klipvoor Dam to Crocodile Riverconfluence, Tolwane tributary	A23K, A23L	0.9	High
IUA15	**Upper Mokolo**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
15_1	Moloko River in A42C, Sand River and Klein Sand, Brakspruit, Sondagsloop, Heuningspruit, Dwars, Jim se loop tributaries	A42C, A42E	1.0	High
15_2	Sterkstroom, Frikkiesloon,	A42D, A42E	0.5	Moderate
15_3	Mokolo River in A42F to inflow Mokolo Dam, Taaibosspruit, Malmanies and Bulspruit tributaries	A42F	0.6	Moderate
15_4	Mokolo Dam	A42F	0.6	Moderate
15_5	Grootspruit and Sandspruit tributaries (Mokolo headwater catchment)	A42B	0.5	Moderate
15_6	Mokolo River from Dwars river to confluence with Sterkstroom, Klein Vaalwaterspruit, Brakspruit	A42E	0.8	Moderate
IUA16	**Lower Mokolo**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
16_1	Tambotie river catchment	A42H (major portion - eastern)	0.5	Moderate
16_2	Poer se Loop catchment	A42G	0.6	Moderate
16_3	Rietspruit catchment	A42G (south western portion)	0.3	Low
16_4	Sandloop	A42J and remaing portion of A42H	0.5	Moderate
16_5	Mokolo mainstem	A42 G, A42H, A42J (along mainnstem river)	1.0	High
IUA17a	**Mothlabatsi/Mamba**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
17a_1	Mothlabatsi, Mamba Rivers	A41A, A41B	1.0	High
17a_2	Headwaters Mothlabatsi (peatlands)	A41A (south eastern)	1.0	High
IUA17b	**Matlabas**			
RU	**Delineation**	**Catchment**	**Prioritisation Rating Score**	**Priority based on rating score**
17b_1	Matlabas	A41D, A41C	1.0	High
17b_2	Catchment area including Steenbokpan	A41E	0.6	Moderate

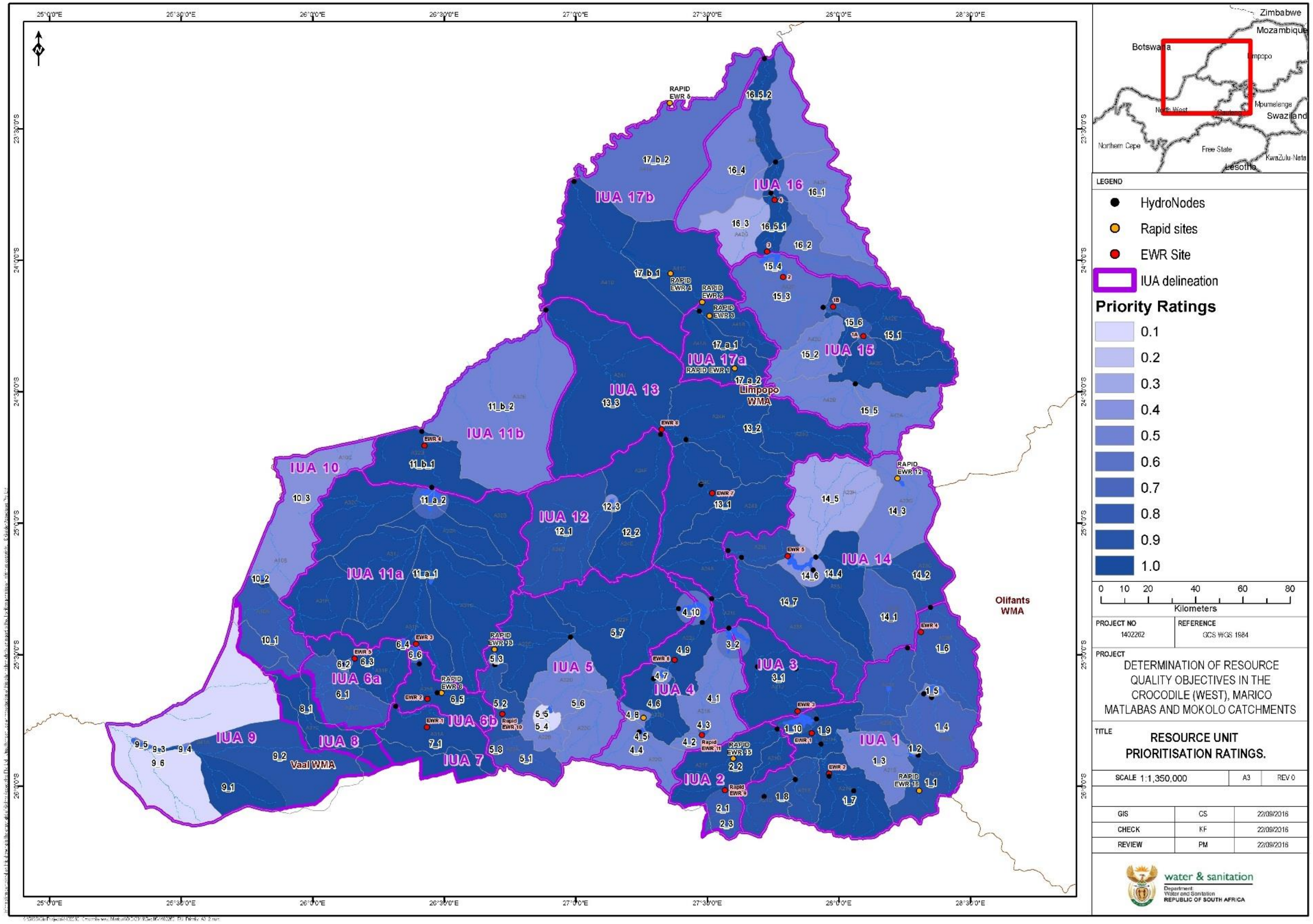

Figure 13: Prioritisation ratings of RUs based on the application of the RU Prioritisation Tool

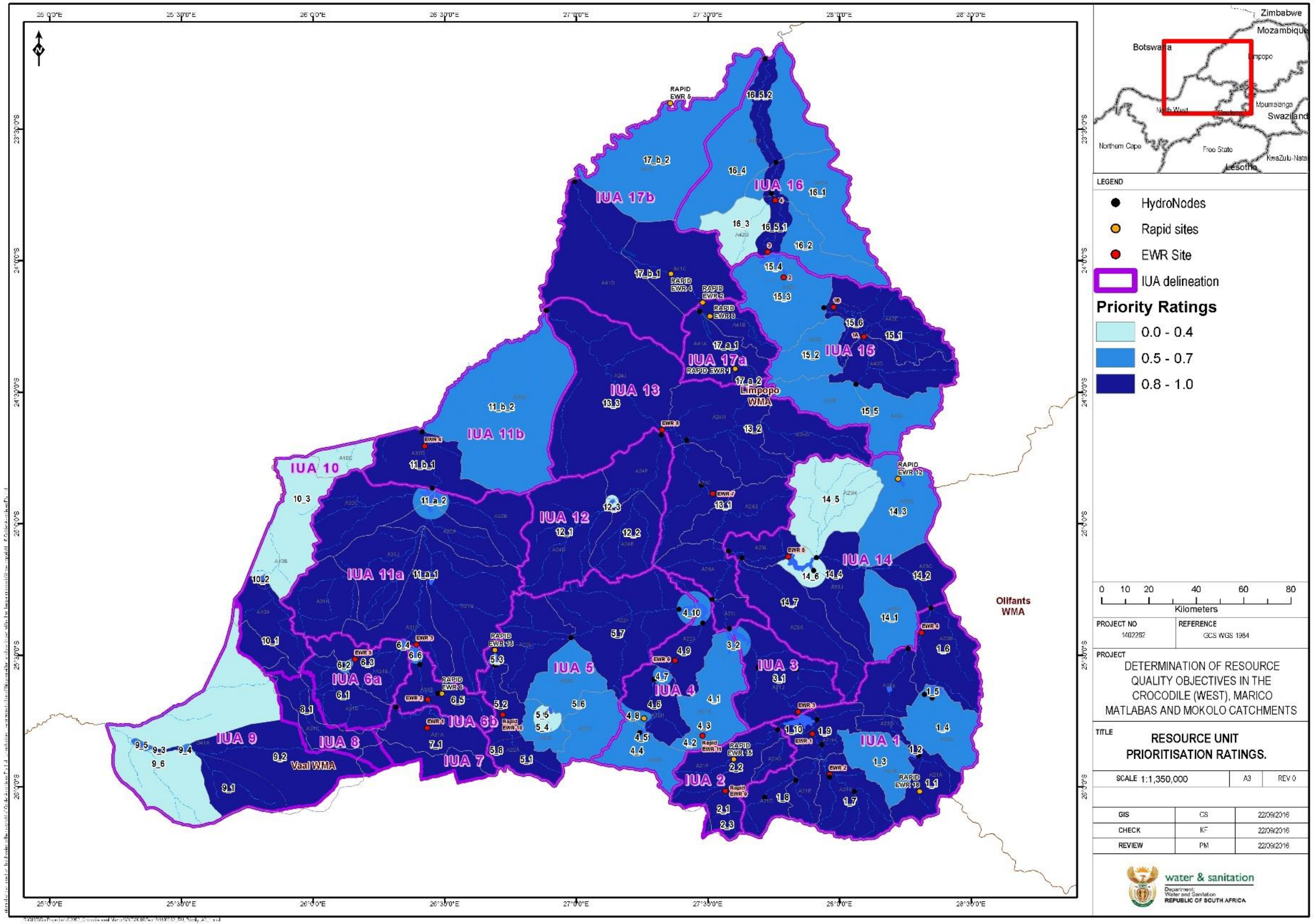

Figure 14: Summary of the Prioritisation ratings of RUs (Dark blue being of higher priority in terms of determining RQOs)

5.2 GROUNDWATER RESOURCE UNITS

Two important aquifer systems have been identified in terms of specifying specific groundwater resource units, *i.e*.:

- Alluvial aquifer systems; and
- Dolomite (karst) aquifer systems.

5.2.1 DELINEATION OF MAJOR DOLOMITE (KARST) AQUIFER RESOURCES

The presence of significant alluvial deposits (referenced as intergranular aquifers) in the river valleys opts for demarcation (*viz*. specific RUs) of these systems as well, as they are in fact acting as an interface between the surrounding intergranular and fractured and fractured aquifers and the surface water body in the drainage channel. Where applicable (*i.e*. where these systems represents a noticeable component of the water resource), it has been specifically mapped as a RU, *i.e*. the Lower Crocodile River (Thabazimbi to Limpopo River confluence, IUA17b) and the Lower Mokolo (A42J). A more detailed mapping of these areas are discussed in section 3.2.6.2 above.

5.2.2 DELINEATION OF MAJOR DOLOMITE (KARST) AQUIFER RESOURCES

In terms of RUs, it is recommended to sub-divide the aquifer systems into the same IUAs/RUs as for the surface water, however, where detailed demarcations for the karst aquifers have been adopted during the water resource classification study (DWA, 2013), the resource units are aligned to include the mapped dolomite resource units specifically. The reason is that the groundwater flow paths through these karst systems are high and flow paths are demarcated by the presence of secondary boundary systems (*i.e*. intrusive dykes acting as flow boundary systems). For the remainder of the study area, *i.e.* the non-karst aquifer units, the groundwater resource units are the same as the surface ones.

The delineation of dolomite resources requires the identification and mapping of small and larger dolomite compartments, at sub quaternary catchment scale, by considering aspects such as geological lithology, aquifer recharge, hydraulic gradients, water level (piezometric) information, water quality data, location of springs, discharge areas and quaternary catchment boundaries.

5.2.2.1 Centurion, Pretoria, Rietvlei-Kempton Park Dolomite Area

The delineations of groundwater resources within the Centurion, Pretoria and Rietvlei Dam dolomite areas are presented in Figure 15. Three main dolomite resource units (a groundwater management unit, GMU) are shown. The boundary of two groundwater management areas (includes more than one GMU), numbered A21A and A21B, correspond to a large extent with the quaternary drainage boundaries A21A and A21B, especially for areas underlain by the weathered and fractured aquifers of the granites and sedimentary rocks of the Pretoria Group.

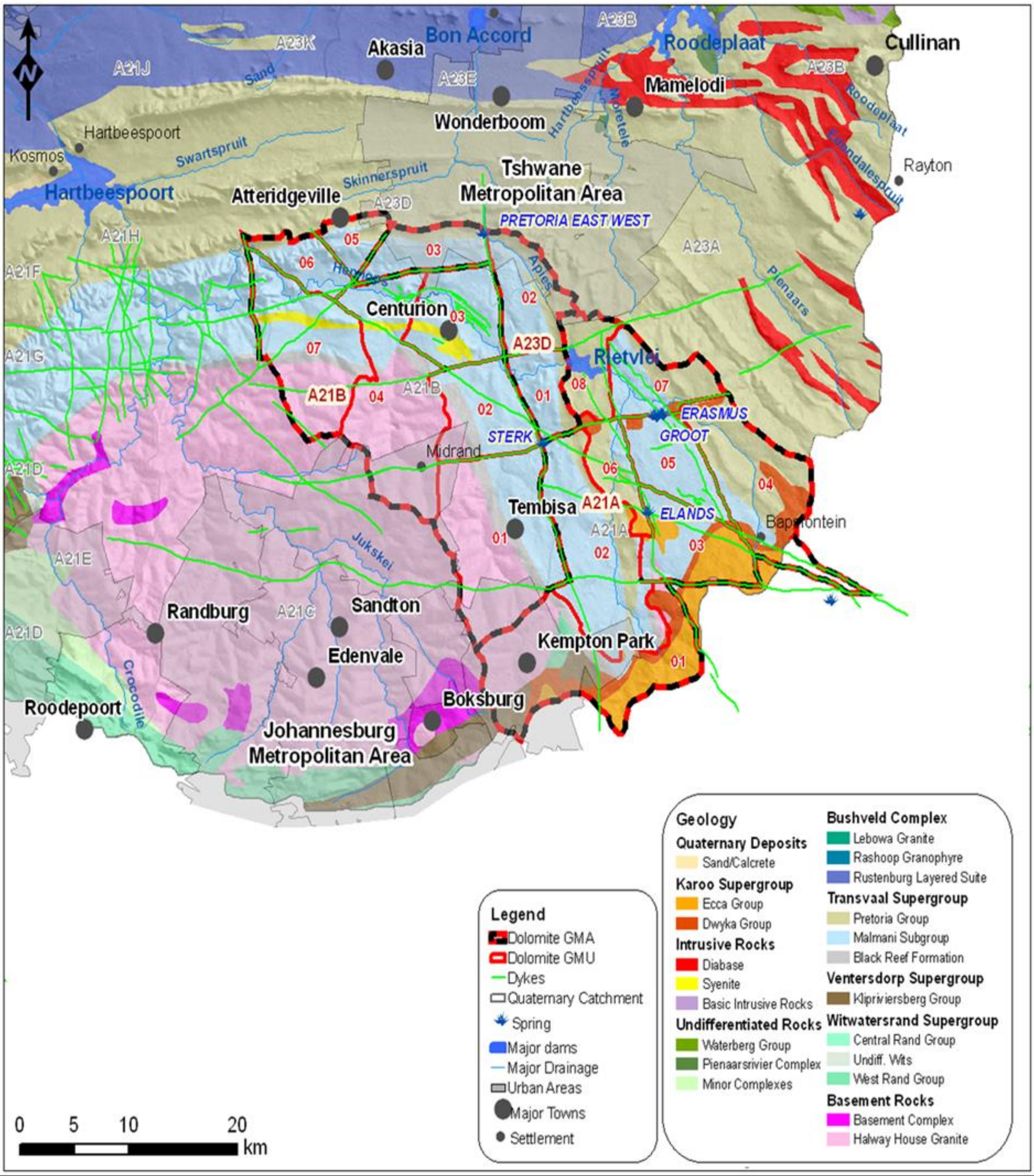

Figure 15: Delineation of the Centurion, Pretoria and Rietvlei-Kempton Park dolomite resources

Eight GMUs were delineated within the Rietvlei-Kempton Park dolomite groundwater management area-A21A totalling 499 km^2, slightly larger than the 483 km^2 of the quaternary catchment drainage A21A. The GMU sub-numbers 01 to 08 follow the drainage as in surface catchments. The lowest number is used for the upper catchment area and the largest number in the discharge area. Springs in the area include the Sterkfontein, Elandsfontein, Erasmusfontein and Grootfontein.

In the Centurion dolomite groundwater management area A22B seven GMUs were delineated totalling 464 km^2, less than the 527 km^2 of the quaternary catchment.

The delineation of groundwater management area A23D entailed only the dolomite resource area, excluding the remaining portion of the total surface catchment area. The presence of impermeable dykes resulted in noticeable differences between the resource and surface drainage boundaries. Springs in the groundwater management area include the well-known Pretoria East and West Fountains.

5.2.2.2 Maloney's Eye (Steenkoppies) and Tarlton Dolomite Areas

This dolomite water area is illustrated in Figure 16 below. Three GMUs were delineated within the Maloney's Eye catchment area groundwater management area-A21F totalling 311 km^2, which includes the Steenkoppies dolomite compartments at 213 km^2. The Maloney's Eye catchment area is a smaller portion of the quaternary catchment A21F at 1000 km^2. The GMU sub-numbers 01 to 03 follow the drainage as in surface catchments, with the Maloney's eye discharging from unit A21F-03 at a natural long term average of 14.7 million m^3 /annum to the Magalies River (see Figure 16). In areas where the catchment is underlain by dolomite the boundary of groundwater management area-A21F differs (being larger) than the surface catchment boundary due to the groundwater boundary conditions of the dolomite compartment boundaries.

The Steenkoppies Dolomite Compartment Unit is one of the major groundwater units in this dolomite water area and contributes to the recharge area of Maloney's Eye which feeds into the Magalies River. This compartment unit is meaningfully used for irrigation in the compartment area and impacts on the water supplies downstream of the Eye.

Five GMUs were delineated within the Tarlton dolomite catchment area, groundwater management area-A21D, which includes the Zwartkranz dolomite compartment, totalling 291 km^2 and smaller than the 372 km^2 of the quaternary catchment drainage A21D. In areas where the catchment is underlain by dolomite the boundary of groundwater management area-A21D differs from the surface catchment boundary The GMU sub-numbers 01 to 05 largely follow the surface drainage, Figure 16. Springs in the area include the Waterfall, Rietspruit (Zwartkranz) and Kromdraai springs. Average annual spring flows for the Zwartkranz Spring is 8.2 million m^3 and for the Kromdraai Spring is 11.7 million m^3 (according to flow measurements by Mr P Hobbs, (Hobbs, 2010) and observations made in 2012).

The Maloney's Eye and Tarlton dolomite water areas are significantly impacted by mine water decanting and water treatment discharges. Decanting of mine water south and near Mogale City (former Krugersdorp) has led to significant pollution, resulting in elevated heavy metal concentrations, high sulphate content, increased electrical conductivity, and a lowering of the pH in abandoned mining areas. The area of decant, is immediately south (GMU unit A21D-02) of the Cradle of Humankind World Heritage Site , which hosts a vast treasure of fossilized remains of past life forms, particular hominids found in over 200 local karst caves.

Surface water drainage (mainly effluent return flows from the Percy Steward wastewater treatment works (WWTW) along the Blougatspruit recharges the underlying kartz aquifer (GMUs: A21D-02 and A21D-04) at approximate 5.9 million m^3 /annum (16.16 Mℓ/d) (Bredenkamp *et al*.1986). Observations by Hobbs, 2010 (pers. comm.) indicates that the loss rate in the Blougatspruit amounts to -23.1l/s/km between the same two specified localities used by Bredenkamp in 1986, (viz.~22l/s/km). Observed increases in chloride and sulphate content in the groundwater originate from the Percy Steward WWTW. The Zwartkranz dolomite compartment is stressed due to groundwater contamination.

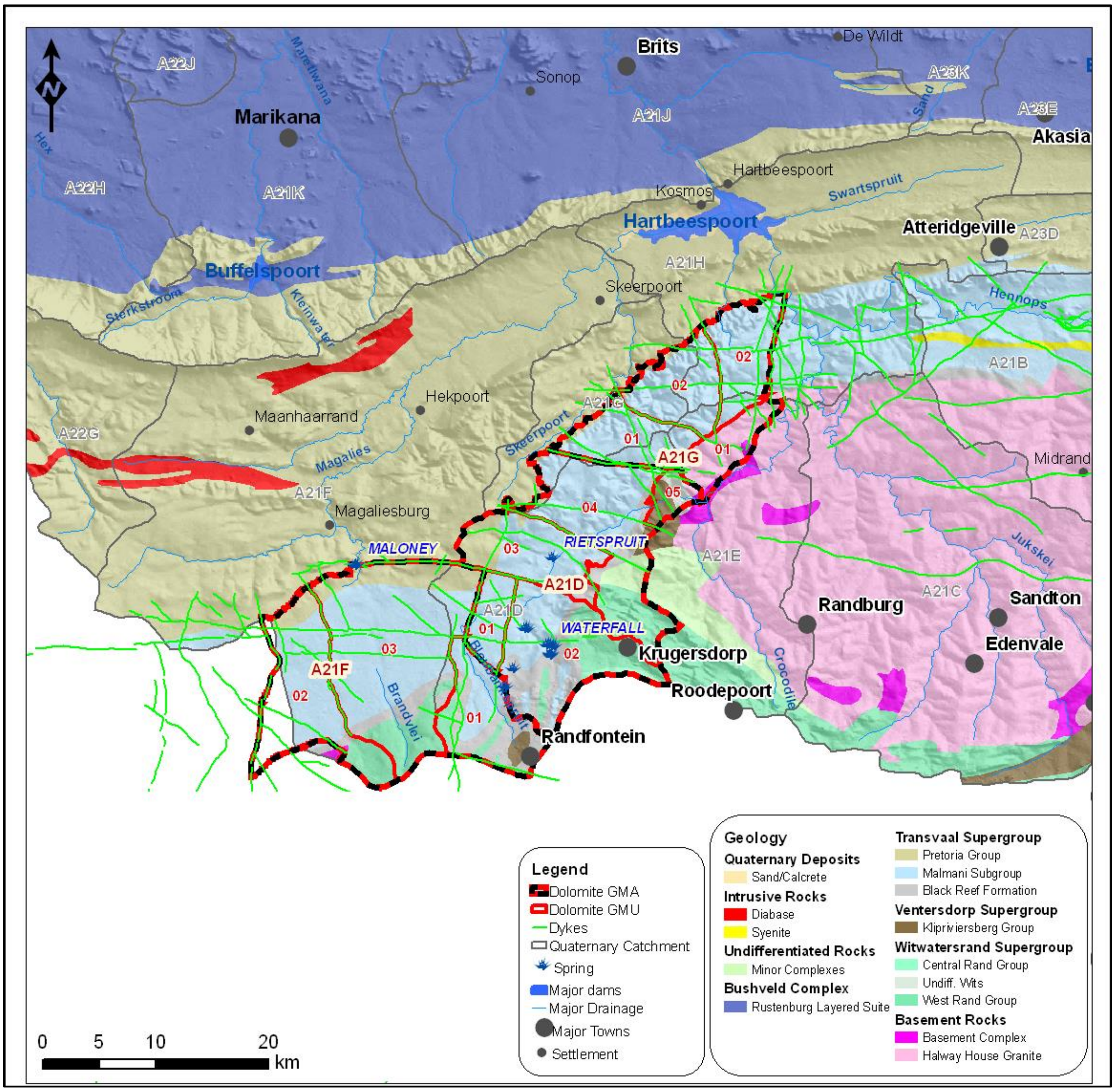

Figure 16: Delineation of the Maloney's Eye Catchment and Tarlton Dolomite resources

5.2.2.3 Zeerust and Marico/Holpan Dolomite Area

The delineation of the Zeerust and Marico/Holpan dolomite areas is presented in Figure 17. Three GMUs were delineated within the Marico/Holpan dolomite catchment area groundwater management area-A31A, totalling 531 km^2 (dolomite sub-compartments numbers 01-03 from the east). The A31A groundwater management area consists predominantly of dolomite formations and is a smaller area than the 632 km^2 of the quaternary catchment A31A. The GMU sub-numbers 01 to 03 follow the general surface drainage, with several springs discharging as surface flows towards the north from which the Marico River originates. Springs in the area include Bokkraal, Grootfontein, Rhenosterfontein and Kuilfontein all discharging to the north.

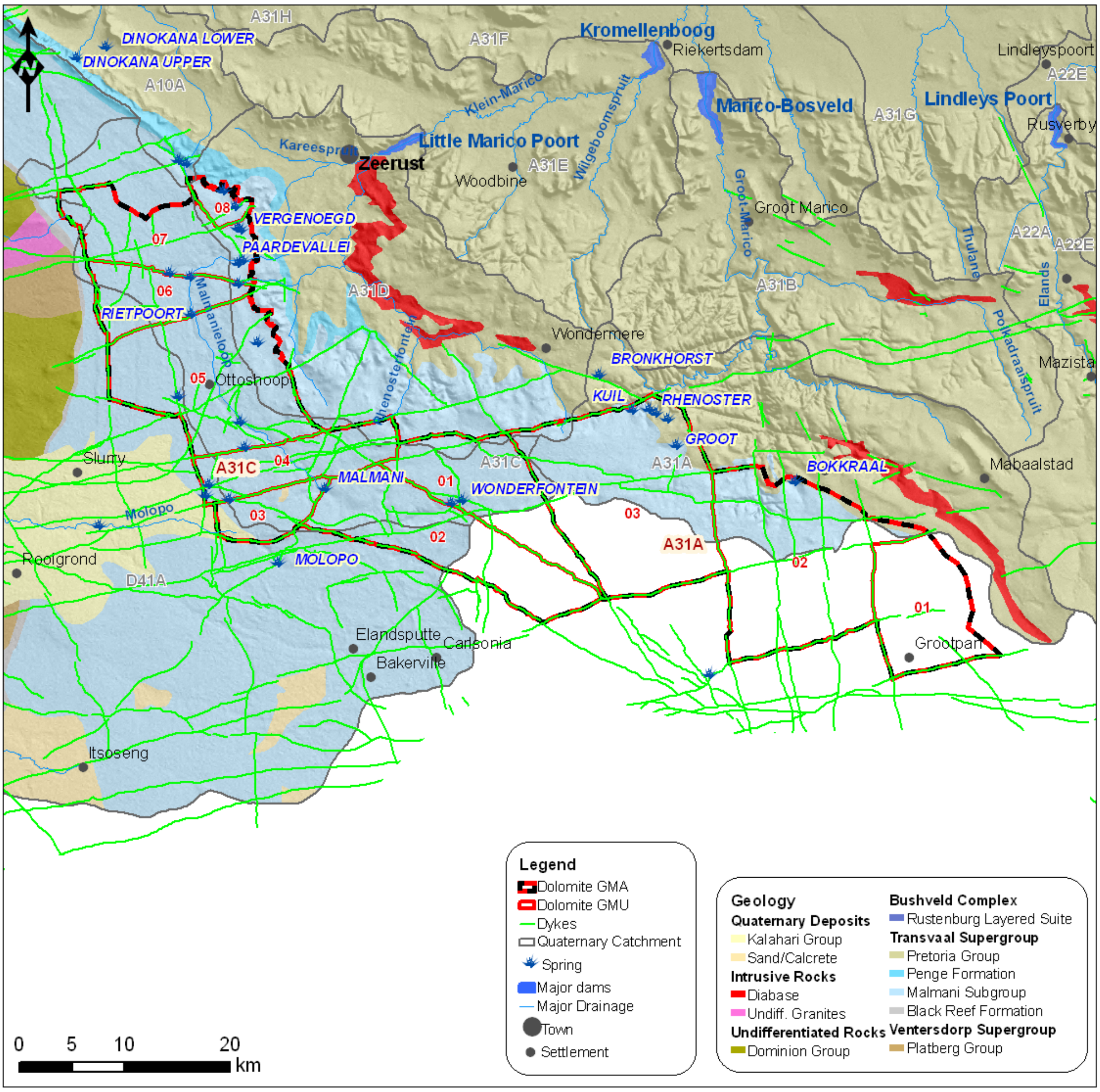

Figure 17: Delineation of the Zeerust and Marico/Holpan dolomite resources

In the Zeerust dolomite area, groundwater management area A31C, up to 08 GMUs were delineated (dolomite sub-compartments 01-08 towards the west), most containing one or more springs. The total area of groundwater management area A31C is 693 km^2, forty three per cent larger than the 485 km^2 of the quaternary catchment A31C.

Prominent dolomite springs in the Zeerust dolomite area include Wonderfontein, Malmani, Buffelshoek, Rietpoort, Doornfontein, Paardenvallei, Vergenoegd, Wolvekoppies and Klaarstroom. The latter four springs and Buffelshoek under natural average conditions discharged water from the karst aquifer to surface flows (approximate 9.3 million m^3 /annum) in the upper Klein Marico River catchment area. Increased abstraction for municipal water supply and extended drought period has however reduced current spring flows.

The steady state annual recharge for the Zeerust, groundwater management area A31C has been simulated at 1330 l/s (approximate 42 million m^3) or 1.9 l/s/km^2. In the Marico/Holpan groundwater management area, A31A the average unit recharge is higher and preliminary estimated at 2.5 l/s/km^2 approximate 42 million m^3 /annum for the total groundwater management area.

Irrigation use dominates and in the groundwater management area A31A (Marico/Holpan Dolomites) which is mainly located in southern portion of the groundwater management area, to the south and outside the quaternary catchment boundary.

Upper Molopo River Dolomite Areas

This area falls in the Upper Molopo River drainage systems, *i.e.* quaternary catchment D41A (IUA 9). Serious water supply shortages have been reported in the IUA area and several long-term dolomite eye’s have dried up completely over the last few decades, for example Grootfontein Eye and Bodebe Eye. The Molopo Eye is still actively flowing, but needs dedicated management as it is currently supporting a large portion of the Mahikeng water supplies.

Over utilisation of the Lichtenburg-Itsoseng GMUs in the last decade, and poor aquifer recharge events have significantly reduced the long-term potential of these dolomite management units.

In terms of RUs, this dolomite water area represents the head water systems of the upper Molopo River and is in a rather deteriorated condition. Water supply to large communities such as Itsoseng, Lichtenburg and Mahikeng, depends solely on these resources.

5.2.3 SELECTION OF GROUNDWATER RESOURCE UNITS

The following aspects of the current status of the groundwater resources are to be addressed through setting of appropriate RQO’s, *i.e.* in terms of

- Karst aquifer systems:
  - Highly vulnerable to land use activities due to prominent, local recharge mechanisms and high potential for pollution;
  - Impacts on dolomite eyes and associated wetlands, *viz.* critical wetlands/eyes in the Itsoseng-Lichtenburg Groundwater Management Area (GMA) where water quality ranges and quantity (aquifer saturation levels) need to be specified;
  - Some areas where over-utilisation of groundwater from dolomite compartments have been noted – such as the Bapsfontein Dolomite Compartment Unit and the central Itsoseng-Lichtenburg, resource quality objectives will have focus specific on groundwater management protocols. Low consumptive water users are ominously impacted to the point where their water use (in many cases legal ones) are forced to be terminated by complete over-utilisation by one of two high-abstraction users; and
  - The principle of “existing uses” which are currently totally abused by irrigators, need to be addressed.
- Utilising deep seated fractured zones in mined/industrialised areas:
  - Deep cycle dewatering of mined areas impacts on local shallow aquifer systems;

  - Protection of the shallow aquifer systems where mining/industrial water uses pose an impact of the groundwater resources; and
  - Land use activities that impact on shallow aquifer systems (quality and quantity).

  All mining areas will have to be earmarked for specific RQOs specifications based on a representative monitoring programme.

- Alluvial Aquifers along the main stem river systems (specifically the Crocodile West System):
  - Potential surface water – groundwater Interaction during periods of high-low flows/groundwater droughts;
  - The case of return flows via the alluvial aquifer systems; and
  - Demarcation of Protection Zones along the main stem rivers in terms of quality and quantity RQO specifications based on the 50 day travel time for organic components (quality) and stream depletion factors (quantity).

The highest impact on water resources in the study area is in the karst aquifer units. In most cases a dolomite eye is present, representing the main discharge point of the dolomite water area. It is a known fact that as soon as groundwater is abstracted from the dolomite aquifer, the eye's discharge is affected over time. There are, especially in the drier western dolomite areas several examples of dolomite eyes that have completely dried up (e.g. the Grootfontein Eye supplying water to Mahikeng) – due to local irrigation and bulk water abstractions. This behaviour, result in a long-term over-abstraction (*i.e.* stress indexes >1.0). The normal practice is to drill production boreholes at the eye and continue with the abstraction to a point where the resource unit is complete dewatered – as the case currently with the Grootfontein and Bodibe Eye's in RUs 9_1 and 9_2.

In other cases, uncontrolled abstraction (*i.e*. complete ignorance from the water users part) such as the Babsfontein Galata Farm case has resulted in the development of ground stability problems which becomes a serious risk to occupants in the immediate area. RQO registers for such cases should be highly effective and implemented by the regulators.

5.3 WETLANDS

5.3.1 Prioritisation of Wetlands

The prioritisation of the wetlands was based predominantly on available information from previous studies supported by inputs provided during the various task team, steering committee and other team meetings held as part of the project. In addition, where new information on wetlands in the area was available, this was also considered in the prioritisation. Other aspects that were also considered in developing the wetland prioritization were:

- Wetland size;
- Wetlands known to have unique or high biodiversity;
- Wetlands occurring in areas where the vegetation grouping has a high threat status (Driver, Sink, Nel, Holness, Van Niekerk, Daniels, Jonas, Majiedt, Harris and Maze, 2012);
- Wetland connectivity in the landscape;

- Whether or not the system is known to support rare or endangered species;
- Systems thought to be unique or representative of a type unique to a particular area or region;
- Whether or not the system can be considered representative of a specific type or representative of an eco-region;
- Systems known to contain peat (peatlands);
- Systems known or thought to be important in terms of supporting livelihoods or providing key ecosystem services;
- Systems thought to be important in terms of the hydrology, geohydrology and/or the biogeochemistry of a particular area or sub-catchment;
- Whether or not the system forms part of a particular complex of wetlands that may be linked by certain attributes or a key driver; and
- Whether or not the system forms part of a biodiversity or landscape corridor that is considered important for a particular area or region or a particular species.

The above criteria were also considered in the context of the health or state of the wetland system and its likely trajectory of change given the current land-uses in the area or whether or not it is considered to be at risk from proposed new water uses in the area. A priority list of what are perceived to be the most important identified wetlands in the study area was compiled. Note that there may still be other wetlands that could rank as important but which were not captured in any of the databases used, or not identified as part of this study.

A preliminary list of priority wetlands per IUA and Resource Unit (RU) is provided in Table 10. A preliminary map showing the distribution of wetlands per IUA and RU is shown in Figure 18.

Table 10: Preliminary list of priority wetlands per IUA and RU indicating the type of system, range of PES and EIS categories captured from the DWA (2013) study, the NFEPA Vegetation Group and Threat Status, whether the system forms part of a Threatened Ecosystem (according to GN 1002, National List of Ecosystems that are Threatened and in need of Protection), whether the system is identified as a WETFEPA, and a brief description of any unique features associated with the wetland systems

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
IUA 1	1_1	-	Pans	C/D to E	Very High	Mesic Highveld Grassland Group 4 - **CR**	Some Notably Glen Austin Pan and pans associated with Rietvlei River Highveld Grassland - **CR**	Some	Endorheic seasonal grass-sedge depressions
	1_1	-	Valley bottom wetlands	A/B to D/E	Moderate	Mesic Highveld Grassland Group 4 – **CR** Dry Highveld Grassland Group 5 - **LT**	Many occur in the Egoli Granite Grassland - **EN**	Mainly those associated with the Rietvlei River	-
	1_3, 1_7, 1_8	-	Hillslope seepage wetlands	C/D to E/F	High	Mesic Highveld Grassland Group 4 – **CR** Dry Highveld Grassland Group 5 - **LT**	Many occur in the Egoli Granite Grassland - **EN**	None	High botanical diversity
	1_1	Rietvlei wetland complex	Peatland	C/D to D/E	High to Very High	Mesic Highveld Grassland Group 4 – **CR** Central Bushveld Group 2 - **VU**	Rietvlei River Highveld Grassland - **CR**	Yes	Peatlands

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
	1_4	Colbyn Valley wetland	Peatland	D	High to Very High	Mesic Highveld Grassland Group 4 – **CR** Central Bushveld Group 2 - **VU**	Marikana Thornveld - **VU**	No	Peatlands
IUA 2	2_1	-	Pans	-	High	Dry Highveld Grassland Group 5 - **LT**	Some occur on the Soweto Highveld Grassland - **VU**	One	Endorheic seasonal grass-sedge depressions
	2_1, 2_2	-	Valley bottom wetlands	-	Moderate	Central Bushveld Group 5 - **VU**	Some occur in the Witwatersberg Skeerpoort Mountain Bushveld – **EN** Others on the Soweto Highveld Grassland - **VU**	None	-
	2_1, 2_2	-	Hillslope seepage wetlands	-	High	Central Bushveld Group 5 - **VU**	Some occur in the Witwatersberg Skeerpoort Mountain Bushveld – **EN** Others on the Soweto Highveld Grassland - **VU**	None	High botanical diversity
	2_1	Maloney's eye	Dolomitic eye and peatland	B	Very High	Central Bushveld Group 5 - **VU**	No	No	Dolomitic eye

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
IUA 4	4_8	Waterval Valley Bottom Mire (peatland)	Unchannelled valley bottom	-	Very High	Central Bushveld Group 1 - **CR**	No	Yes	Peatland at the headwaters of the Waterkloofspruit
IUA 5	5_1, 5_2	-	Pans	-	Very High	Mesic Highveld Grassland Group 4 - **CR**	Rand Highveld Grassland - **VU**	None	Endorheic seasonal grass-sedge depressions
	5_1	-	Valley bottom wetlands	-	Moderate	Mesic Highveld Grassland Group 4 - **CR**	Rand Highveld Grassland - **VU**	None	-
	5_1	-	Hillslope seepage wetlands	-	High	Mesic Highveld Grassland Group 4 - **CR**	Rand Highveld Grassland - **VU**	None	High botanical diversity
IUA 7	7_1	-	Valley bottom wetlands	C/D	Moderate to High	Mesic Highveld Grassland Group 4 - **CR**	Rand Highveld Grassland - **VU**	No	-
	7_1	-	Pans	D	High	Mesic Highveld Grassland Group 4 - **CR**	Rand Highveld Grassland - **VU**	No	-
	7_1	-	Tufa waterfall	B	Very High and very sensitive to water quality changes	Mesic Highveld Grassland Group 4 - **CR**	No	No	Waterfall composed of limestone or calcium carbonate formed by the precipitation of carbonate

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
									minerals. Very rare type of waterfall in SA
	7_1	Marico eye (Kaaloog se Loop)	Valley bottom Peatland	B/C	Very High	Mesic Highveld Grassland Group 4 - **CR**	No	No	Dolomitic eye
IUA 8	8.1	Malmanie Loop	Valley bottom mire or peatland	B to C/D	Very High	Dry Highveld Grassland Group 5 - **LT**	No	Yes	Dolomitic eye with a valley bottom peatland downstream. Unique biota associated with the dolomitic eye.
IUA 9	9_1	-	Pans	-	High	Dry Highveld Grassland Group 5 - **LT**	Western Highveld Sandy Grassland - CR	None	Endorheic temporary to seasonal depressions
	9_6	-	Pans	-	High	Eastern Kalahari Bushveld Group 1 - **LT**	Mafikeng Bushveld – VU	Some	Endorheic seasonal grass-sedge depressions
	9_2	-	Valley bottom wetlands	-	Moderate	Dry Highveld Grassland Group 5 - **LT**	No	No	-
	9_4	-	Valley bottom wetlands	-	Moderate	Eastern Kalahari Bushveld Group 1 - LT	No	No	-

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
	8_1, 9_2	Molopo	Unchannelled valley bottom wetlands and peatlands	B to D	Very High	Dry Highveld Grassland Group 5 - **LT**	No	Yes	Molopo Eye and peatland. Is important for water supply and biodiversity support
	9_1	Bodibe peatland	Unchannelled valley bottom wetlands	E/F	Very High	Dry Highveld Grassland Group 5 - **LT**	No	No	Potfontein eye and Bodibe peatland.
IUA 10	10_1	Ngotwana Wetland	Unchannelled valley bottom wetland and spring	B to D/E	High to Very High	Central Bushveld Group 2 - **VU**	No	No	High biodiversity wetland in semi-arid climate with its source in Botswana. Important grazing and water resource for local community
	10_1	Dinokana eye and Wetland	Unchannelled valley bottom, spring and hillslope seepage wetlands	C to D/E	High to Very High	Central Bushveld Group 2 - **VU**	No	No	High biodiversity wetland and important for water supply
IUA 11b	11_b_1	Lower Marico River	Riparian zone and floodplains	B to D	Very High	Central Bushveld Group 2 - **VU**	No	Yes	Old growth riparian forest assemblages, floodplain features, paleo-channels as well as backwater

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
									features
	11_b_2	Lengope la Kgamanyane River	Floodplain	C	High	Central Bushveld Group 2 – **VU**	No	No	-
	11_b_2	Lenkwane River	Floodplain	C	High	Central Bushveld Group 2 - **VU**	No	No	-
	11_b_2	-	Pans	B to D	High to Very High	Central Bushveld Group 2 - **VU**	No	Some	-
IUA 13	13_3	Sections of the Crocodile River	Riparian zone, off-channel wetlands, backwaters and floodplains	B to D	High	Central Bushveld Group 2 and 3 **– VU to EN**	No	Yes	Riparian zone, floodplain and off-channel features
IUA 14	14_2, 14_4	Moretele River floodplain	Floodplain	D to E	Very High	Central Bushveld Group 2 - **VU**	Springbokvlakte Thornveld - **VU**	Yes	High biodiversity wetland and important bird habitat. Important grazing resource for local community
	14_1	Apies River floodplain	Floodplain	E to F	Very High	Central Bushveld Group 2 - **VU**	Springbokvlakte Thornveld - **VU**	No	Important grazing resource for local community and important tributary of the Moretele

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
									River floodplain
	14_3	Plat River floodplain	Floodplain	E to F	Very High	Central Bushveld Group 2 - **VU**	Springbokvlakte Thornveld - **VU**	No	Important tributary of the Moretele River floodplain system
	14_4	Tswaing Crator	Depression	-	Very High	Central Bushveld Group 2 - **VU**	No	Yes	Unique endorheic system
IUA 15	15_1	-	Valley bottom wetlands	A/B to C/D	High	Central Bushveld Group 3 - **EN**	No	Yes	Part of the Waterberg system with a unique combination of flora and faunal associations
	15_5	-	Valley bottom wetlands	A/B to C/D	High	Central Bushveld Group 1 - **EN**	No	No	Part of the Waterberg system with a unique combination of flora and faunal associations. I
	15_1	-	Hillslope seepage wetlands	A/B to C/D	High	Central Bushveld Group 3 - **EN**	No	No	Part of the Waterberg system with a unique combination of flora and faunal associations

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
	15_5	-	Hillslope seepage wetlands	A/B to C/D	High	Central Bushveld Group 1 - **EN**	No	No	Part of the Waterberg system with a unique combination of flora and faunal associations
IUA 16	16_3	-	Valley bottom wetlands	-	High	Central Bushveld Group 4 – **VU** to **EN**	No	No	-
	16_3	-	Hillslope seepage wetlands	-	High	Central Bushveld Group 4 - **VU**	No	No	-
	16_5	Mokolo River and floodplain	Floodplain	C/D to D/E	High	Central Bushveld Group 4 - **VU**	No	Yes	Old growth riparian forest assemblages, alluvial aquifer and floodplain as well as backwater features
	16_1	Tambotie River floodplain	Floodplain	C/D to D/E	High to Very High	Central Bushveld Group 4 - **VU**	No	No	Old growth riparian forest assemblages, alluvial aquifer and floodplain features
IUA 17b	17_b_1	Lower Matlabas River	Valley bottom wetland	B/C	High	Central Bushveld Group 4 – **EN**	No	Parts of the system	-
	17_b_1	Aslaagte	Valley bottom	B	High	Central Bushveld Group 4 –	No	No	-

IUA	RU	Wetland	Type	PES	EIS	NFEPA Wetland Vegetation Group and Threat Status	Part of a Threatened Ecosystem	Identified as a WETFEPA	Unique features
			wetland			**EN**			
	17_b_2	Limpopo River and associated riparian zone and floodplain features	Riparian zone and floodplains	B to D	Very High	Central Bushveld Group 4 - **VU**	No	Yes	Old growth riparian forest assemblages, floodplain features, paleo-channels as well as backwater features
	17_b_2	-	Valley bottom wetland	B	High	Central Bushveld Group 4 – **EN**	No	Yes	Large oxbow-type wetland linked to the Limpopo River
	17_a_2	Matlabas Peatland/Mire	Valley bottom wetland	B	Very High	-	No	No	Peatland in the headwaters of a tributary of the Motlhabatsi River
	17_b_1, 17_b_2	-	Pans	B to D	High to Very High	Central Bushveld Group 4 - **EN**	No	No	Old growth riparian forest assemblages, alluvial aquifer and floodplain features

VU: Vulnerable
EN: Endangered
CR: Critical
LT: Least Threatened

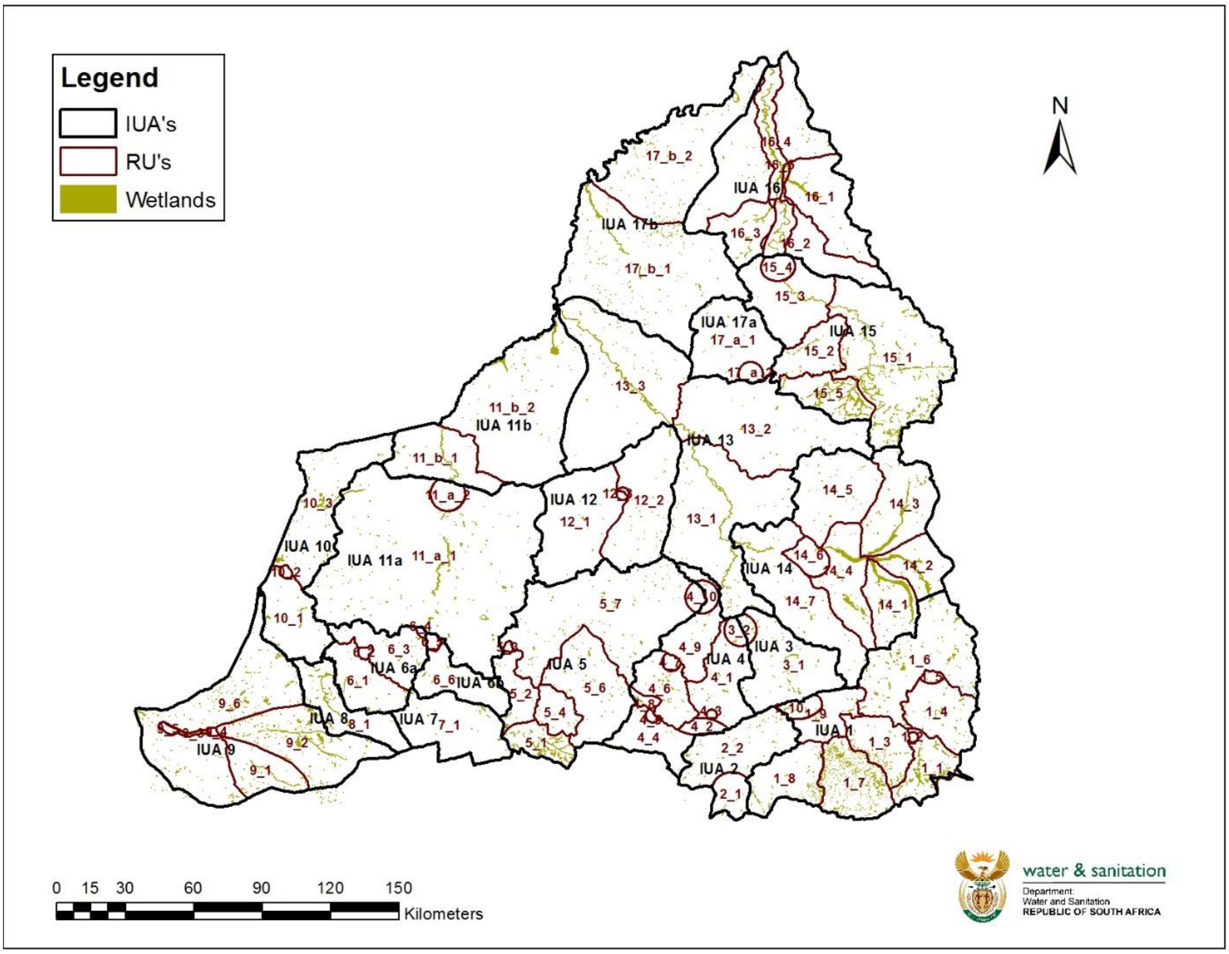

Figure 18: Map showing the distribution of wetlands per IUA and RU for the study area

6 SUMMARY AND CONCLUSION

In terms of the various components and considerations assessed for RU delineation and prioritisation and based on the understanding and expert knowledge of the Mokolo, Matlabas, Crocodile (West) and Marico catchments, the results of the delineation and prioritisation process are as follows:

- 82 water resource RUs were delineated (including river, dam, groundwater and wetland components)
- 57 RUs have been prioritised (which includes river reaches, groundwater priority areas and wetland systems) and,
- 18 dam RUs have been prioritised.

The RU prioritisation results, once presented and discussed with stakeholders at project steering committee meetings will be then be finalised.

RQOs for the prioritised and selected rivers, dams and groundwater RUs, and wetlands/wetland clusters will then be determined for the sub-components and indicators that are still to be selected (Steps 4 and 5 of the RQO process).

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APPENDIX A

SUMMARY PRIORITIZATION SCORES, RATING AND RATIONALE PER RESOURCE UNIT

Table A1: Tabulation of the Scores and Results of the application of the Resource Unit Prioritisation Tool (RUPT) in the the Mokolo, Matlabas, Crocodile (West) and Marico catchment

Resource Unit	Position of resource unit within IUA	Importance for users (Current & anticipated future use)					Threat posed to users	Ecological Importance				Threat faced by ecological component of the RU	Management Considerations	Practical Considerations			Prioritisation Score
	Position of RU	Culture services to society	Supporting livelihoods	Strategic requirements	Supporting and regulating services	Contribution to the economy	Threat posed to users	High Ecological importance and Sensitivity	EC or PES of A/B	Freshwater Ecosystem Priority Areas	Priority conserv-ation plans	Threat posed to ecology	PES lower than a D or lower than MC	Availability of data	Accessibility	Safety risk	
IUA 1																	
1_1	1	0.5	0	0	1	0.5	1	0	0	0.5	0.5	0.5	1	1	1	1	0.9
1_2	1	0	0	0.5	0.5	0.5	1	0	0	1	1	1	0	1	1	1	0.9
1_3	0	0.5	0	0	0.5	0	1	0	0	0.5	0	1	1	0	0.5	0.5	0.5
1_4	0	0.5	0	0.5	0.5	0.5	1	0.5	0	0.5	0.5	1	1	0.5	1	0.5	0.7
1_5	0	0.5	0	1	0.5	0.5	1	0	0	0	0.5	1	0	0.5	1	0.5	0.5
1_6	1	1	0.5	0	0.5	0.5	1	0.5	0	0.5	0.5	1	0	0.5	1	0.5	0.8
1_7	1	1	0	0.5	0.5	0.5	1	0	0	0	0	1	1	1	1	0.5	1.0
1_8	1	0.5	0	0	0.5	0.5	1	0	0	0	0.5	1	1	0.5	1	0.5	0.9
1_9	1	0.5	0.5	0.5	0.5	0.5	1	0.5	0	0.5	0	1	1	1	1	0.5	1.0
1_10	1	0.5	1	1	0.5	1	1	0	0	0	0.5	1	0	1	1	0.5	0.9
IUA 2																	
2_1	0	0.5	0.5	0	1	0.5	0	1	0	1	1	1	0	0.5	1	0.5	0.8
2_2	1	0.5	0.5	0	0.5	0.5	0	0	0.5	0	1	0.5	0	0	0.5	0.5	1.0
2_3	0	0	0.5	0	0.5	0	1	0	0	1	1	0.5	0	0	1	0.5	0.8
IUA 3																	
3_1	1	0.5	0.5	1	0.5	1	1	0.5	0	0	0	0.5	1	1	1	0.5	1.0
3_2	1	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0	0	0	0	0.5	0.5	0.5	0.6
IUA 4																	
4_1	0	0.5	0	0	0	0.5	0.5	0.5	0	0.5	0.5	0	1	0.5	0.5	0.5	0.5
4_2	0	0.5	0	0	0	0.5	0.5	1	0	1	1	1	0	0.5	0.5	0.5	0.5
4_3	1	0.5	0.5	0	0	0.5	1	0	0	0	0	0	0	0.5	0.5	0.5	0.7
4_4	0	0.5	0	0	0	0	0.5	0.5	0	1	0.5	0.5	1	0	0.5	0.5	0.5
4_5	1	0.5	0	0	0	0.5	0	0	0	0	0.5	0	0	0	0.5	0.5	0.5
4_6	1	0	0.5	0	0.5	0.5	1	0	0	0	0	1	1	0	0.5	0.5	1.0
4_7	0	0.5	1	0	0	0.5	1	0.5	0	0	1	0.5	0	0	0.5	0.5	0.5
4_8	0	0	0	0	1	0	0.5	0.5	0.5	1	1	1	0	0	0.5	0.5	0.5
4_9	1	0	0	0	0	0	1	0	0	0	0	1	1	0.5	0.5	0.5	1.0
4_10	1	0	0.5	0	0	0.5	0.5	0	0	0	0	0	0	0.5	0.5	0.5	0.6
IUA 5																	
5_1	1	0	0	0	0.5	0	0	0.5	0	1	0	1	0	0	0.5	0.5	0.8
5_2	1	0	0.5	0	0	0.5	0.5	0.5	0	0	1	1	0	0	0.5	0.5	0.9

5_3	1	0.5	0.5	0	0	0.5	0.5	0	0	0	0	0	0	0	0.5	0.5	0.6
5_4	0	0	0.5	0	0	1	1	0.5	0	0.5	0	0.5	0	0	0.5	0.5	0.5
5_5	0	0.5	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0.5	0.5	0.1
5_6	0	0.5	0.5	0	0	0.5	0.5	0.5	0	0	1	1	0	0	0.5	0.5	0.5
5_7	1	0.5	0.5	0	0.5	0.5	0.5	0	0	0	0.5	0.5	1	0	0.5	0.5	1.0
5_8	1	0	0.5	0	0	1	1	0	0	0	0	0	0	0.5	0.5	0.5	0.8
IUA 6a																	
6_1	0	1	0.5	0	0.5	0	1	0.5	0	0.5	0.5	0.5	0	0	0.5	0.5	0.8
6_2	0	0.5	0.5	0	0	0	1	0	0	0	0	0	0	0.5	1	0.5	0.6
6_3	0	0.5	0.5	0	0	0	0.5	0.5	0	0.5	0	0.5	1	0.5	1	0.5	1.0
6_4	0	0.5	0.5	0	0	0	1	0	0	0	0	0	0	0.5	1	0.5	0.6
IUA 6b																	
6_5	1	0	1	0	0	0.5	0.5	0	0	0	1	0	0	1	0.5	0.5	1.0
6_6	1	1	1	0	1	0	0.5	1	0.5	1	1	0.5	0	1	1	0.5	0.7
IUA 7																	
7_1	1	1	0	0	1	1	0	1	0.5	1	1	0.5	0	1	1	0.5	1.0
IUA 8																	
8_1	0	0.5	0	0	1	0	0	0.5	0	1	1	0.5	0	0	0.5	0.5	1.0
IUA 9																	
9_1	0	0.5	0.5	0	0.5	0	1	0	0	0	0	1	1	0	0.5	0.5	1.0
9_2	0	1	0.5	0	0.5	0	0.5	0.5	0	1	0.5	0.5	1	0	0.5	0.5	0.9
9_3	0	0.5	0.5	0	0.5	0	1	0	0	0	0	1	1	0	0.5	0.5	1.0
9_4	0	0.5	0.5	0	0	0.5	1	0	0	0	0	0	0	0	0.5	0.5	0.5
9_5	0	0.5	0.5	0	0	0.5	1	0	0	0	0	0	0	0	0.5	0.5	0.5
9_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.1
IUA 10																	
10_1	0	0.5	0.5	0	0.5	0	0	0.5	0	0	0	0.5	0	0	0.5	0.5	0.8
10_2	0	0	0.5	0	0	0.5	1	0	0	0	0	0	0	0	0.5	0.5	1.0
10_3	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.4
IUA 11a																	
11a_1	1	1	1	1	1	0	0.5	0	0	1	1	1	0	0.5	0.5	0.5	1.0
11a_2	1	0.5	0	1	0	0	0.5	0	0	0	0	0.5	0	0.5	0.5	0.5	0.7
IUA 11b																	
11b_1	1	0.5	0	0	0	0.5	0	0.5	0	1	1	1	0	0.5	0.5	0.5	1.0
11b_2	0	0	0.5	0	0	0.5	0	1	0	0	1	1	0	0	0.5	0.5	0.5
IUA 12																	
12_1	0	0.5	0.5	0	0	0.5	0.5	0	0	1	0	0.5	1	0	0.5	0.5	0.9
12_2	0	0.5	0.5	0	0	0.5	0.5	0	0	0	0	1	1	0	0.5	0.5	1.0
12_3	0	0.5	0.5	0	0	0.5	0.5	0	0	0	0.5	0	0	0	0.5	0.5	0.4

IUA 13																	
13_1	1	0.5	0.5	1	0.5	1	0.5	0.5	0	1	1	0.5	1	0.5	0.5	0.5	1.0
13_2	1	0.5	0.5	1	0.5	1	0.5	0.5	0	1	1	0.5	1	0.5	0.5	0.5	1.0
13_3	1	0.5	0.5	1	0.5	1	0.5	0.5	0	1	1	0.5	1	0.5	0.5	0.5	1.0
IUA 14																	
14_1	0	1	1	0	0.5	0.5	1	0	0	0.5	0	1	1	0	0	0.5	0.7
14_2	1	0.5	0.5	0	0.5	0.5	0.5	0.5	0	0.5	0	0.5	1	0	0.5	0.5	0.9
14_3	0	0.5	0.5	0	0.5	0	0	0.5	0	0.5	0	1	1	0	0.5	0.5	0.5
14_4	1	0.5	0.5	0	1	0	0	0.5	0	1	1	1	1	1	0.5	0.5	1.0
14_5	0	0.5	0.5	0	1	0	0	0.5	0	1	0	0.5	0	0	0.5	0.5	0.3
14_6	1	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.4
14_7	1	1	0	0	0	0	0	0.5	0	0.5	0	1	1	0.5	0.5	0.5	0.9
IUA 15																	
15_1	1	0.5	0.5	0	0	0	0.5	0.5	0	1	1	1	1	0.5	0.5	0.5	1.0
15_2	0	0	0	0	0	0.5	0	1	0.5	0	1	1	1	0	0.5	0.5	0.5
15_3	1	0.5	0	0	0	0.5	0	0.5	0.5	0	0.5	0.5	0	0.5	0.5	0.5	0.6
15_4	1	0.5	0	0	0	0	1	0	0	0	0	0	0	0.5	0.5	0.5	0.6
15_5	0	0.5	0	0	0.5	0	0.5	1	0	1	1	1	0	0	0.5	0.5	0.5
15_6	1	0.5	0.5	0.5	0	0.5	0.5	0.5	0	0	0.5	1	0	0.5	0.5	0.5	0.8
IUA 16																	
16_1	0	0	0	0	0.5	0.5	0	1	0.5	0	1	1	0	0	0.5	0.5	0.5
16_2	0	0	0	0	0	0	0	0.5	0.5	0.5	1	0.5	1	0	0.5	0.5	0.6
16_3	0	0	0	0	0	0	0	0.5	0	1	1	0.5	0	0	0.5	0.5	0.3
16_4	0	0	0	0	0.5	0.5	1	0.5	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5
16_5	1	0.5	0.5	0	1	0.5	0.5	0.5	0	0.5	0.5	0.5	0	0.5	0.5	0.5	1.0
IUA 17a																	
17a_1	0	0	0	0	0.5	0	0	1	0	1	1	0	1	0.5	0.5	0.5	1.0
17a_2	0	0	0	0	0.5	0	0	1	0	1	1	0	1	0.5	0.5	0.5	1.0
IUA 17b																	
17b_1	1	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0.5	0.5	0.5	1.0
17b_2	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0.6

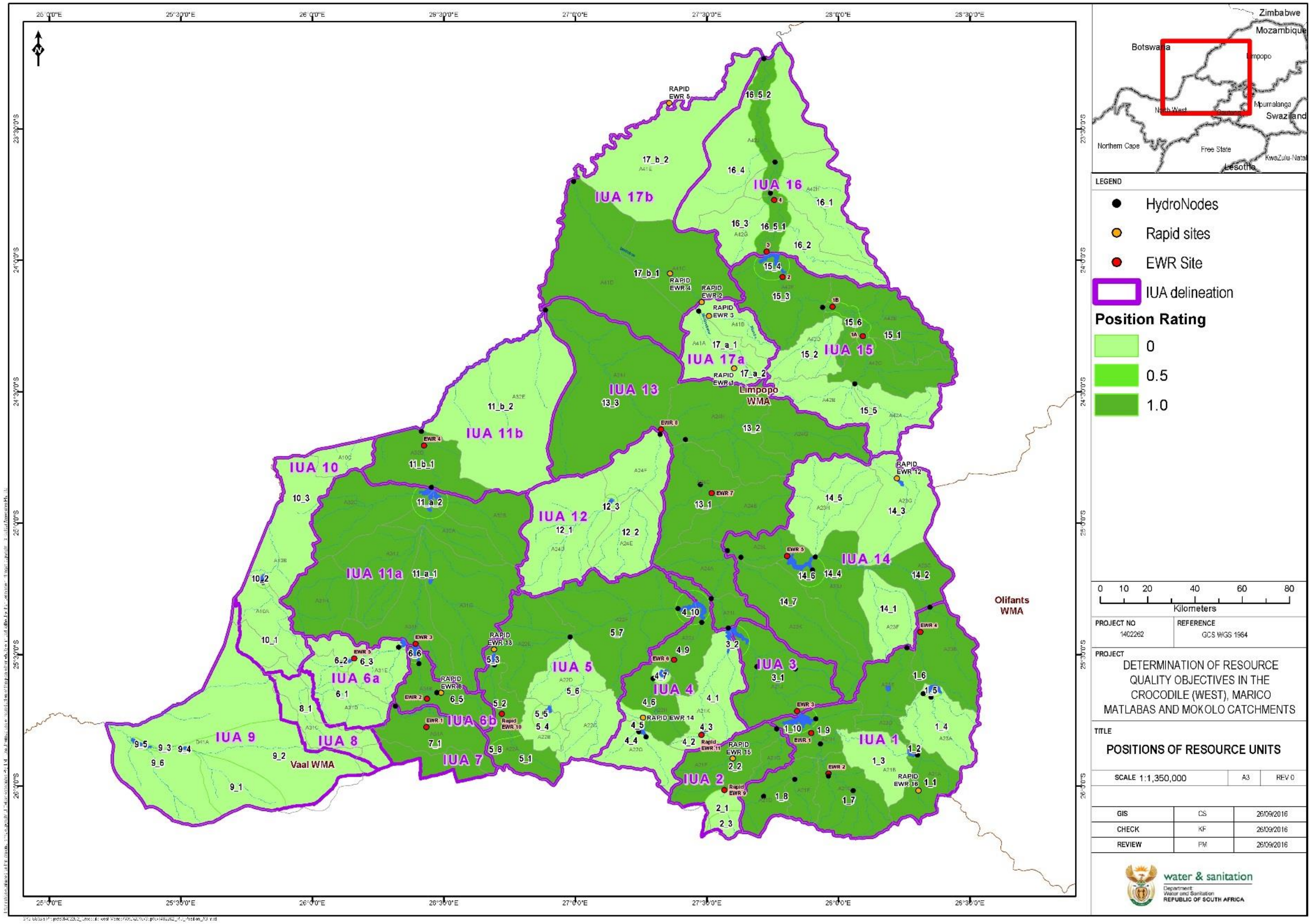

Figure A-1: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Positiion of Resource Unit

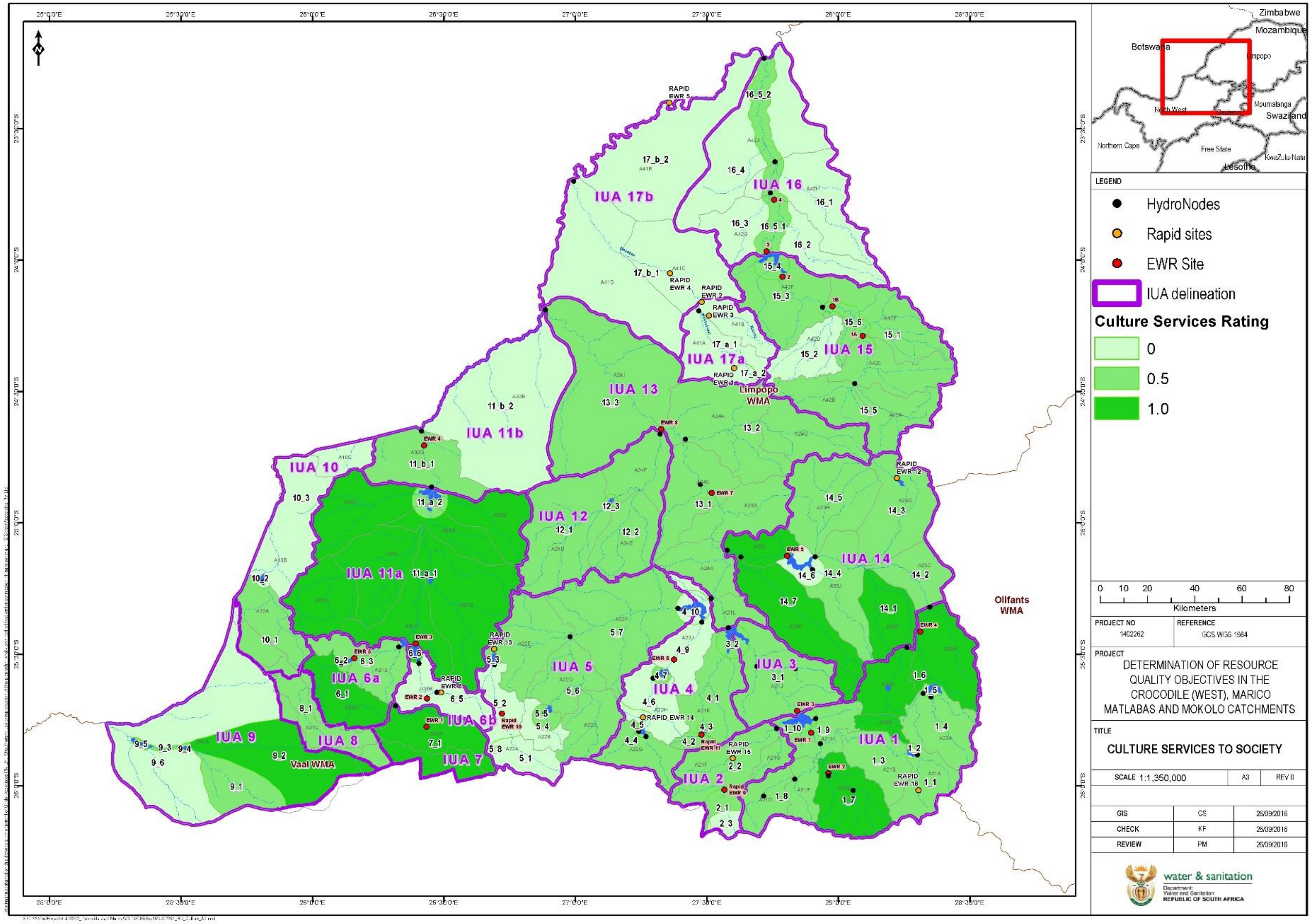

Figure A-2: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Cultural Services to Society

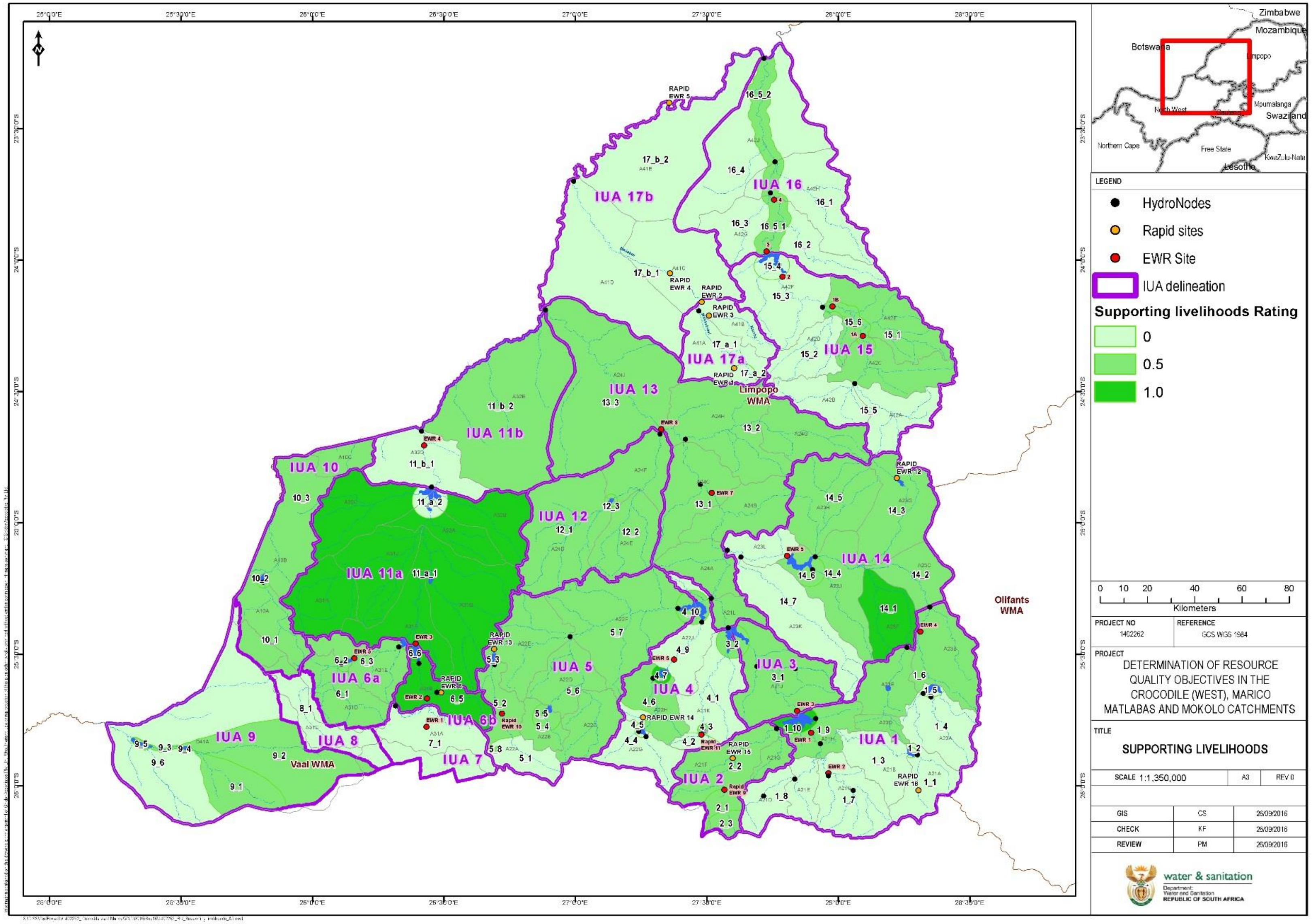

Figure A-3: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Supporting Livelihoods

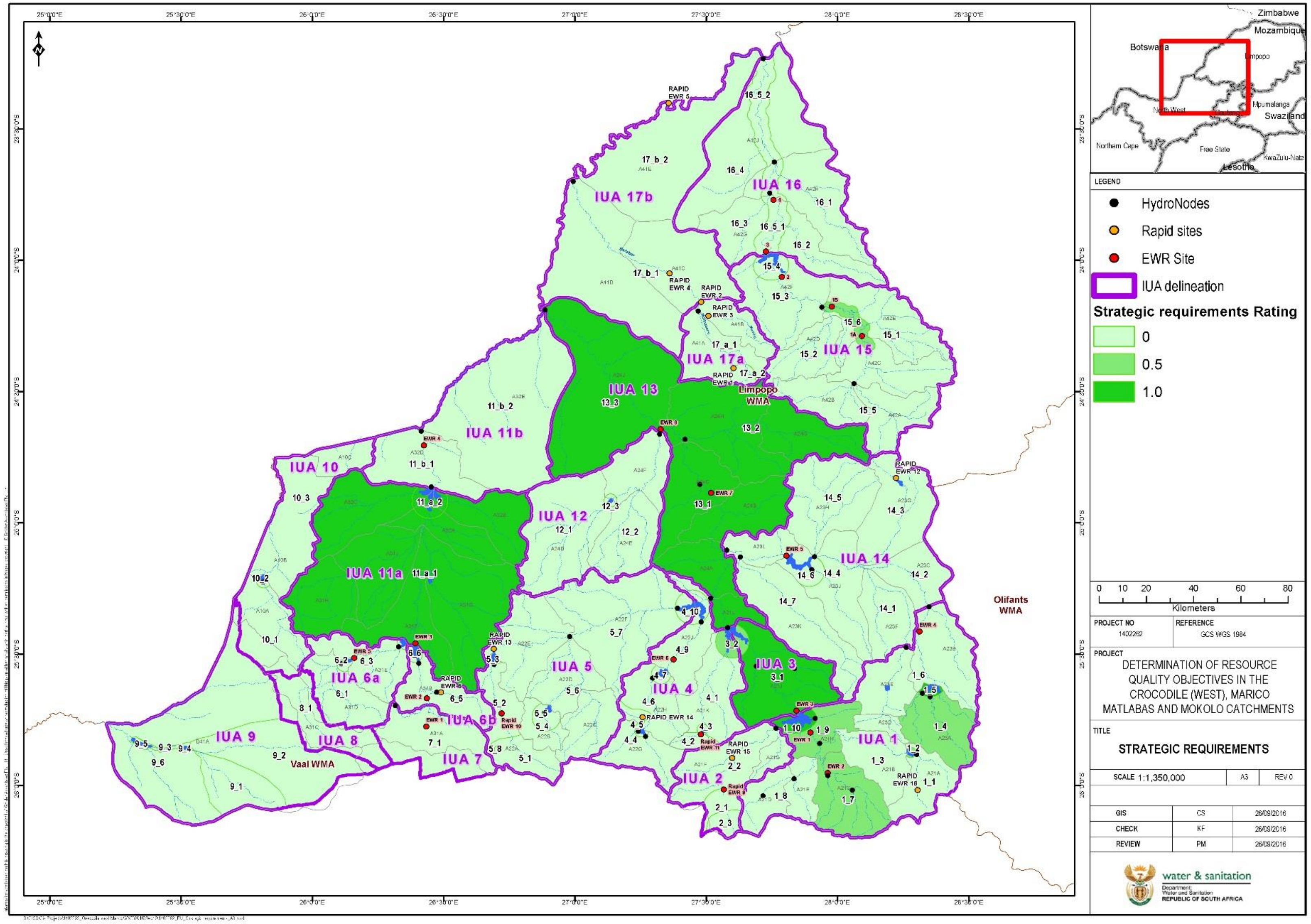

Figure A-4: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Strategic Requirements

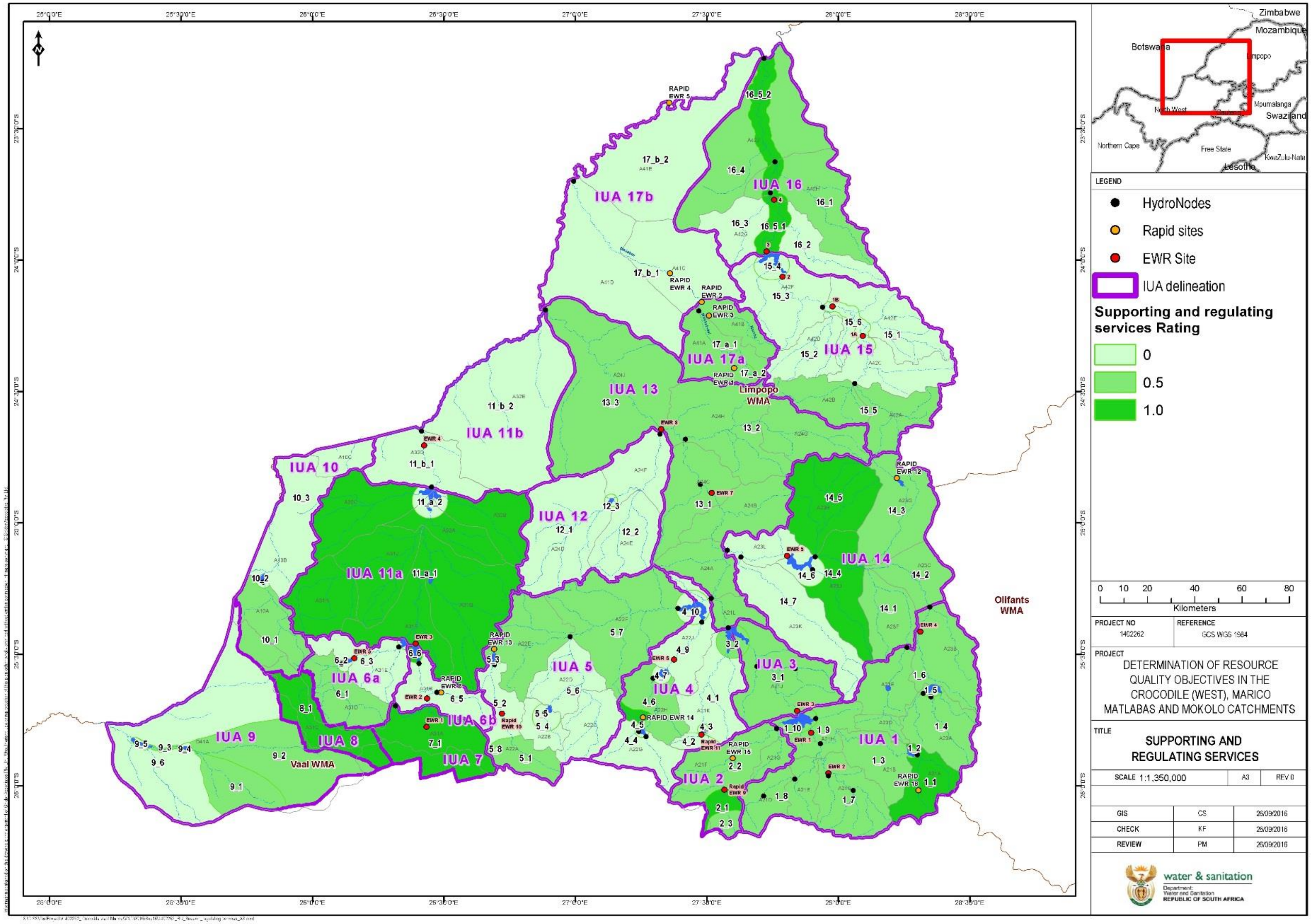

Figure A-5: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Supporting and Regulating Services

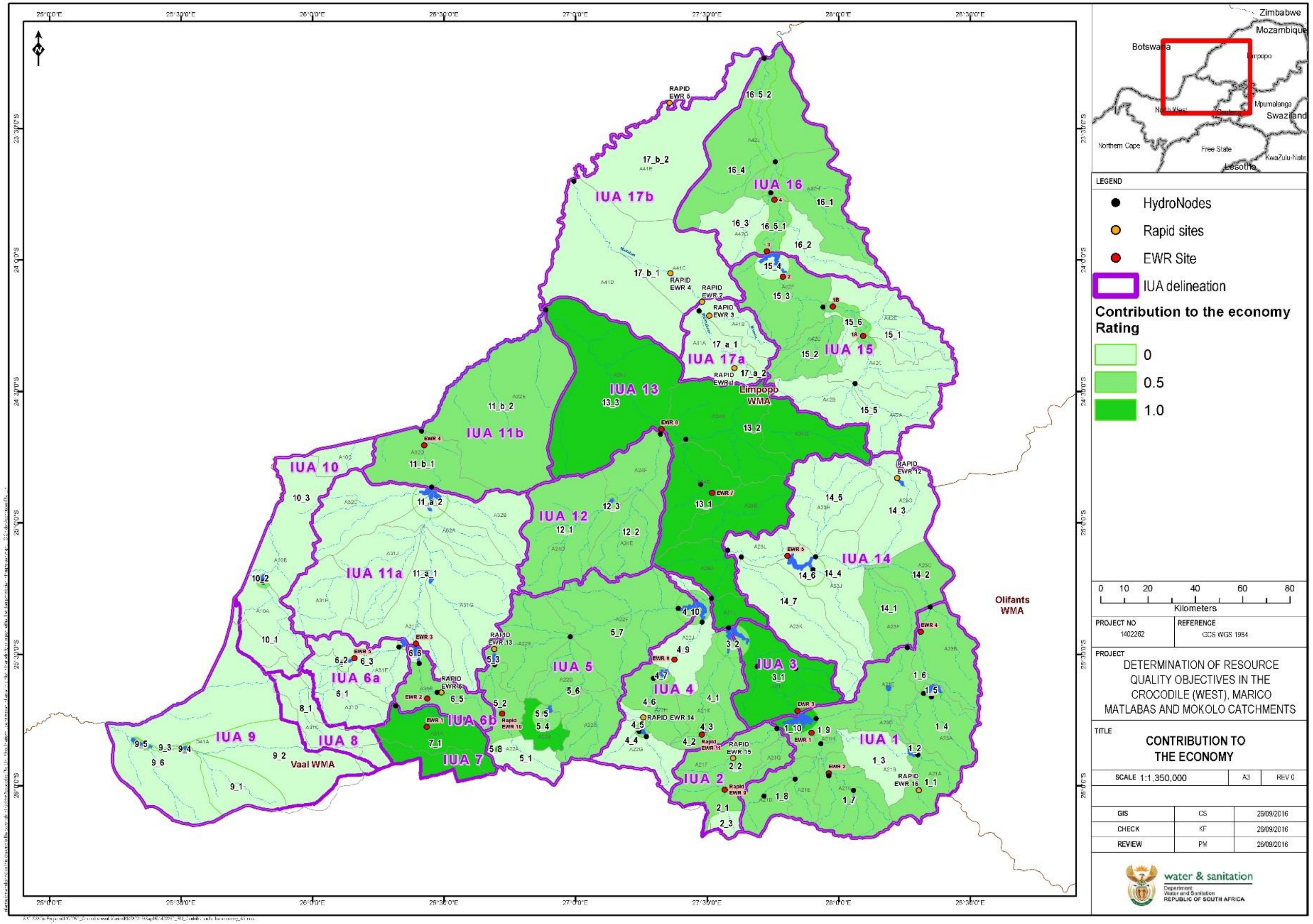

Figure A-6: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Contribution to the Economy

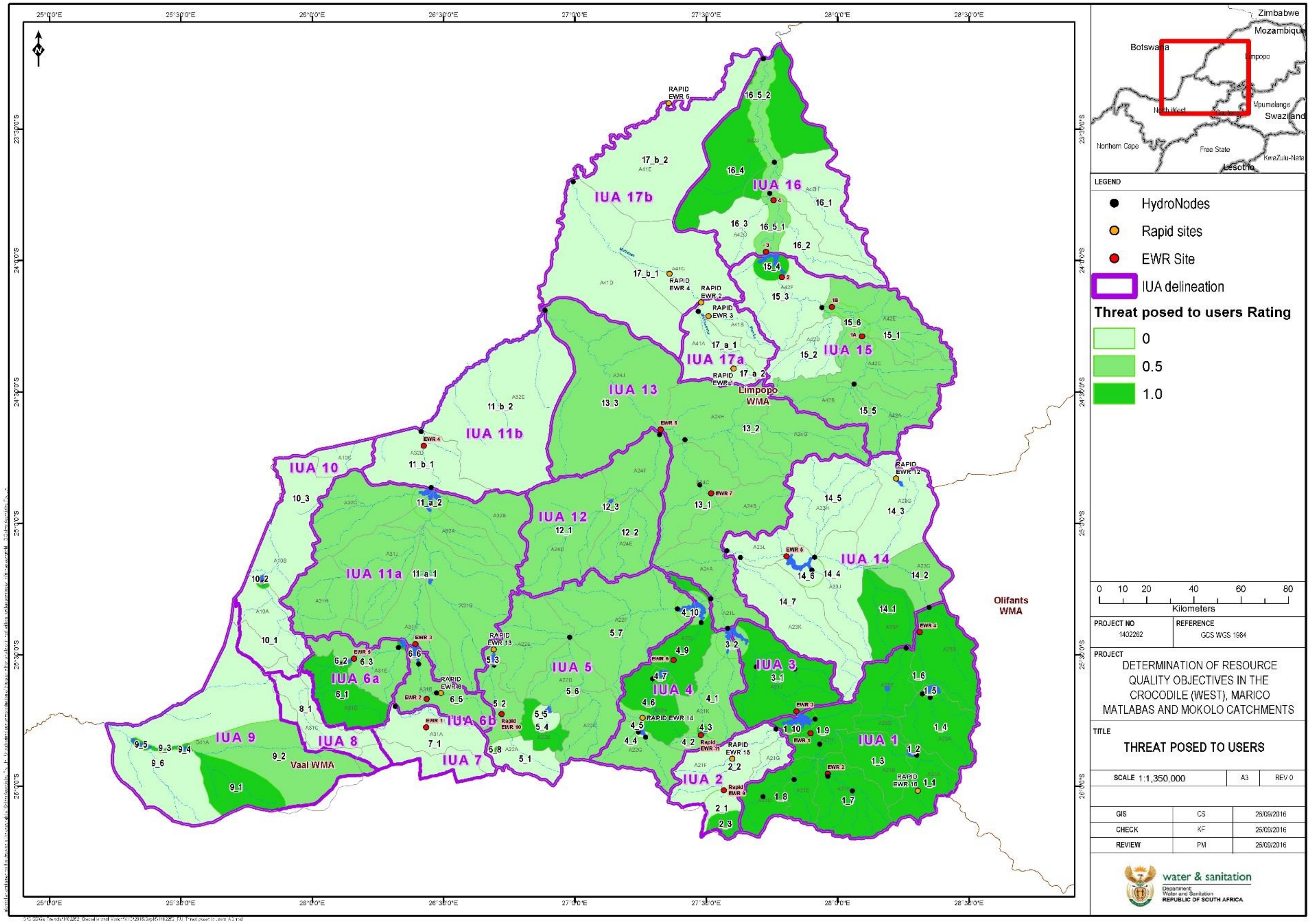

Figure A-7: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Threat Posed to Users

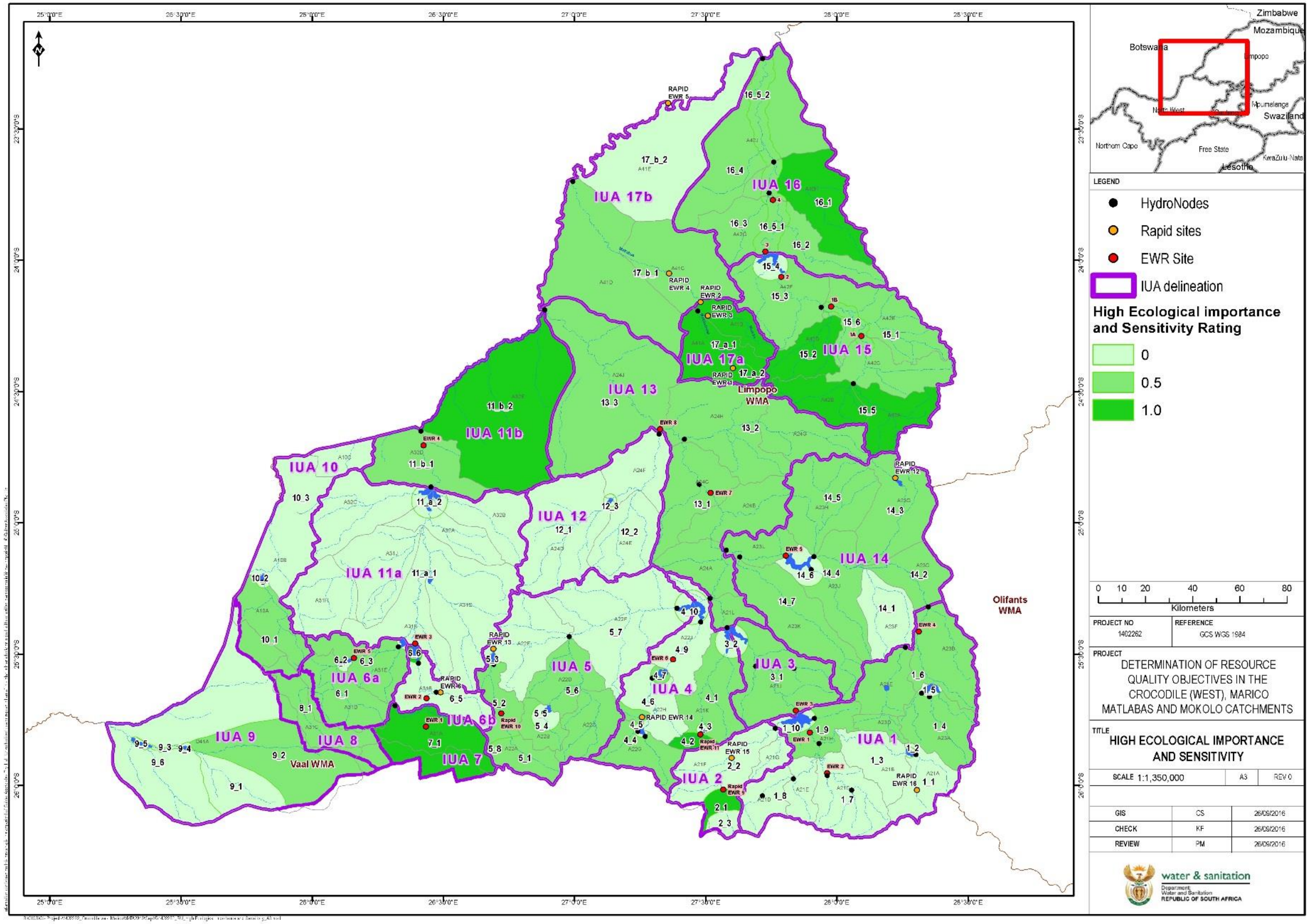

Figure A-8: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - High Ecological Importance and Sensitivity

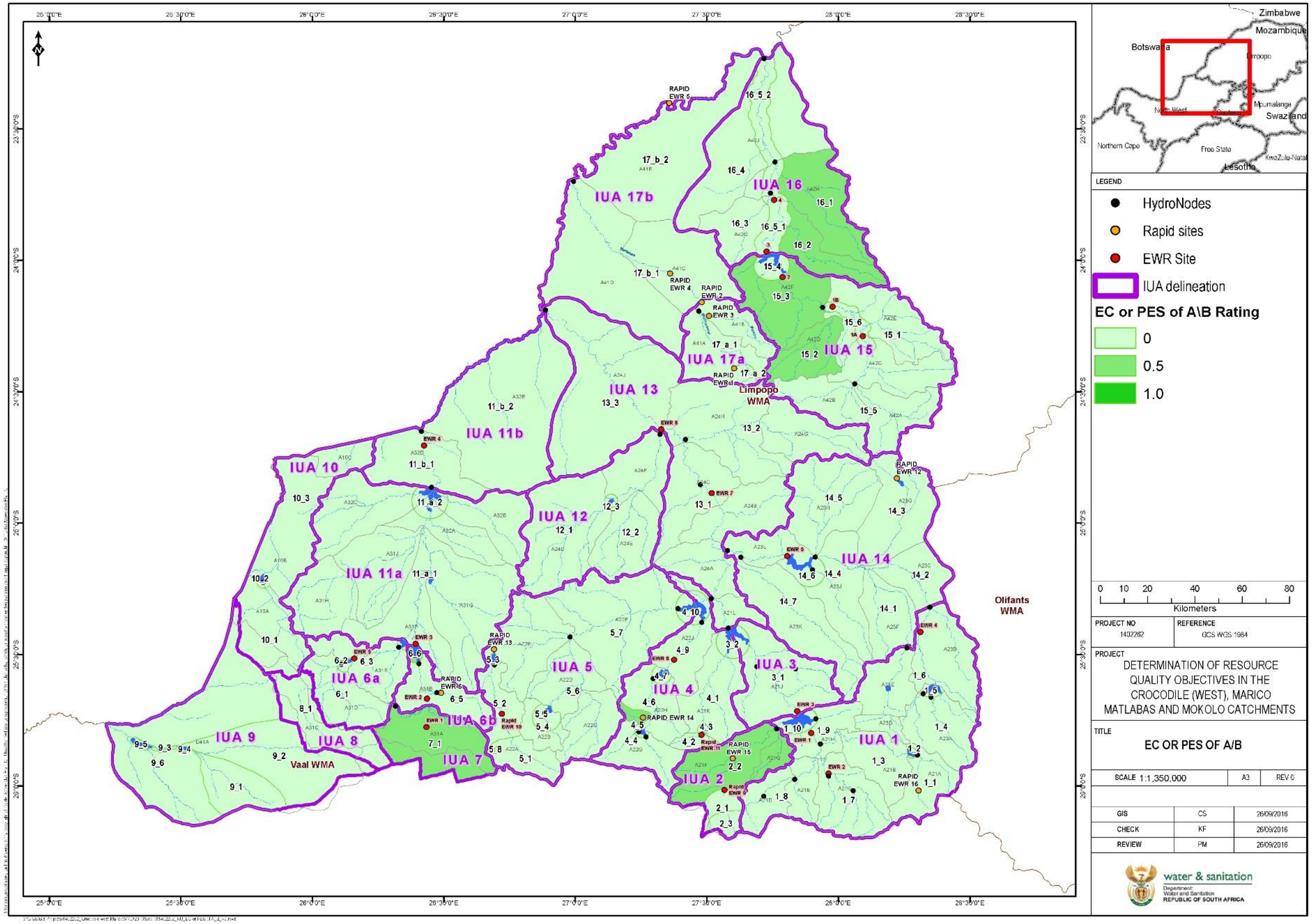

Figure A-9: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - EC or PES of A/B

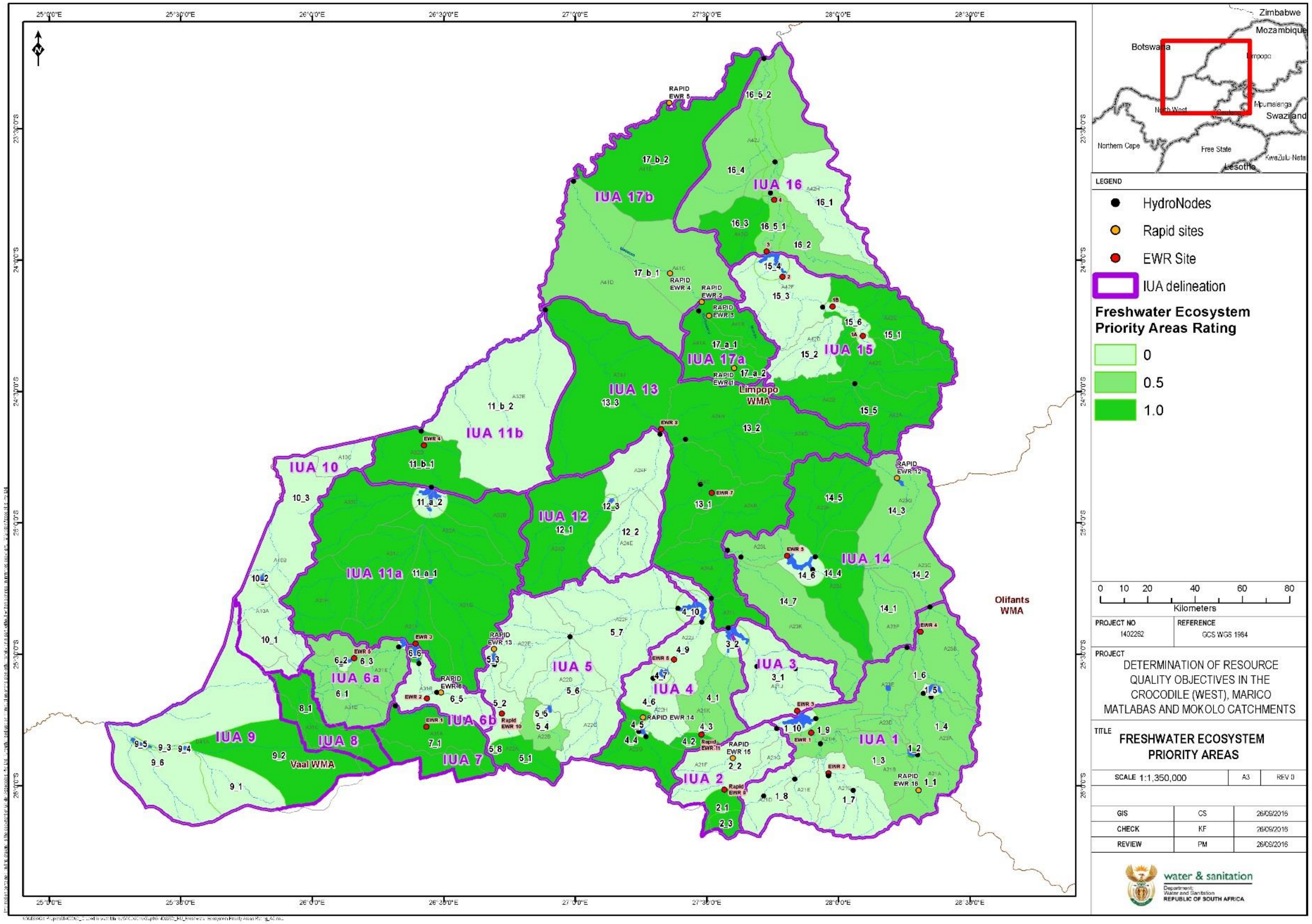

Figure A-10: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Freshwater Ecosystem Priority Areas

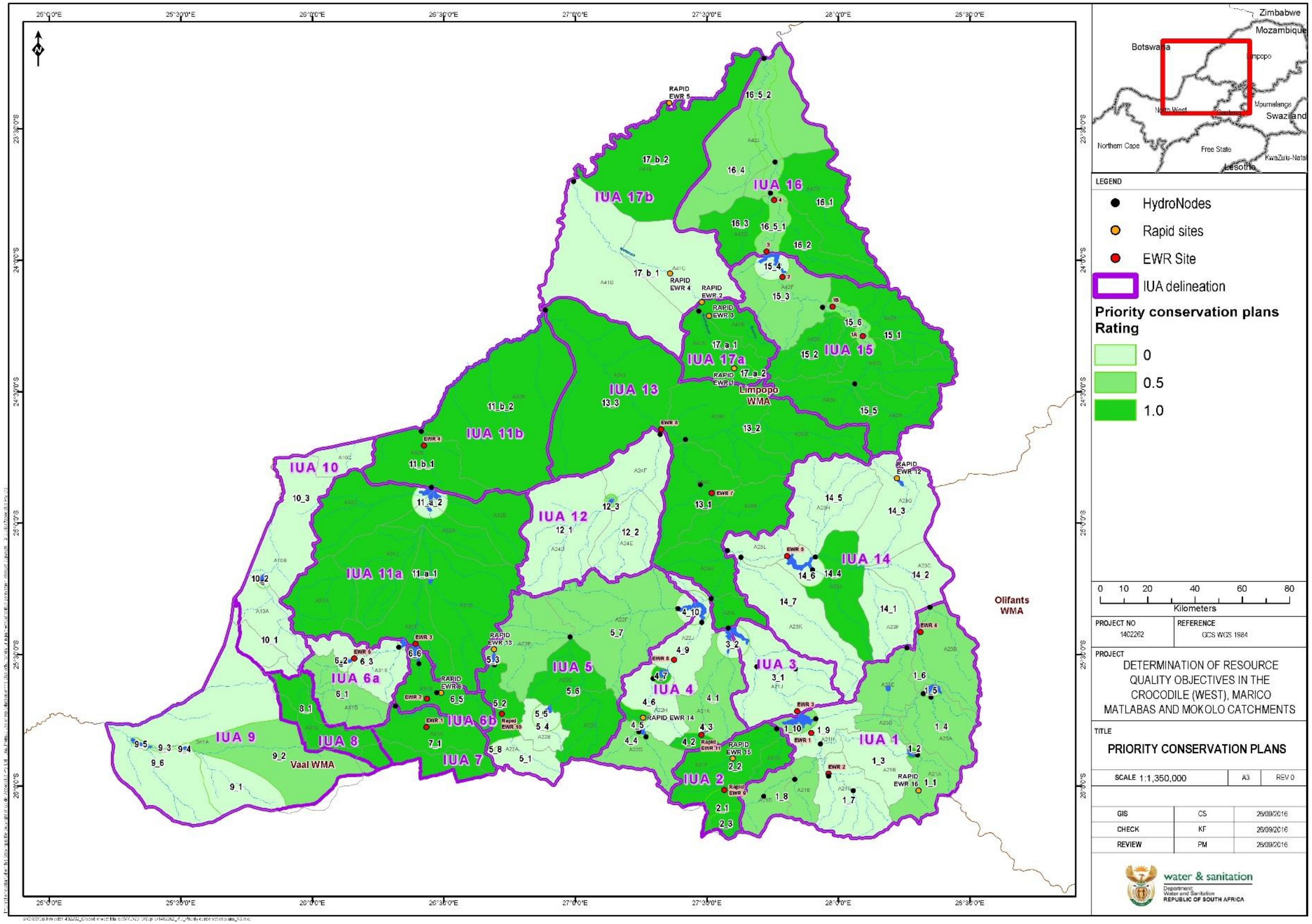

Figure A-11: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Priority Conservation Plans

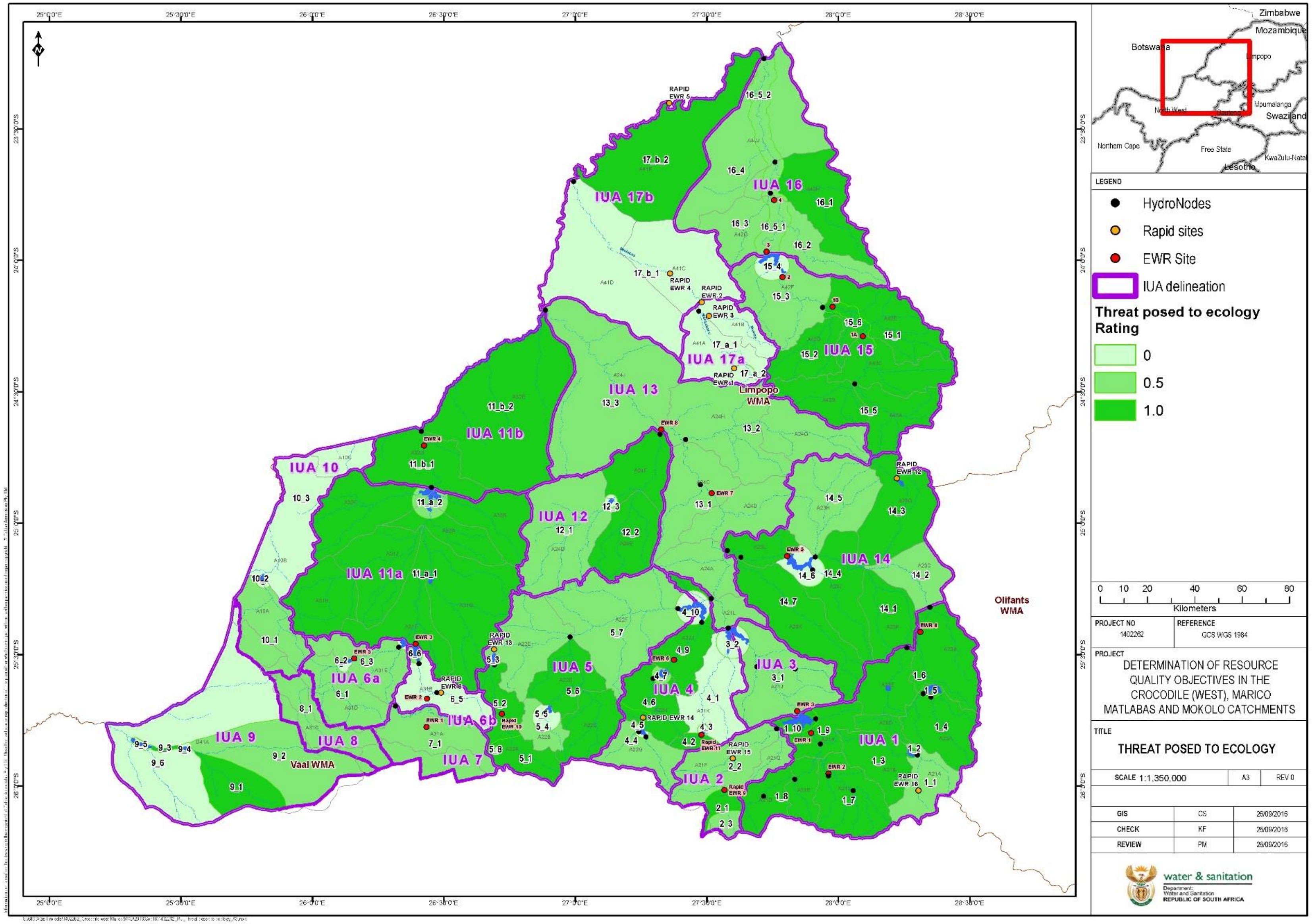

Figure A-12: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Threat Posed to Ecology

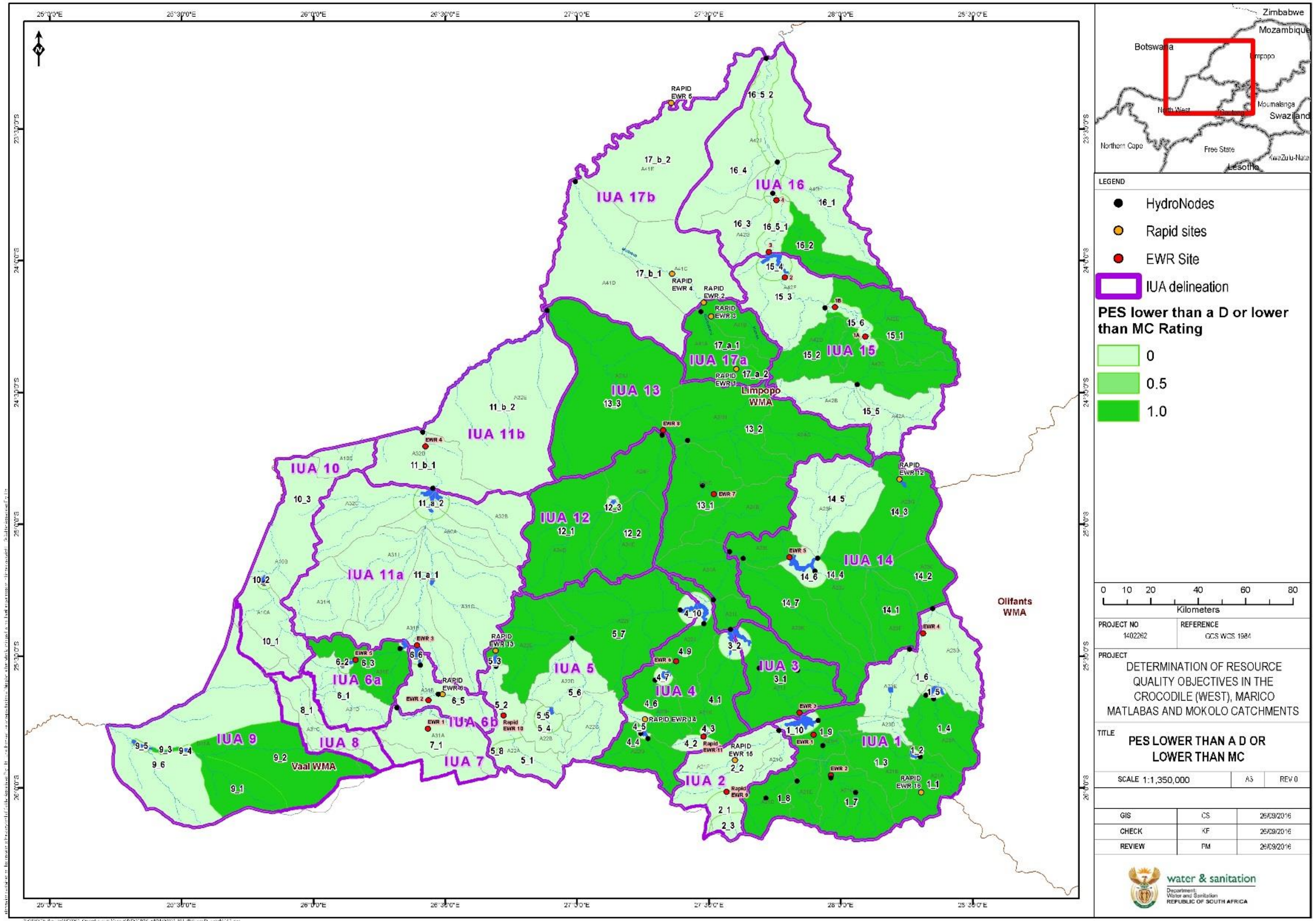

Figure A-1**3**: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - PES lower than a D EC or lower than the MC

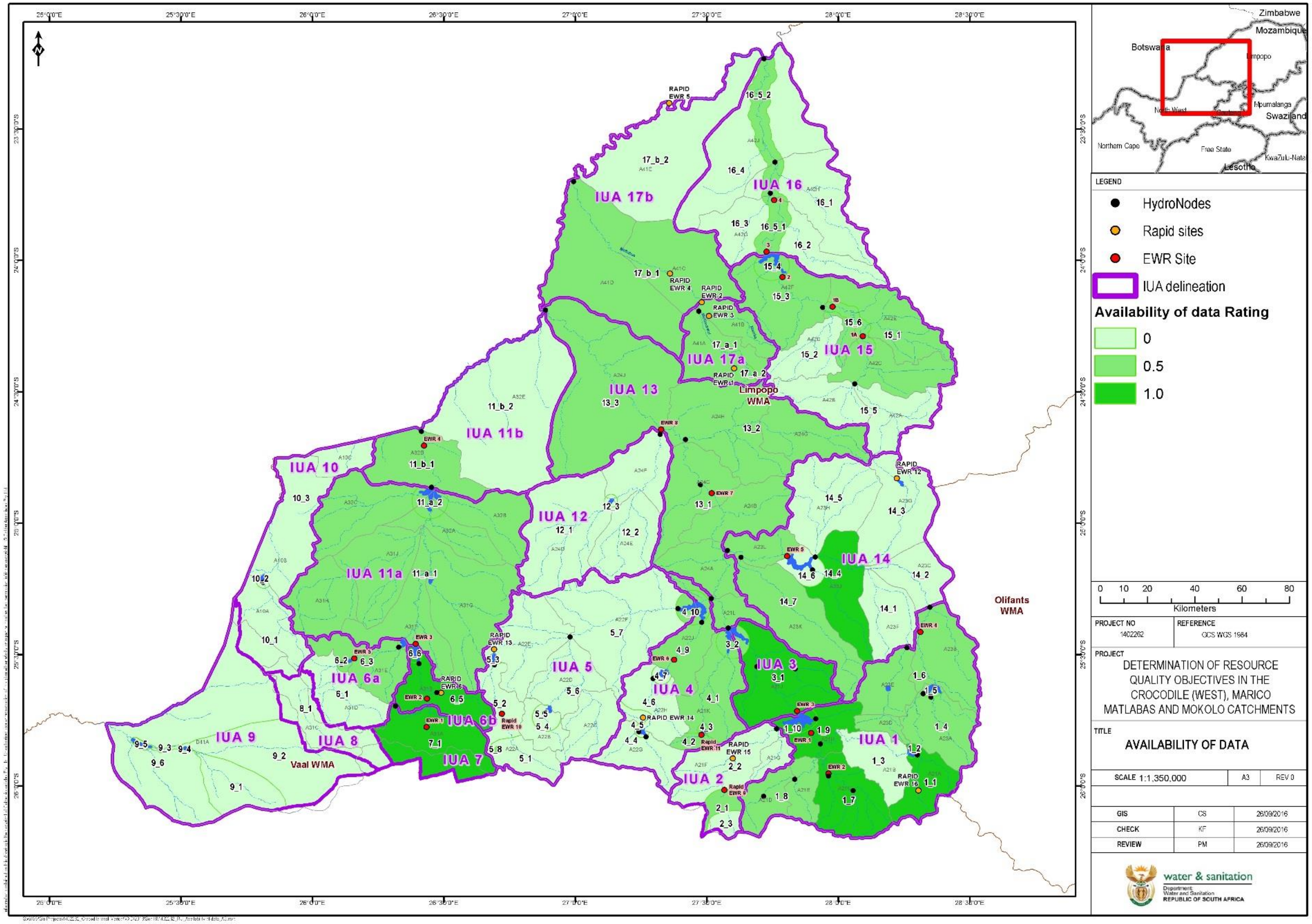

Figure A-14: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Availability of Data

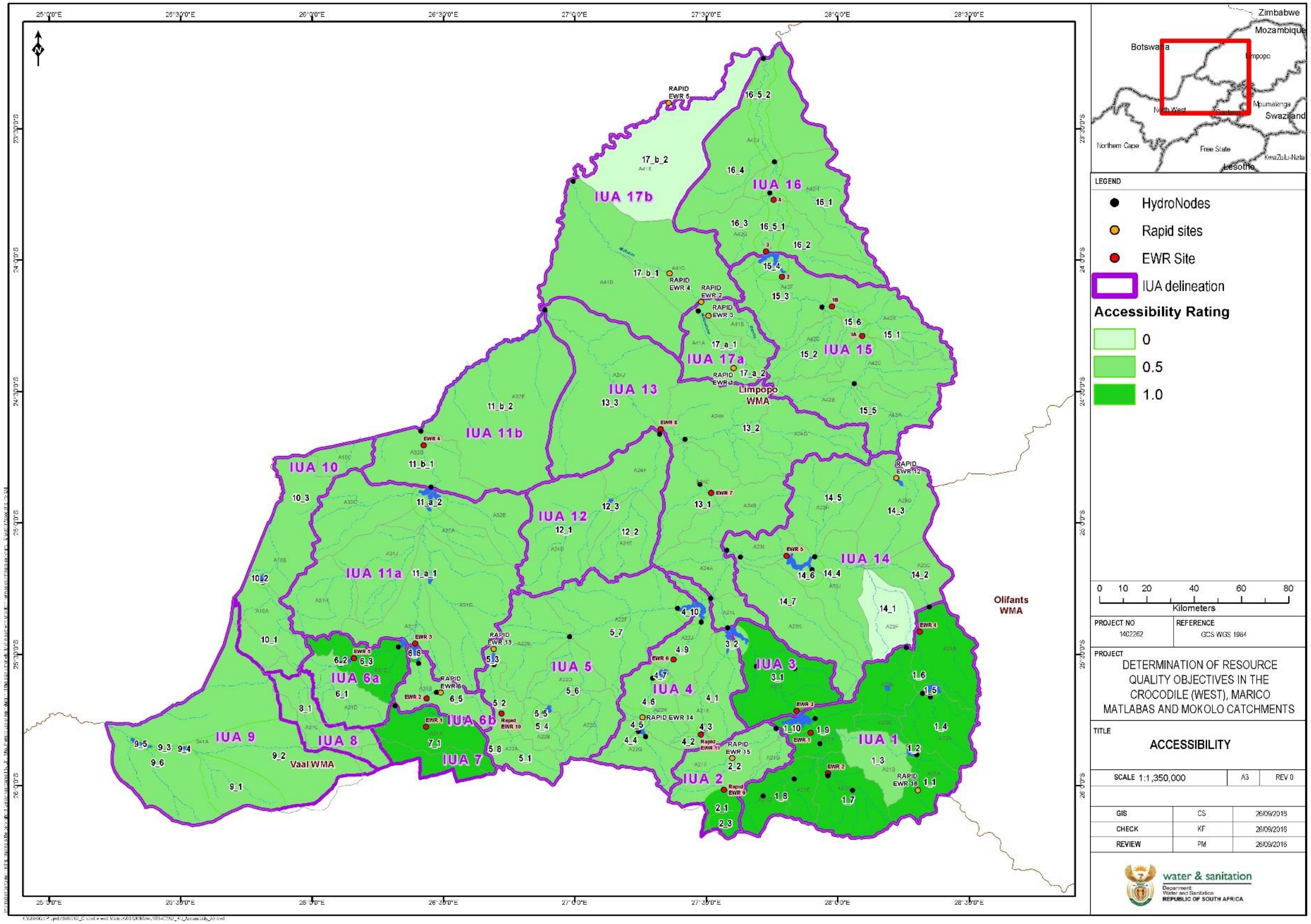

Figure A-15: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion – Accessibility

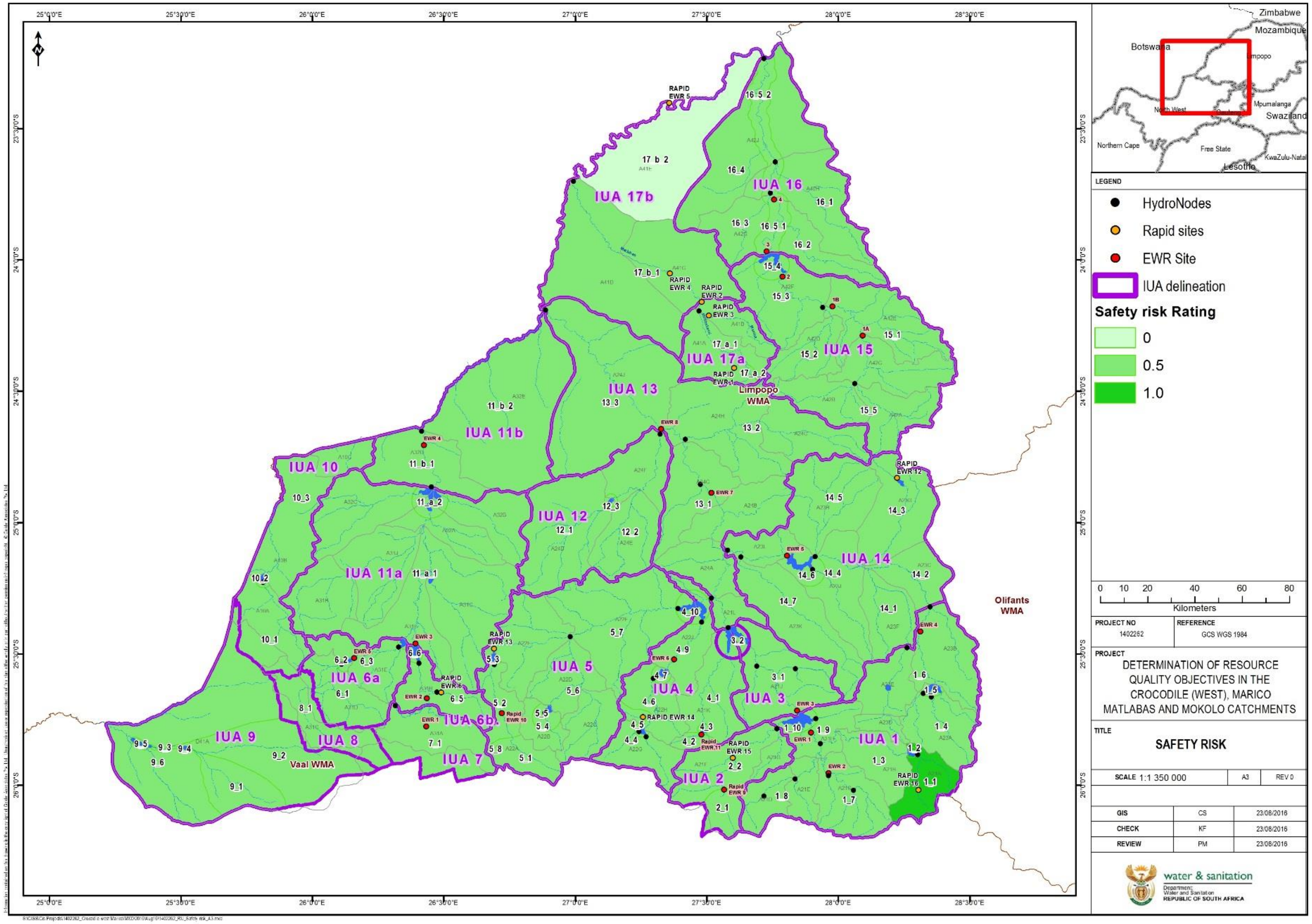

Figure A-16: Mokolo, Matlabas, Crocodile (West) and Marico Resource Units: Rating scores for criterion - Safety Risk