CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS WATER MANAGEMENT AREA: (WMA 4) - WP 10383

ECOLOGICALLY SUSTAINABLE BASE CONFIGURATION (ESBC) SCENARIO REPORT

FINAL

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LIST OF ABBREVIATIONS AND ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EIS	Ecological importance and sensitivity
ESBC	Ecologically Sustainable Base Configuration
EWR	Ecological Water Requirements
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
KNP	Kruger National Park
MC	Management Class
NFEPA	National Freshwater Ecosystem priority areas
NWA	National Water Act
PES	Presentation Ecological State
REC	Recommended Ecological Category
RDM	Resource Directed Measures
RQOs	Resource Quality Objectives
WMA	Water Management Area
WRCS	Water Resource Classification System
WRYM	Water Resources Yield model

GLOSSARY

Some key terms and definitions as for Water Resource Classification as applied in the study:

Ecological Importance and Sensitivity (EIS)	Key indicators in the ecological classification of water resources. Ecological importance relates to the presence, representativeness and diversity of species of biota and habitat. Ecological sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels, physico-chemical conditions, etc.
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
Ecological Water Requirement Sites	Specific points on the river as determined through the site selection process. An EWR site consists of a length of river which may consist of various cross-sections for both hydraulic and ecological purposes. These sites provide sufficient indicators to assess environmental flows and assess the condition of biophysical components (drivers such as hydrology, geomorphology and physico-chemical) and biological responses (*viz*. fish, invertebrates, riparian vegetation).
Integrated unit of analysis (IUAs)	The basic unit of assessment for the classification of water resources. The IUAs incorporates socio-economic zones and are defined by catchment area boundaries.
Management Class (MC)	The MC is representative of those attributes that the DWA (as the custodian) and society require of different water resources (consultative process). The process requires a wide range of trade-offs to assessed and evaluated at a number of scales. Final outcome of the process is a set of desired characteristics for use and ecological condition each of the water resources in a given catchment. The WRCS defines three management classes, Class I, II, and III based on extent of use and alteration of ecological condition from the predevelopment condition.
Present Ecological State (PES)	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses *viz*. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.
Recommended Ecological Category (REC)	The Recommended Ecological Category is the future ecological state (Ecological Categories A to D) that can be recommended for a resource unit depending on the EIS and PES. The REC is determined based on

	ecological criteria and considers the EIS, the restoration potential of the system and attainability there-of.
River Node	These are modelling point's representative of an upstream reach or area of an aquatic eco-system (rivers, wetlands, estuaries and groundwater) for which a suite of relationships apply.
Scenario	Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition.
Significant Water Resources	Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in their quality and quantity of water. Water resources are deemed to be significant based on factors such as, but not limited to, aquatic importance, aquatic ecosystems to protect and socio-economic value.
Sub-nodes	Finer scale of modelling points defined within a particular IUA at which flows and water qualities will be set to protect a particular ecological subarea that is identified as important and sensitive.
Sub-quaternary catchments	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments). The update of the PES and EIS (2010) status has been determined per sub-quaternary.
Trade-offs	Balancing of all factors in relation to the water resource and/or and IUA(s) that are not necessarily attainable at the same which may involve a giving up of one benefit, advantage, etc. in order to gain another regarded as more desirable. This may include balancing of those factors between use and protection (which may or may not be conflicting), between downstream impacts and upstream uses and vice versa, between possible use of resources within a catchment and between catchments, and between possible resource uses between different parts of the country. Decisions on these trade-offs will have different implications for different stakeholders at local, regional and national levels.
Water Resource Yield Model (WRYM)	The WRYM is a yield model, developed by the Department of Water Affairs, to assess system yield. In terms of the WRCS process it will be used to assess the for the IUAs for the different catchment configuration scenarios.

EXECUTIVE SUMMARY

Background

Chapter 3 of the National Water Act (NWA, Act 106 of 1998) provides for the protection of water resources through the implementation of resource directed measures (RDM) which includes the Classification of water resources, setting the Reserve and Resource Quality Objectives. Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources and the need to develop and use them.

The Chief Directorate: Resource Directed Measures (RDM) has initiated the Classification of Significant Water Resources Study for the Olifants Water Management Area (WMA). The purpose of this study is to coordinate the implementation of the 7 step process of the Water Resource Classification System (WRCS) in the Olifants WMA in order to determine a suitable management class (MC) for all significant water resources. As part of the Classification process Step 4 requires that the Ecologically Sustainable Base Configuration (ESBC) Scenario is defined.

In terms of the classification of water resources, an ESBC scenario is established in order to understand what the result would be in terms of system yield of implementing the minimum base level of ecological protection required to ensure sustainable use of the catchment water resources (which includes the consideration of ecological, water quality and quantity needs). It is not the target scenario but informs the minimal protection level required constructed as a starting point for the hydrological analysis of the water resource system.

Once this sustainable ecological protection level is understood, various levels of resource directed protection can be assessed in terms of the overall socio-economic implications to the Integrated Units of Analysis (IUAs) and WMA.

This report therefore details the establishment of the ESBC scenario and the system water balance that results by implementation of the scenario.

Approach

The process followed in terms of the establishment of the ESBC is that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWAF, February 2007a and 2007b).

The ESBC scenario, which would permit the maximum water use scenario, requires that the base condition for each water resource is at minimum established as either a D category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However where the ecological condition requires it, a higher ecological category needs to be set.

The ESBC scenario is established once this base condition is hydrologically and ecologically tested to ensure that it is feasible and can be achieved *i.e.* This result will reflect if the catchment water balance would be in a surplus or deficit by implementing a D category EWR.

In terms of the Olifants WMA the D ecological category (EC) was not selected as the default ESBC. Rather the selected EC per IUA was based on the assessment of the present ecological state (PES) and ecological/conservation importance of water resources within the IUAs and represented as a proportional aggregation.

Based on the present ecological condition of water resources within the Olfants WMA the IUA scale ESBC ECs tested (outlet of IUAs) are listed in Table E1. The IUA management classes (MCs) associated with this ESBC scenario are also indicated.

An ESBC ecological category for each IUA is representative of the PES per biophysical node within that IUA (based on EC proportional representation of the nodes in the sub-quartenary catchments). However where a biophysical node is different to the overall IUA ESBC ecological category (*i.e.* requiring a higher level of ecological protection), this higher ecological category is accounted for in the hydrological model by the inclusion of the relevant sub node.

Table E1: EC (PES) tested for the ecological sustainable base configuration (aggregated per IUA)

IUA	Catchment area	Aggregated Ecological Category (ESBC)	IUA Management Class associated with scenario
1	Upper Olifants River catchment	D	III
2	Wilge River catchment area	C	II
3	Selons River area including Loskop Dam	C	II
4	Elands River catchment area	D	III
5	Middle Olifants up to Flag Boshielo Dam	D	III
6	Steelpoort River catchment	D	III
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D	III
8	Spekboom catchment	C	II
9	Ohrigstad River catchment area	D	III
10	Lower Olifants	C	II
11	Ga-Selati River area	D	III
12	Lower Olifants within Kruger National Park	C	II
13	Blyde River catchment area	A/B	I

Having established the ECs required for the sustainable use of the water resources in the Olifants WMA (the EC represented per IUA above), the ESBC scenario (Scenario 1) that was tested in the hydrological model included the following parameters:

ESBC Scenario (PES Scenario0	Water Requirements	EWR
1	2010 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows

The yield model for the Olifants WMA was setup and calibrated, and run with the ESBC scenario. The assessment allowed for evaluation of the yield that would result in the catchment with the EWRs required for maintaining the PES ecological category. This allowed for the assessment of the water balance (surpluses/deficits) per IUA. The planning scenarios for the WMA are also considered at this point to understand the availability of water.

Results of Scenario 1 (ESBC):

The yield analysis results per IUA with the above ESBC scenario indicate varying degrees of water surpluses and deficits as shown in Table E2. The Olifants WMA has an overall water deficit of 159 million m^3 with implementation of the ESBC scenario (EWR for the maintaining the base case ecological condition).

Table E2: Water balance per IUA for the ecological sustainable base configuration (ESBC) scenario

IUA	Catchment	A * Water User Requirements (million m^3/a)	B Yield (million m^3/a)	EWR (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	122	87	22.5	(35)
2	Wilge River catchment area	45	71.5	57.8	26.5
3	Selons River area including Loskop Dam	46	192	108.9	146
4	Elands River catchment area	16	45.7	10.8	29.7
5	Middle Olifants up to Flag Boshielo Dam	249	76	92.3	(173)
6	Steelpoort River catchment	42	119	26	77
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	13	10	124.2	(3)
8	Spekboom catchment	37	124.6	34.1	87.6
9	Ohrigstad River catchment area	49	30	17.3	(19)
10	Lower Olifants	141	159	315	18
11	Ga-Selati River area	32	10	18.1	(22)
12	Lower Olifants within Kruger National Park	63	59	**269.7**[#]	(4)
13	Blyde River catchment area	18	0	114.8	(18)
	TOTAL	**873**	**983.8**		**110.8**
OLIFANTS WMA WATER BALANCE (Volume of water required to meet the EWR – flow at IUA 12[#])		**Column B – (A + 269.7)**			**(159)**

*Water user requirements includes that of the irrigation, domestic, industrial, mining, power generation and forestry sectors within the Olifants WMA.

[#]IUA 12 is the most downstream IUA in the WMA and 269.7 million m^3/a is the total volume required in the lower reaches of the Olifants River to maintain an ecological logical category of C before it reaches Mozambique.

This configuration of ecological categories ensures that a sustainable level of ecosystem functioning is maintained in the Olifants WMA. The water resource system would have to provide

for the required volume of EWRs needed (volumes as indicated in Table E2 above) to maintain this configuration.

The deficit that exists indicates that water would have to be transferred into the Olifants system to ensure PES level of ecological protection required for the ESBC scenario is met. Augmentation options of where this water could be obtained and at what cost, needs to be assessed and evaluated to determine what is the most feasible and practical intervention in terms of the economy of the Olifants WMA. While some of the proposed options identified through the Olifants River Water Supply System Reconciliation Strategy will be assessed through the socio-economic evaluation component of the scenario analysis, the selection of the required interventions and the decision on the provision of this water is beyond the scope of the Classification study.

Alternate Catchment Configuration Scenarios

Having established the ESBC (detailed above), the classification process requires that additional catchment scenarios are configured for the IUAs within the WMA to assess the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible and achievable in terms of a MC.

The alternate catchment configuration scenarios to be assessed are listed in Table E3.

Table E3: Alternate catchment configuration scenarios

Scenario	Water Requirements	EWR
2	2010 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows
3	2010 Water Requirements as per Reconciliation Strategy	Class III throughout the system (EWR D Category)
4	2035 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
5	2035 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows

The focus of this report is scenario 1, the ESBC scenario. Scenarios 2 to 5 are listed here but will be discussed in more detail in Task 5 of the WRCS process, ‘Evaluation of scenarios’, to follow.

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1 INTRODUCTION

1.1 Background

The National Water Act (Act No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without seriously affecting the functioning of the water resource systems. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of resource directed measures (RDM). As part of the RDM, a management class (MC) has to be determined for a significant water resource, as the means to ensure a desired level of protection. The purpose of the MC is to establish clear goals relating to the water quantity and quality of the relevant water resource.

The classification system, the Reserve and RQOs together are intended to ensure comprehensive protection of all water resources. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical and affordable.

The Chief Directorate: Resource Directed Measures (CD:RDM) of the Department of Water Affairs (DWA) is tasked with the responsibility of ensuring that the water resources are classified in terms of the Water Resource Classification System (WRCS) to ensure that a balance is sought between the need to protect and sustain water resources and the need to develop and use them. The CD: RDM has identified the need to undertake the classification of significant water resources (rivers, wetlands, groundwater and lakes) in the Olifants Water Management Area (WMA) in accordance with the WRCS.

The MC and associated resource quality objectives (RQOs) will assist the DWA make more informed decisions regarding the authorisation of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of the present and proposed developments.

1.2 Study Area

The spatial extent for the classification study includes secondary drainage regions B1 to B7, the catchment area of the Olifants Water Management Area (WMA). This includes the Upper, Middle and Lower Olifants and Steelpoort River sub-catchment areas within the Olifants WMA (see Figure 1). The Letaba River catchment area is not included in the study area.

The Olifants River originates at Trichardt to the east of Johannesburg and initially flows northwards before gently curving in a generally eastward direction through the Kruger National Park and into Mozambique, where it joins the Limpopo River before discharging into the Indian Ocean. The Olifants WMA corresponds with the South African portion of the Olifants River catchment (excluding the Letaba River catchment). It falls within three provinces, *viz*. a small part to the west within Gauteng, with the southern part mainly in Mpumalanga and the northern part in Limpopo Province. The main tributaries are the Wilge, Elands and Ga-Selati Rivers on the left bank and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank.

Distinct differences in climate occur; from cool Highveld in the south to subtropical, east of the escarpment. Mean annual rainfall is in the range of 500 mm to 800 mm over most of the WMA.

Figure 1: Study area – The Olifants WMA

The main economic activity in the WMA is related to coal, platinum, vanadium, chrome, copper and phosphate mining. The coal mining is located in the upper reaches of the catchment around Witbank, Middelburg and Delmas. There are large thermal coal fired power stations associated with the coal mining. The platinum, chrome and vanadium mines are located in the Steelpoort and middle areas of WMA while the copper and phosphate mining occurs in the lower Olifants around Phalaborwa. There are also large steel foundries located in Middelburg and Witbank.

Extensive irrigation occurs in the vicinity of the Loskop Dam, along the lower reaches of the Olifants River, near the confluence of the Blyde and Olifants Rivers, as well as in the Steelpoort valley and upper Selati catchment. Much of the central and north western areas of the WMA are largely undeveloped, with scattered rural villages where the people are mainly dependent on income from migrant workers in the Gauteng area, Witbank, Middelburg and Phalaborwa are the largest urban centres. Land use in the WMA is characterised by rain-fed cultivation in the southern and north-western parts, with grain and cotton as main products. While most of the WMA remains under natural vegetation for livestock and game farming as well as conservation, severe overgrazing is prevalent in many areas. Afforestation is found in some of the higher rainfall areas, with notable plantations in the upper Blyde River valley.

With the Olifants River flowing through the Kruger National Park, which is located at the downstream extremity of the WMA, the provision of water to meet ecological requirements is one of the controlling factors in the management of water resources throughout the catchment.

Most surface runoff originates from the higher rainfall southern and mountainous areas. There are 9 major dams constructed in the Olifants River and the major tributaries which regulate the flow in the river system.

Large quantities of groundwater are abstracted for irrigation in the north-west of the water management area, as well as for rural water supplies throughout most of the area. Potential for increased groundwater utilisation has been identified on the Nebo Plateau north-east of Groblersdal. Substantial amounts of water are transferred into the water management area as cooling water for power generation, while smaller transfers are made to neighbouring water management areas.

1.3 Purpose of the Study: Classification of Significant Water Resources in the Olifants WMA

The purpose of this study is to coordinate the implementation of the 7 step process of the WRCS (see Figure 2) in the Olifants WMA in order to determine a suitable MC for the significant water resources and in so doing deliver the Integrated Water Resource Management (IWRM) template with recommendations for presentation to the delegated authority of DWA.

The determination of the MC is necessary to facilitate a balance between protection and use of water resources. In determining the class, it is important to recognise that different water resources will require different levels of protection. In addition to achieving ecological sustainability of the significant water resources through classification, the process will allow due consideration of the social and economic needs of competing interests by all who rely on the water resources.

The WRCS will be applied taking account of the local conditions, socio-economic imperatives and system dynamics within the context of the South African situation. The process will also require a

wide range of complex trade-offs to be assessed and evaluated at a number of scales.

The Olifants WMA is a highly utilised and regulated catchment and like many other WMAs in South Africa its water resources are becoming more stressed due to an accelerated rate of development resulting in the scarcity of water resources. There is an urgency to ensure that water resources in the Olifants River catchment area are able to sustain their level of uses and be maintained at their desired states. The MC of the significant water resources in Olifants WMA will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users. The MC of the water resource will therefore set the boundaries for the volume, distribution and quality of the Reserve and RQOs, and thus the potential allocable portion of a water resource for use.

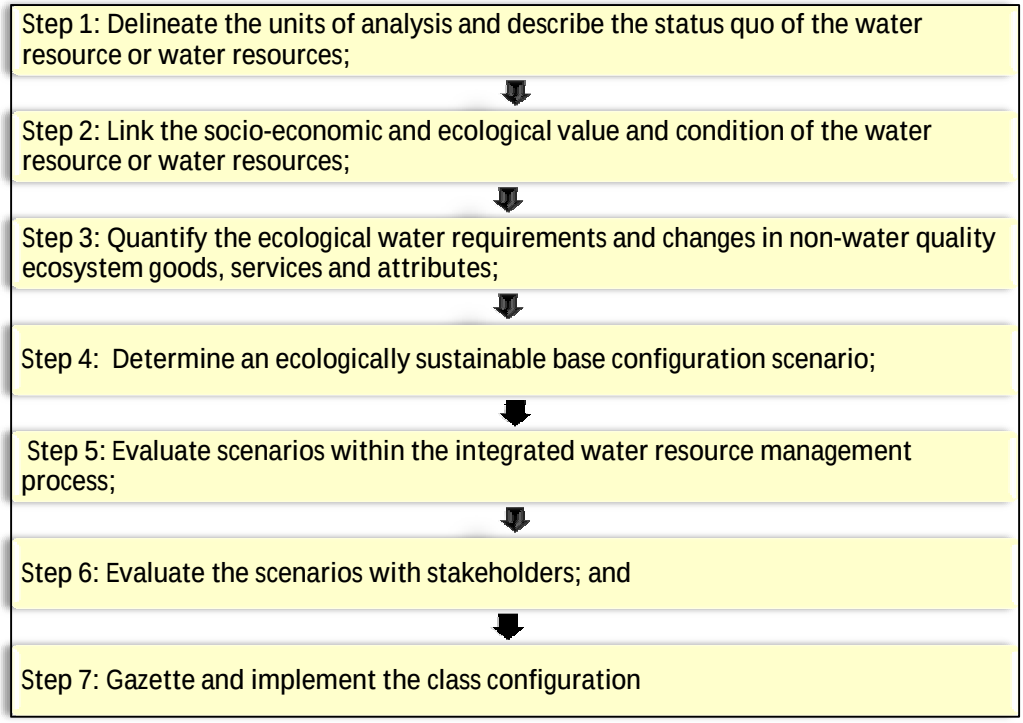

Figure 2: Steps to determine the Management Class

2 INTEGRATED UNITS OF ANALYSIS AND THE RIVER NODES

2.1 Integrated Units of Analysis (IUAs)

As part of the classification process to date, thirteen Integrated Units of Analysis (IUAs) have been defined for the Olifants WMA (see Figure 3 and Table 1 below). These have been based on socio-economics of the areas, water uses and users, envisaged level of protection required and significance of the resource. The availability of representative Ecological Water Requirement (EWR) sites within each IUA and catchment boundaries and catchment modelling schematics were also considered. The WRCS Guideline, Volume 2, Ecological, hydrological and water quality guidelines for the 7-step classification procedure (February 2007) was followed in terms of IUA delineation. The scale definition of the IUAs is secondary drainage regions.

The IUAs are approximate socio-economic boundaries, and are delineated to facilitate the integration of ecological and socio-economic aspects that is required for the evaluation of scenarios as part of the Classification process.

Table 1: Catchment areas of the thirteen IUAs defined for the Olifants WMA

IUA	Catchment Area	Quaternary Catchment
1	Upper Olifants River catchment	B11A, B11B, B11C, B11D, B11E, B11F, B11G, B11H, B11J, B11K, B11L, B12A, B12B, B12C, B12D
2	Wilge River catchment area	B20A, B20B, B20C, B20D, B20E, B20F,B20G, B20H, B20J
3	Selons River area including Loskop Dam	B12E, B32A, B32B, B32C
4	Elands River catchment area	B31A, B31B, B31C, B31D, B31E, B31F, B31G
5	Middle Olifants up to Flag Boshielo Dam	B32D, B31H, B31J, B32E, B32F, B32G, B32H, B32J, B51A, B51B, B51C, B51D, B51E
6	Steelpoort River catchment	B41A, B41B, B41C, B41D, B41E, B41F,B41G, B41H, B41J, B41K
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	B51F, B51G, B51H, B52A, B52B, B52C, B52D, B52E, B52F, B52G, B52H, B52J
8	Spekboom catchment	B42A, B42B, B42C, B42D, B42E, B42F, B42G, B42H
9	Ohrigstad River catchment area	B60E, B60F, B60G,B60H
10	Lower Olifants	B60J, B71A, B71B, B71C, B71D, B71E, B71F, B71G, B71H, B71J, B72A, B72B, B72C
11	Ga-Selati River area	B72E, B72F,B72G, B72H, B72J, B72K
12	Lower Olifants within Kruger National Park	B72D, B73A, B73B, B73C, B73D, B73E,B73F, B73G, B73H, B73J
13	Blyde River catchment area	B60A,B60B, B60C, B60D

2.2 River Nodes

The WRCS process requires that river nodes be established through the network of significant water resources within the IUAs delineated. Rivers nodes are established to account for interactions between ecosystems and to account for specific catchment issues or impacts and to serve as modelling points for the Classification process in a catchment. The nodes are used to assess the response of upstream water resources to changes in water quality, quantity and timing (DWA,

2007). River nodes could either be biophysical nodes or allocation nodes. Biophysical nodes should be located at interactions between ecosystems and at the end points of eco-system reaches to account for interactions. Management or allocation nodes should be located at the downstream edge of a reach of interest, as required for modelling and to allow for meaningful trade-offs.

The establishment of biophysical and management (allocation) nodes is guided by a number of considerations. The key considerations are:

- Significant water resources
- Biophysical and eco-regional characteristics;
- Location of Ecological Water Requirement (EWR) sites and ecological information;
- Ecological Importance and Sensitivity categories of water resources;
- Present ecological state;
- Broad-scale hydrological and geomorphological characteristics;
- Water infrastructure;
- Water management, planning and allocation information.

A total of 121 river nodes (HN1 to HN 121) were identified for the Olifants WMA (Figure 3). From the final 121 identified river nodes, 87 were selected for the scenario analysis as part of the classification process. The selected river nodes listed in Table 2 are located at the end points of ecosystems and allocation reaches and have been included in the yield modelling. The assessment of scenarios will determine if the required flows at the river nodes can be met and evaluate trade-offs that may have to be made.

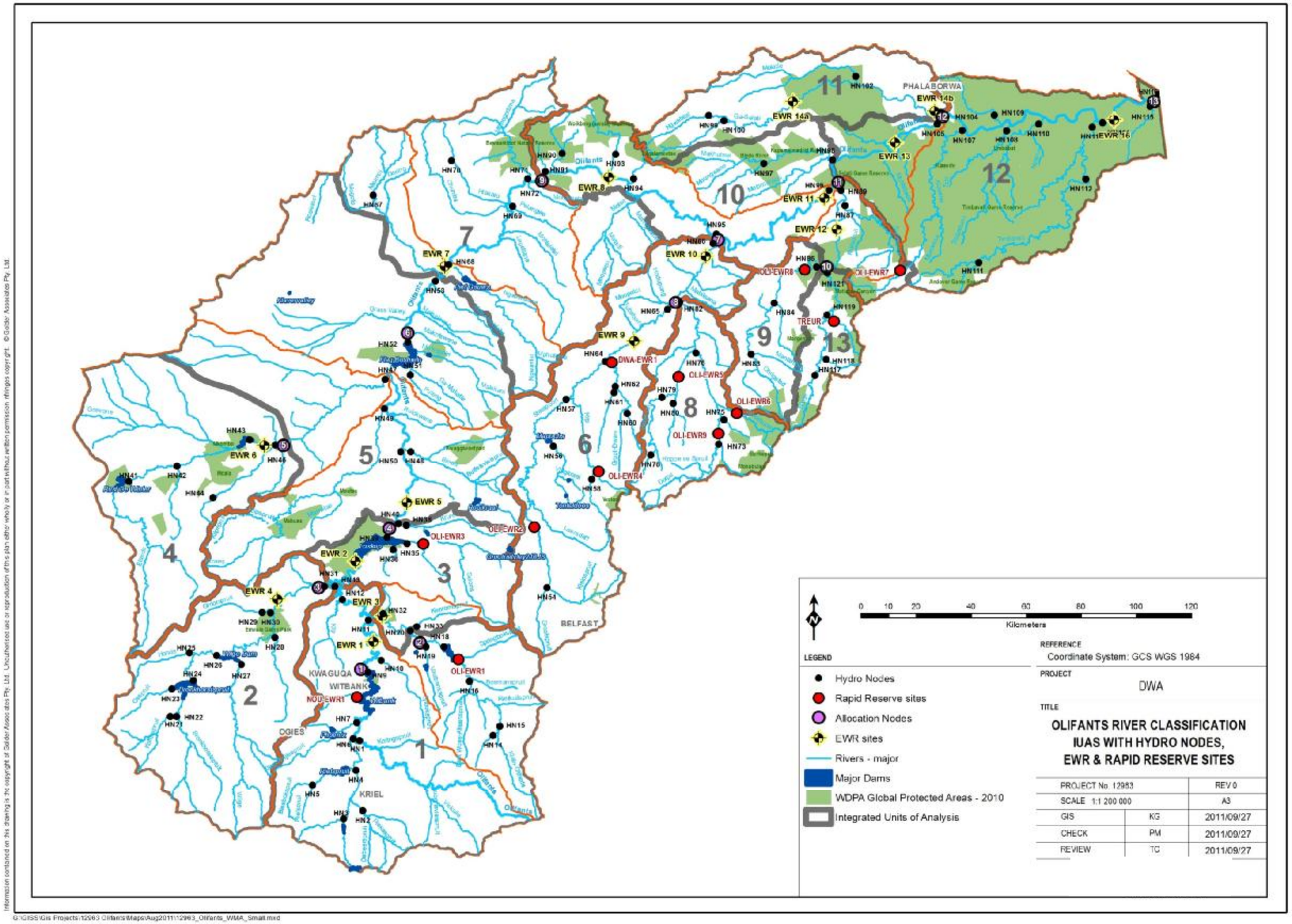

Figure 3: IUAs delineated within the Olifants WMA indicating river nodes and EWR sites

Table 2: River nodes selected that define the network of significant water resources for scenario analysis

IUA	Node no	Quaternary catchment	River	EI	ES	PES	Node Type and considerations
1	HN1	B11A, B11B	Olifants (confluence with Steenkoolspruit)	High	High	D	Management Unit, biophysical, water quality impacts
	HN2	B11C	Piekespruit (confluence with Steenkoolspruit)	High	High	B	Biophysical
	HN3	B11D	Dwars-indie-Wegspruit (confluence with Trichardtspruit)	High	High	C	Biophysical
	HN5	B11E	Blesbokspruit (confluence with Rietspruit)	High	High	B	Biophysical
	HN8	B11G	Noupoortspruit (EWR site – NOU-EWR1)	EIS=Moderate		C/D	Management Unit, water quality impacts on Witbank Dam
	HN13	B11L	Olifants (outlet of IUA1)	Very high	Very high	B	Biophysical & outlet of IUA1
	HN14	B12A	Boschmansfontein (confluence with Klein Olifants)	Moderate	High	C	Biophysical
	HN17	B12C	Klein Olifants (EWR site – OLI-EWR1)	EIS=Low		C	Impacts from upstream mining and agricultural activities
	HN20	B12D	Klein Olifants (outlet of quaternary)	Moderate	High	D	Management Unit, impacts fromdam and Middelburg town
2	HN28	B20G	Saalboomspruit (confluence with Wilge)	Moderate	High	C	Management Unit, future mining impacts
	HN30	B20H	Wilge	High	Very high	B	Management Unit, biophysical
	HN31	B20J	Wilge (EWR site – EWR4, outlet of IUA2)	EIS=High		C	Biophysical & outlet of IUA2
3	HN32	B12E	Doringboomspruit (confluence with Klein Olifants)	High	High	B	Biophysical
	HN33	B12E	Keeromspruit (confluence with Klein Olifants)	High	High	C	Biophysical
	HN34	B12E	Klein Olifants (EWR site – EWR3)	EIS =Moderate		C	Biophysical, Management Unit
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3)	EIS=Very high		B	Biophysical, inflow to Loskop Dam
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)	High	High	B	Biophysical
	HN37	B32A	Olifants (EWR site – EWR2)	EIS=High		C	Management Unit, biophysical
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons)	High	High	B	Biophysical

IUA	Node no	Quaternary catchment	River	EI	ES	PES	Node Type and considerations
			Kruis (confluence with Selons)	High	High	B	Biophysical
			Selons (confluence with Olifants)	High	Very high	C	Biophysical
	HN40	B32C	Olifants (outlet of quaternary – outlet of IUA3)	High	High	D	outlet of IUA3
4	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam. Included: B31A (Elands) B31B (Hartbeesspruit) B31C (Elands)	 High High High	 High Very high Very high	 C C C	 Biophysical Biophysical Biophysical, management of system releases from dam
	HN42	B31D	Enkeldoringspruit (confluence with Elands)	High	High	C	Biophysical
	HN43	B31F	Elands (releases from Mkumbe Dam)	High	High	C	Management Unit, biophysical, releases from dam
	HN44	B31G	Kameel (upper part only	Moderate	High	D	Biophysical, before impacts of town and villages
	HN45	B31G	Elands (EWR site – EWR6)	EIS=Moderate		D	Biophysical
	HN46	B31G	Elands (outlet of quaternary – outlet of IUA4)	Low	Moderate	E	Management Unit & outlet of IUA4
5	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included: B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)	 Moderate High	 High Moderate	 B C	 Biophysical Biophysical
	HN50	B32D	Olifants (EWR site – EWR5)	EIS=Moderate		C	Management Unit, biophysical, confluence with Elands
	HN51	B51B	Puleng (upper part only)	High	High	B	Biophysical
	HN53	B51D, B51E	Olifants (outlet of quaternary– outlet of IUA5)	Moderate	High	D	Management Unit & outlet of IUA5
6	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	 High High	 High Very high	 C D	 Biophysical Biophysical
	HN55	B41B	Steelpoort (EWR site – OLI-EWR2)	EIS=Moderate		D	Biophysical
	HN56	B41C	Masala (confluence with Steelpoort), including Tonteldoos and Vlugkraal)	High	High	C	Biophysical

IUA	Node no	Quaternary catchment	River	EI	ES	PES	Node Type and considerations
	HN57	B41D, B41E	Steelpoort (inflow to De Hoop Dam)	High	Very high	C	Biophysical & management unit
	HN58	B41F	Draaikraalspruit (confluence with Klip)	High	Very high	B	Biophysical
	HN59	B41F	Klip (EWR site – OLI-EWR4)	EIS=Moderate		C	Biophysical, inflow to De Hoop Dam
	HN60	B41G	Kraalspruit (confluence with Groot Dwars)	High	Very high	B	Biophysical
	HN63	B41H	Dwars (EWR site – DWA-EWR1)	EIS=High		B/C	Biophysical, mining impacts, confluence with Steelpoort
	HN64	B41J	Steelpoort (EWR site – EWR9)	EIS=High		D	Biophysical
	HN66	B41J, B41K	Steelpoort (EWR site – EWR10) (confluence with Olifants – outlet of IUA6)	Moderate	High	D	Management Unit & outlet of IUA6
7	HN67	B51F	Nkumpi (outlet of quaternary)	High	Moderate	C	Biophysical
	HN68	B51G	Olifants (EWR site – EWR7)	EIS=Moderate		E	Biophysical & management unit
	HN69	B52E	Palangwe (confluence with Olifants)	High	High	C	Biophysical
	HN70	B52F	Hlakaro (outlet)	High	High	C	Biophysical
	HN71	B52J	Mphogodima (confluence with Olifants)	High	High	C	Biophysical
	HN72	B52A, E, G, J	Olifants (outlet of quaternary – outlet of IUA7)	Moderate	High	D	Management Unit & outlet of IUA7
8	HN74	B42B	Dorpspruit (EWR site – OLI-EWR9)	EIS=Low		C/D	Biophysical, water quality impacts from Lydenburg
	HN77	B42D	Spekboom (EWR site – OLI-EWR6)	EIS=High		C	Biophysical
	HN80	B42G	Rooiwalhoek-se-Loop (confluence with Watervals)	High	Very high	B	Biophysical
	HN81	B42G	Watervals (EWR site – OLI-EWR5)	EIS=Moderate		C	Biophysical, confluence with Spekboom
	HN82	B42H	Spekboom (outlet of quaternary – outlet of IUA 8)	High	Moderate	B	Confluence with Steelpoort & outlet of IUA8
9	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit (confluence with Ohrigstad) Mantshibi (confluence with Ohrigstad) Ohrigstad (outlet of quaternary)	 High High Moderate	 Very high Very high Very high	 C C D	 Biophysical Biophysical Biophysical & management unit
	HN84	B60G	Vyehoek (confluence with Ohrigstad)	High	Very high	C	Biophysical
	HN85	B60H	Ohrigstad (EWR site – OLI-EWR8)	EIS=Moderate		C	Biophysical
	HN86	B60H	Ohrigstad (outlet of quaternary – outlet of IUA9B)	High	Very high	D	Inflow to Blyderivierpoort Dam & outlet of IUA9

IUA	Node no	Quaternary catchment	River	EI	ES	PES	Node Type and considerations
10	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu	High	Moderate	B	Biophysical, confluence with Blyde
	HN88	B60J	Blyde (EWR site – EWR12)	EIS=High		B/C	Biophysical & releases from Blyderivierpoort Dam
	HN89	B60J	Blyde (confluence with Olifants)	Very high	Very high	C	Biophysical
	HN90	B71A	Paardevlei (confluence with Tongwane)	High	Very high	B	Biophysical
	HN91	B71A	Tongwane (confluence with Olifants)	High	High	B	Biophysical
	HN92	B71B	Olifants (EWR site – EWR8)	EIS=Moderate		C/D	Biophysical & management unit
	HN93	B71C	Mohlapitse (upper reaches)	Very high	Very high	B	Biophysical, conservation area
	HN94	B71D	Kgotswane (confluence with Olifants)		Moderate	B	Biophysical
	HN95	B71D, B71F	Olifants (confluence with Steelpoort)	High	Very high	D	Biophysical & management unit
	HN96	B71G, H, J	Olifants (EWR11, confluence with Blyde)	EIS=High		E	Biophysical & management unit
	HN97	B72A	Makhutswi, including Moungwane and Malomanye	High	High	C	Biophysical
	HN98	B72C	Olifants (outlet – outlet of IUA10)	High	High	C	Biophysical, management unit & outlet of IUA10
11	HN101	B72H	Ga-Selati (EWR site – EWR14a)	EIS=Moderate		C	Biophysical
	HN102	B72J	Molatle (confluence with Ga-Selati)	Moderate	Moderate	B	Biophysical
	HN103	B72K	Ga-Selati (EWR site – EWR14b)	EIS=Moderate		E	Biophysical, management unit & outlet of IUA11
	HN104	B72K	Ga-Selati (outlet of quaternary – outlet of UIA11)	High	High	E	Management, confluence with Olifants & outlet of IUA11
12	HN105	B72D	Olifants (EWR site – EWR13)	EIS=Moderate		C	Biophysical & management unit
	HN106	B73A	Klaserie (EWR site – OLI-EWR7)	EIS=High		B/C	Biophysical & management unit
	HN107	B73B	Klaserie (confluence with Olifants)	High	High	C	Biophysical, releases from Klaserie Dam
	HN108	B73C	Tsiri (confluence with Olifants)	High	Low	B	Biophysical
	HN109	B73C	Tshutshi (confluence with Olifants)	High	Low	B	Biophysical
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	High	Low	B	Biophysical
	HN112	B73F	Timbavati (outlet of quaternary)	High	Moderate	B	Biophysical
	HN113	B73G	Timbavati, including Shisakashonghondo	High	Moderate	B	Biophysical

IUA	Node no	Quaternary catchment	River	EI	ES	PES	Node Type and considerations
	HN114	B73G, B73H	Olifants (EWR site – EWR16)	EIS=High		C	Biophysical & management unit
	HN115	B73J	Hlahleni (confluence with Olifants)	High	Low	A	Biophysical
	HN116	B73J	Olifants (outlet of quaternary – outlet of IUA12)	High	Low	C	Biophysical, management unit & outlet of IUA12
13	HN117	B60A	Blyde (confluence with Lisbon)	High	Very high	C	Biophysical
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit	High	Very high	B	Biophysical
	HN119	B60B	Blyde (outlet of quaternary)	High	Very high	B	Biophysical
	HN120	B60C	Treur (EWR site – TRE-EWR1)	EIS=Very high		B	Biophysical
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	High	Very high	B	Biophysical, dolomitic fountains, conservation area including Kadishispruit, Belvedere, Muilhuisspruit,

3 ESTABLISHMENT OF THE ECOLOGICAL SUSTAINABLE BASE CONFIGURATION SCENARIO

Determining the class of a water resource in terms of the process, involves taking into account the social, economic and ecological landscape in a catchment in order to assess the costs and benefits associated with utilisation versus protection of a water resource. As such, classification is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use and the broader goals of the IUA and WMA. The basis for determining the MC is the determination of the ecological sustainable level of protection that is required for water resources and integrating this with the economic and social goals. It is therefore important that an appropriate ecological protection base level (base condition) is established for the water resources; and from this determine what is feasible by understanding the economic and social implications of attaining the minimal (sustainable) level of ecological protection. Once this sustainable ecological protection level is understood, various levels of resource directed protection can be assessed in terms of the overall implications to the IUA and WMA.

The ecologically sustainable base configuration scenario (ESBC) defines this lowest theoretical level of protection required for the sustainable use of the water resources of a catchment. It is not the target scenario but informs the minimal protection level required as a starting point for the hydrological analysis of the water resource system.

This task has been undertaken in compliance with the requirements of the study terms of reference that specify that the classification process is required to build from existing and current initiatives undertaken in support of integrated water resource management.

3.1 Objectives of step 4 of the WRCS

The objective of step 4 of the WRCS is to determine the ESBC and to establish starter catchment configuration scenarios. The ESBC defines the base ecological condition (ecological category of A, B, C or D) for each water resource (and the EWRs required for maintaining that category), and the yield that would result.

The establishment of the ESBC requires the running of a hydrological model using the base condition ecological water requirements (EWRs) (water quality and quantity) as the hydrology, to test whether these EWRs for all nodes can be met.

The following activities have been undertaken as part of Step 4 of the WRCS, the:

- Determination of an ESBC scenario that meets feasibility criteria for water quantity, water quality, and ecological needs;
- Consideration of the planning scenarios as detailed in the Olifants Water Supply System Reconciliation Strategy (future use, equity considerations and existing lawful use); and
- Establishment of alternate catchment configuration starter scenarios.

The process followed is that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, 2007a and 2007b).

3.2 Purpose of the report

In terms of the WRCS 7 step process applied to the determination of a MC, the study process for the Olifants WMA is now at step 4 (Figure 2), 'the determination of the ecologically sustainable base configuration (ESBC) scenario'.

In respect of step 4 of the process, the purpose of this report is:

- To describe the process undertaken to establish the ESBC scenario;
- To define the ESBC scenario for each IUA (and identified sub-nodes) and present the results of the yield modelling; and
- To describe the alternate catchment configuration scenarios that will be tested in step 5 of the WRCS process.

4 THE APPROACH FOLLOWED

The approach followed to determine the ESBC scenario for the Olifants WMA included the following steps:

- Assessment of the present ecological state and minimal protection level required for the water resources within the Olifants WMA at the identified nodes;
- Establishment of the ESBC per IUA, and at relevant sub-nodes;
- Setting up of yield model;
- Running of yield model with ESBC scenario;
- Analysis of results of the yield analysis (water surpluses/deficits per IUA);
- Consideration of planning options;
- Description of alternate catchment configuration starter scenarios to be assessed as part of Step 5 of the WRCS process.

The approach is discussed in more detail in sections 4.1 to 4.4 that follow.

4.1 Base condition of water resources: Present Ecological Status (PES)

An ESBC scenario is established in order to understand what the result would be in terms of system yield of implementing the minimum base level of ecological protection required to ensure sustainable use of the catchment water resources (consideration of ecological, water quality and quantity needs). This involves the linking of the flow and resource condition using the lowest ecological category as a starting point, ensuring that the river reaches are maintained in their minimal sustainable condition.

In terms of the WRCS, the base condition for each water resource is set at a minimum which is either a D ecological category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However where the ecological condition requires it, a higher ecological category needs to be set.

In the Olifants WMA after consultation with the Project Steering Committee, the D ecological category (EC) was not selected as the default for the ESBC. Rather the selected EC was based on the assessment of the present ecological state (PES) and ecological/conservation importance of water resources within the IUAs. The PES of the water resources in the Olifants WMA was thus used as the base ecological condition for the yield analysis. The ecological condition of the water resources used in the yield modelling included the PES condition at the various EWR sites from the comprehensive and rapid Reserve determination studies that were undertaken for the WMA. The PES EWR for the sites are summarised in Table 3.

PES per river node and the ESBC ecological category determined for each IUA is listed in (Table 4). The ESBC EC per IUA is an aggregation of the PES of the biophysical nodes for sub-quarternary catchments within that IUA. The aggregated IUA ESBC EC is based on the proportion (percentage) per EC within an IUA and was calculated using the ECs for the sub-nodes. The percentages are listed in Table 4. Based on Table 11.1 in the ‘Overview and 7 step Classification

Procedure' guideline (DWA, 2007a), the aggregated EC for an IUA was then determined.

Where a biophysical node has a higher PES and/or a higher ecological importance than the aggregated IUA scale ESBC ecological category, this more protective ecological category was accounted for by using sub nodes in these quartenary catchments. The list and location of these sub-nodes (higher protection) are shown in Table 5 and Figure 4 respectively.

The river Freshwater Ecosystem Priority Areas (FEPAs) identified through the National Freshwater Ecosystem Priority Areas Project of the Water Research Commission of 2011, were assessed to determine if they were adequately protected through the ECs for the sub-nodes for these catchments. FEPAs have been identified as those areas that are important for sustaining the integrity and continued functioning of their related ecosystems. The FEPAs in the Olifants WMA are shown in Figure 5. Forty nine (49) FEPAs are present in the Olifants WMA (refer to Appendix A). The assessment of the FEPAs in relation to the sub-nodes and the catchment areas requiring higher ecological protection identified for the Olifants WMA show good alignment (refer to Figure 4 and Figure 5). The FEPAs will be protected by the level of protection proposed in this process – 82 % of the FEPAs (40) are within areas of the IUAs that require a higher level of protection than the IUA class.

Table 3: Summary of PES for EWR sites per IUA

EWR site	River	Quaternary catchment	PES	VMAR ($10^6 m^3$)	%EWR	Level
EWR1	Olifants	B11J	E*	184.52	18.6	Comprehensive
EWR2	Olifants	B32A	C	500.63	23.8	Comprehensive
EWR3	Klein Olifants	B12E	D	81.54	27.0	Comprehensive
EWR4	Wilge	B20J	B	175.50	29.9	Comprehensive
EWR5	Olifants	B32D	C	570.98	19.1	Comprehensive
EWR6	Elands	B31G	E*	60.30	17.9	Comprehensive
EWR7	Olifants	B51G	E*	726.52	12.7	Comprehensive
EWR8	Olifants	B71B	E*	813.04	15.2	Comprehensive
EWR9	Steelpoort	B41J	D	120.17	15.2	Comprehensive
EWR10	Steelpoort	B41K	D	336.63	12.1	Comprehensive
EWR11	Olifants	B71J	E*	1321.8	13.7	Comprehensive
EWR12	Blyde	B60J	B	383.70	34.5	Comprehensive
EWR13	Olifants	B72D	C	1760.7	23.6	Comprehensive
EWR14a	Ga-Selati	B72H	C	52.20	31.2	Comprehensive
EWR14b	Ga-Selati	B72K	E*	72.74	24.8	Comprehensive
EWR16	Olifants	B73H	C	1916.9	21.6	Comprehensive
TRE-EWR1	Treur	B60C	A/B	49.28	45.4	Rapid 3
NOU-EWR1	Noupoortspruit	B11G	C/D	4.28	25.9	Rapid 3
DWA-EWR1	Dwars	B41H	B/C	31.43	25.9	Intermediate
OLI-EWR1	UKlein Olifants	B12C	C	44.46	28.86	Rapid 3
OLI-EWR2	Upper Steelpoort	B41B	C	63.46	29.78	Rapid 3
OLI-EWR3	Kranspoortspruit	B32A	B	4.71	46.01	Rapid 3
OLI-EWR4	Klip	B41F	C	5.20	27.49	Rapid 1
OLI-EWR5	Watervals	B42G	C	36.39	23.48	Rapid 3
OLI-EWR6	Upper Spekboom	B42D	C	28.04	33.52	Rapid 3
OLI-EWR7	Klaserie	B73A	B/C	25.54	38.95	Rapid 3
OLI-EWR8	Ohrigstad	B60H	C	65.49	26.35	Rapid 2
OLI-EWR9	Dorpspruit	B42B	C/D	63.19	19.28	Rapid 1

* D category was used during modelling

Refer to Ecological Water Requirements Quantification Report (RDM/WMA04/00/CON/CLA/0511), September 2011, for more detailed information on the EWR sites.

Table 4: PES per river nodes for the network of significant water resources and ESBC EC per IUA

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
1	HN1	B11A, B11B	Olifants (confluence with Steenkoolspruit)	D	B = 15% C = 35% D = 50%	Class III	D
	HN2	B11C	Piekespruit (confluence with Steenkoolspruit)	B*			
	HN3	B11D	Dwars-indie-Wegspruit (confluence with Trichardtspruit)	C*			
	HN4	B11D	Steenkoolspruit (outlet of quaternary)	D			
	HN5	B11E	Blesbokspruit (confluence with Rietspruit)	B*			
	HN6	B11E	Steenkoolspruit (confluence with Olifants)	D			
	HN7	B11F	Olifants (outlet of quaternary)	D			
	HN8	B11G	Noupoortspruit (EWR site – NOU-EWR1)	C*			
	HN9	B11G	Olifants (releases from Witbank Dam)	D			
	HN10	B11H	Spookspruit (confluence with Olifants)	C			
	HN11	B11J	Olifants (EWR site 1 – EWR1)	D			
	HN12	B11K, B11L	Klipspruit (confluence with Olifants)	D			
	HN13	B11L	Olifants (outlet of IUA1)	B*			
	HN14	B12A	Boschmansfontein (confluence with Klein Olifants)	C*			
	HN15	B12A	Klein Olifants (outlet of quaternary)	C			
	HN16	B12B	Klein Olifants (outlet of quaternary)	D			
	HN17	B12C	Klein Olifants (EWR site – OLI-EWR1)	C			
	HN18	B12C	Klein Olifants (releases from Middelburg Dam)	C			
	HN19	B12D	Vaalbankspruit (confluence with Klein Olifants)	D			
	HN20	B12D	Klein Olifants (outlet of quaternary)	D			
2	HN21	B20A	Bronkhorstpruit (outlet of quaternary)	C	B = 9% C = 82%	Class II	C
	HN22	B20B	Koffiespruit (confluence with Bronkhorstspruit)	C			

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
	HN23	B20C	Osspruit (inflow to Bronkhorstspruit Dam)	D	D = 9%		
	HN24	B20C	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	C			
	HN25	B20D	Hondespruit (confluence with Bronkhorstspruit)	C			
	HN26	B20D	Bronkhorstpruit (confluence with Wilge)	C			
	HN27	B20E, B20F	Wilge (confluence with Bronkhorstspruit	C			
	HN28	B20G	Saalboomspruit (confluence with Wilge)	C			
	HN29	B20H	Grootspruit (confluence with Wilge)	C			
	HN30	B20H	Wilge	B*			
	HN31	B20J	Wilge (EWR site – EWR4, outlet of IUA2)	C			
3	HN32	B12E	Doringboomspruit (confluence with Klein Olifants)	B*	B = 45% C = 33% D = 22%	Class II	C
	HN33	B12E	Keeromspruit (confluence with Klein Olifants)	C*			
	HN34	B12E	Klein Olifants (EWR site – EWR3)	C			
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3)	B*			
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)	B*			
	HN37	B32A	Olifants (EWR site – EWR2)	C			
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)	 B* B* C*			
	HN39	B32C	Olifants (releases from Loskop Dam)	D			
	HN40	B32C	Olifants (outlet of quaternary – outlet of IUA3)	D			
4	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam. Included: B31A (Elands)	 C* C*	C = 50% D = 33% E = 17%	Class III	D

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
			B31B (Hartbeesspruit) B31C (Elands)	C*			
	HN42	B31D	Enkeldoringspruit (confluence with Elands)	C			
	HN43	B31F	Elands (releases from Mkumbe Dam)	C			
	HN44	B31G	Kameel (upper part only	D			
	HN45	B31G	Elands (EWR site – EWR6)	D			
	HN46	B31G	Elands (outlet of quaternary – outlet of IUA4)	E#			
5	HN47	B31H, B31J	Elands (outlet of quaternary, confluence with Olifants))	D	B = 29% C = 29% D = 43%	Class III	D
	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included: B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)	 B* C*			
	HN49	B32G, H	One node at outlet of B32H, confluence with Olifants Included: B32G (Moses) B32H (Mametse and Moses)	 C D			
	HN50	B32D	Olifants (EWR site – EWR5)	C			
	HN51	B51B	Puleng (upper part only)	B*			
	HN52	B51B	Olifants (releases from Flag Boshielo Dam)	D			
	HN53	B51D, B51E	Olifants (outlet of quaternary– outlet of IUA5)	D			
6	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	 C* D*	B = 23% C = 46% D = 31%	Class III	D
	HN55	B41B	Steelpoort (EWR site – OLI-EWR2)	D			
	HN56	B41C	Masala (confluence with Steelpoort), including Tonteldoos and Vlugkraal)	C*			

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
	HN57	B41D, B41E	Steelpoort (inflow to De Hoop Dam)	C*			
	HN58	B41F	Draaikraalspruit (confluence with Klip)	B*			
	HN59	B41F	Klip (EWR site – OLI-EWR4)	C			
	HN60	B41G	Kraalspruit (confluence with Groot Dwars)	B*			
	HN61	B41G	Klein Dwars (Confluence with Groot Dwars)	D			
	HN62	B41G	Upper reaches of Dwars (before mining impacts)	C			
	HN63	B41H	Dwars (EWR site – DWA-EWR1)	B*			
	HN64	B41H	Steelpoort	C			
	HN65	B41J	Steelpoort (EWR site – EWR9)	D			
	HN66	B41J, B41K	Steelpoort (EWR site – EWR10) (confluence with Olifants – outlet of IUA6)	D			
7	HN67	B51F	Nkumpi (outlet of quaternary)	C*	C = 67% D = 17% E = 17%	Class III	D
	HN68	B51G	Olifants (EWR site – EWR7)	E#			
	HN69	B52E	Palangwe (confluence with Olifants)	C*			
	HN70	B52F	Hlakaro (outlet)	C*			
	HN71	B52J	Mphogodima (confluence with Olifants)	C*			
	HN72	B52A, E, G, J	Olifants (outlet of quaternary – outlet of IUA7)	D			
8	HN73	B42A, B42B	One node for Dorpspruit at outlet of B42B. Included: Hoppe se Spruit (confluence) Doringbergspruit (confluence)	 C C	B = 20% C = 80%	Class II	C
	HN74	B42B	Dorpspruit (EWR site – OLI-EWR9)	C			
	HN75	B42C	Potloodspruit (confluence with Dorps)	C			
	HN76	B42D, B42E	Dorps (confluence with Spekboom) Spekboom (confluence with Dorps)	C C			
	HN77	B42D	Spekboom (EWR site – OLI-EWR6)	C			

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
	HN78	B42F	Potspruit (confluence with Watervals)	C			
	HN79	B42F	Watervals (releases from Buffelskloof Dam)	C			
	HN80	B42G	Rooiwalhoek-se-Loop (confluence with Watervals)	B*			
	HN81	B42G	Watervals (EWR site – OLI-EWR5)	C			
	HN82	B42H	Spekboom (outlet of quaternary – outlet of IUA 8)	B			
9	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit (confluence with Ohrigstad) Mantshibi (confluence with Ohrigstad) Ohrigstad (outlet of quaternary)	 C* C*	C = 75% D = 25%	Class III	D (mainstem) Tributaries are in a higher ecological condition (C). Mainstem Ohrigstad is highly impacted (D)
	HN84	B60G	Vyehoek (confluence with Ohrigstad)	C*			
	HN85	B60H	Ohrigstad (EWR site – OLI-EWR8)	C			
	HN86	B60H	Ohrigstad (outlet of quaternary – outlet of IUA9B)	D			
10	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu	B*	B = 50% C = 33% D = 8% E = 8%	Class II	C
	HN88	B60J	Blyde (EWR site – EWR12)	B*			
	HN89	B60J	Blyde (confluence with Olifants)	C			
	HN90	B71A	Paardevlei (confluence with Tongwane)	B*			
	HN91	B71A	Tongwane (confluence with Olifants)	B			
	HN92	B71B	Olifants (EWR site – EWR8)	C			
	HN93	B71C	Mohlapitse (upper reaches)	B*			
	HN94	B71D	Kgotswane (confluence with Olifants)	B*			
	HN95	B71D, B71F	Olifants (confluence with Steelpoort)	D			
	HN96	B71G, H, J	Olifants (EWR11, confluence with Blyde)	E#			
	HN97	B72A	Makhutswi, including Moungwane and Malomanye	C			
	HN98	B72C	Olifants (outlet – outlet of IUA10)	C			
11	HN99	B72E	Ngwabatse (confluence with Ga-Selati)	D	B = 17%	Class III	D

IUA	Node no	Quaternary catchment	Nodes	PES	% EC representation at nodes per IUA	Representative IUA Scale Class for ESBC Scenario	ESBC EC per IUA (main stem river)
	HN100	B72F, G	Ga-Selati (outlet of quaternary)	C	C = 33% D = 17% E = 33%		
	HN101	B72H	Ga-Selati (EWR site – EWR14a)	C			
	HN102	B72J	Molatle (confluence with Ga-Selati)	B*			
	HN103	B72K	Ga-Selati (EWR site – EWR14b)	E#			
	HN104	B72K	Ga-Selati (outlet of quaternary – outlet of UIA11)	E#			
12	HN105	B72D	Olifants (EWR site – EWR13)	C	A = 8% B = 59% C = 33%	Class II	C
	HN106	B73A	Klaserie (EWR site – OLI-EWR7)	B			
	HN107	B73B	Klaserie (confluence with Olifants)	C			
	HN108	B73C	Tsiri (confluence with Olifants)	B*			
	HN109	B73C	Tshutshi (confluence with Olifants)	B*			
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	B*			
	HN111	B73E	Sesete (confluence with Timbavati)	B*			
	HN112	B73F	Timbavati (outlet of quaternary)	B*			
	HN113	B73G	Timbavati, including Shisakashonghondo	B*			
	HN114	B73G, B73H	Olifants (EWR site – EWR16)	C*			
	HN115	B73J	Hlahleni (confluence with Olifants)	A*			
	HN116	B73J	Olifants (outlet of quaternary – outlet of IUA12)	C			
13	HN117	B60A	Blyde (confluence with Lisbon)	C*	B = 80% C = 20%	Class I	A/B
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit	B*			
	HN119	B60B	Blyde (outlet of quaternary)	B*			
	HN120	B60C	Treur (EWR site – TRE-EWR1)	B			
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	B*			

*Addressed by sub-node

D category was used for the yield modelling

Table 5: Sub-nodes within IUAs requiring a higher level of ecological protection than the IUA ESBC

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA ESBC
1 Upper Olifants River catchment	HN2	B11C	Piekespruit	High	High	**B**	D
	HN3	B11D	Dwars-indie-Wegspruit	High	High	**C**	
	HN5	B11E	Blesbokspruit	High	High	**B**	
	HN13	B11L	Olifants (outlet of IUA1)	Very high	Very high	**B**	
	HN14	B12A	Boschmansfontein	Moderate	High	**C**	
2 Wilge River catchment area	HN30	B20H	Wilge	High	Very high	**B**	C
3 Selons River area including Loskop Dam	HN32	B12E	Doringboomspruit	High	High	**B**	C
	HN33	B12E	Keeromspruit	High	High	**C**	
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3)	EIS=Very high		**B**	
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)	High	High	**B**	
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)	 High High High	 High High Very high	 **B** **B** **C**	
	HN40	B32C	Olifants (outlet of quaternary – outlet of IUA3)	High	High	**D**	
4 Elands River catchment area	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam. Included: B31A (Elands) B31B (Hartbeesspruit)	 High High High	 High Very high Very high	 **C** **C** **C**	D
5 Middle Olifants up to Flag	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included:				D

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA ESBC
Boshielo Dam			B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)	Moderate High	High Moderate	**B** **C**	
	HN51	B51B	Puleng (upper part only)	High	High	**B**	
6 Steelpoort River catchment	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	 High High	 High Very high	 **C** **D**	D
	HN56	B41C	Masala (including Tonteldoos and Vlugkraal)	High	High	**C**	
	HN57	B41D, B41E	Steelpoort	High	Very high	**C**	
	HN58	B41F	Draaikraalspruit	High	Very high	**B**	
	HN60	B41G	Kraalspruit (	High	Very high	**B**	
	HN63	B41H	Dwars (EWR site – DWA-EWR1)	EIS=High		**B/C**	
7 Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	HN67	B51F	Nkumpi (outlet of quaternary)	High	Moderate	**C**	D
	HN69	B52E	Palangwe	High	High	**C**	
	HN70	B52F	Hlakaro (outlet)	High	High	**C**	
	HN71	B52J	Mphogodima	High	High	**C**	
8 Spekboom catchment	HN80	B42G	Rooiwalhoek-se-Loop	High	Very high	**B**	C
9 Ohrigstad River catchment area	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit Mantshibi	 High High	 Very high Very high	 **C** **C**	D
	HN84	B60G	Vyehoek	High	Very high	**C**	
10 Lower Olifants	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu	High	Moderate	**B**	C
	HN88	B60J	Blyde (EWR site – EWR12)	EIS=High		**B/C**	
	HN90	B71A	Paardevlei	High	Very high	**B**	
	HN91	B71A	Tongwane	High	High	**B**	
	HN93	B71C	Mohlapitse (upper reaches)	Very high	Very high	**B**	

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA ESBC
	HN94	B71D	Kgotswane		Moderate	**B**	
11 Ga-Selati River area	HN102	B72J	Molatle	Moderate	Moderate	**B**	D
12 Lower Olifants within Kruger National Park	HN108	B73C	Tsiri	High	Low	**B**	C
	HN109	B73C	Tshutshi	High	Low	**B**	
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	High	Low	**B**	
	HN112	B73F	Timbavati	High	Moderate	**B**	
	HN113	B73G	Timbavati, including Shisakashonghondo	High	Moderate	**B**	
	HN114	B73G, B73H	Olifants (EWR site – EWR16)	EIS=High		**C**	
	HN115	B73J	Hlahleni	High	Low	**A**	
13 Blyde River catchment area	HN117	B60A	Blyde	High	Very high	**C**	A/B
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit	High	Very high	**B**	
	HN119	B60B	Blyde (outlet of quaternary)	High	Very high	**B**	
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	High	Very high	**B**	

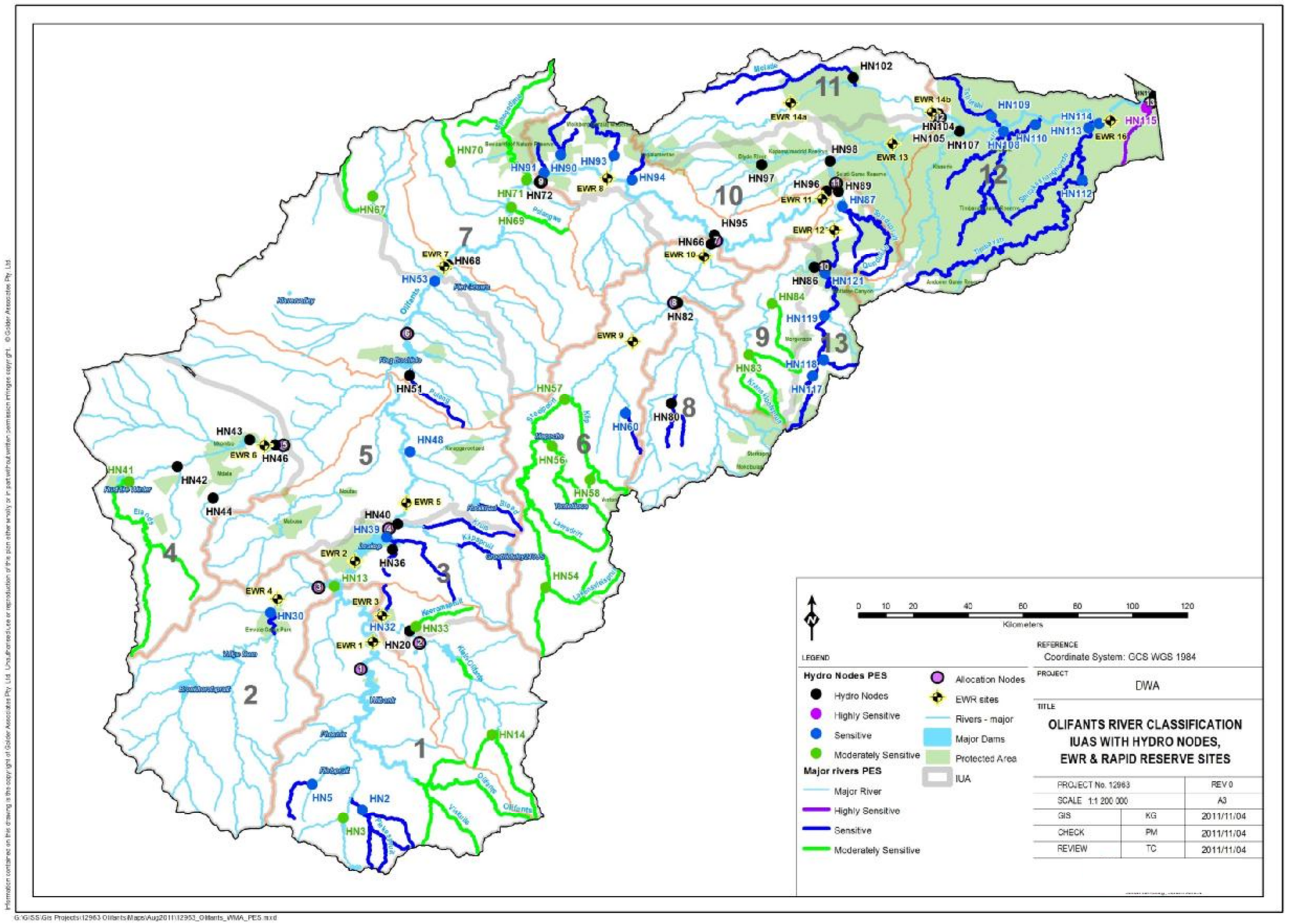

Figure 4: Sub-catchments within network of significant water resources requiring higher level of protection than IUA scale ESBC EC (indicated by blue, green and purple shading)

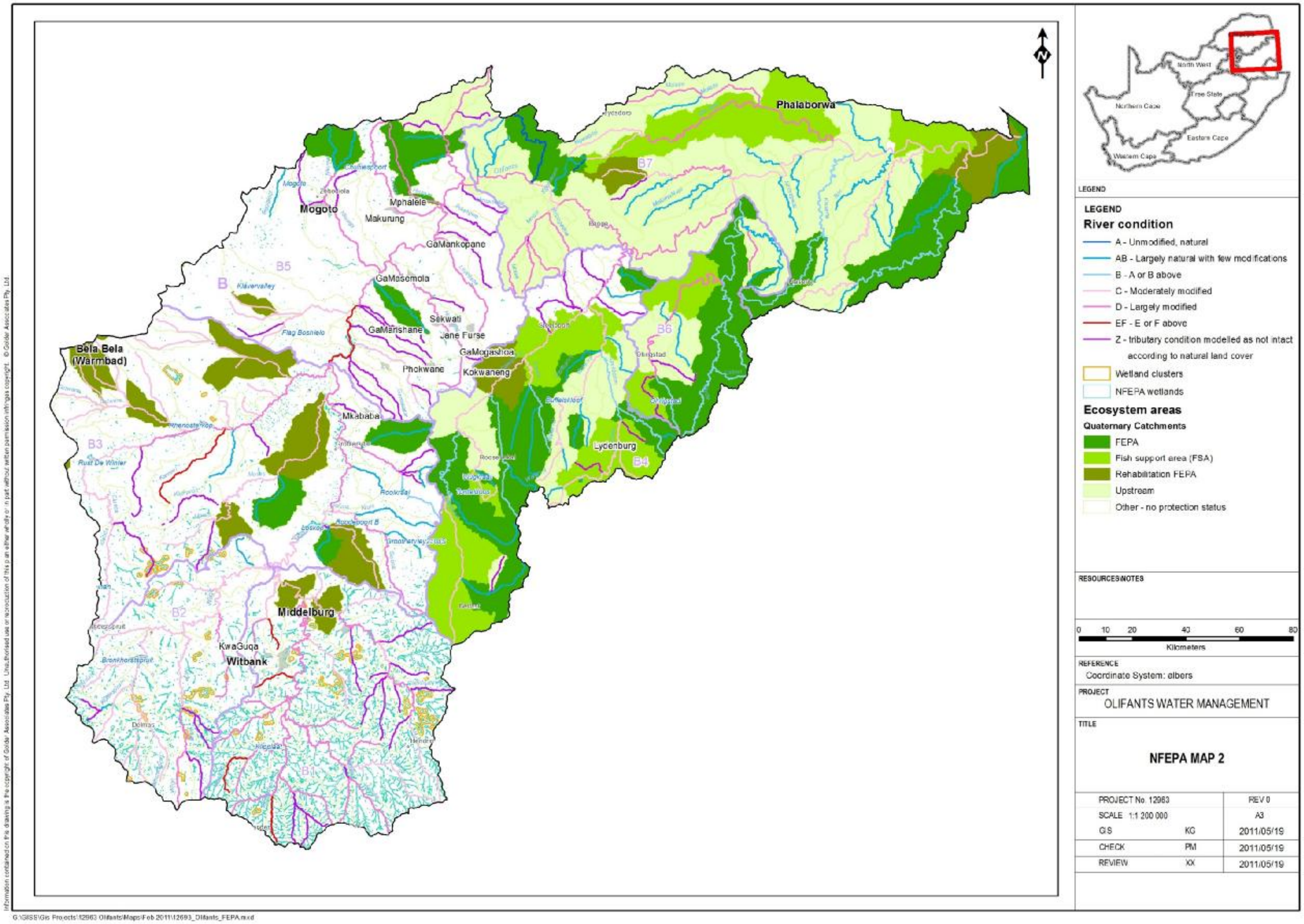

Figure 5: River Freshwater Ecosystem Priority Areas (FEPAs) identified for the Olifants WMA

4.2 The ESBC per IUA

At least one EWR site per IUA was used during the yield modelling to evaluate the implementation of the Reserve and the resulting water balance for the Olifants WMA. Where the PES is currently in an E category, a D category was used for modelling purposes. The EWR PES used for modelling purposes per IUA are provided in Table 6.

Table 6: PES EC per EWR site (per IUA)

IUA	EWR site	River	EWR (PES EC) used in WRYM
1	EWR1 EWR3	Olifants Klein Olifants	D D
2	EWR4	Wilge	B
3	EWR2	Olifants	C
	EWR5	Olifants	C
4	EWR6	Elands	D
5	EWR7	Olifants	D
6	OLI-EWR2ex	Upper Steelpoort	C
	EWR9	Steelpoort	D
	EWR10	Steelpoort	D
	DWA-EWR1	Dwars	B/C
7	EWR8	Olifants	D
8	OLI-EWR5ex	Spekboom	C
9	OLI-EWR8	Ohrigstad	D
10	EWR11 EWR12	Olifants Blyde	D B
11	EWR14a EWR14b	Upper Ga-Selati Lower Ga-Selati	C D
12	EWR13 EWR16	Olifants Olifants	C C
13	B60Dex	Blyde (Treur extrapolated)	B

Based on the present ecological condition of water resources within the Olfants WMA, the IUA scale ESBC ECs tested (outlet of IUAs) are listed in Table 7 below and indicated in Figure 6. The management classes (MCs) associated with this ESBC (EC) scenario are also reflected.

Table 7: EC tested for the ecological sustainable base configuration (per IUA)

IUA	Catchment area	Ecological Category (ESBC)	IUA Management Class associated with scenario
1	Upper Olifants River catchment	D	III
2	Wilge River catchment area	C	II
3	Selons River area including Loskop Dam	C	II
4	Elands River catchment area	D	III
5	Middle Olifants up to Flag Boshielo Dam	D	III
6	Steelpoort River catchment	D	III
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D	III
8	Spekboom catchment	C	II
9	Ohrigstad River catchment area	D	III
10	Lower Olifants	C	II
11	Ga-Selati River area	D	III
12	Lower Olifants within Kruger National Park	C	II
13	Blyde River catchment area	A/B	I

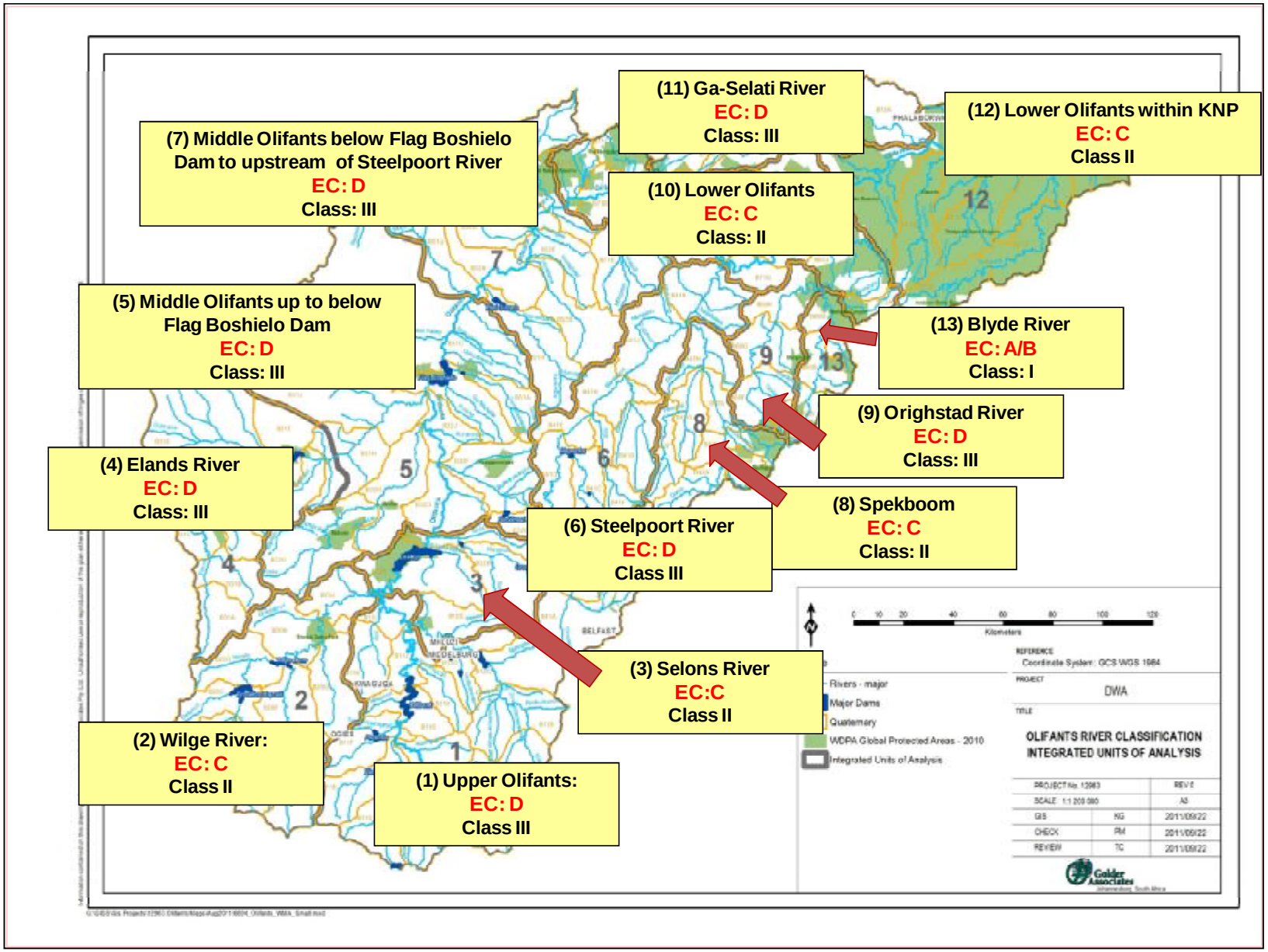

Figure 6: ESBC per IUA as tested in the yield model

This configuration of ecological categories ensures that a sustainable level of ecosystem functioning is maintained in the Olifants WMA. The water resource system will have to provide for the required volume of EWRs needed to maintain this configuration. The annual ecological water requirements (EWR) needed per IUA is indicated in Table 8 below.

Table 8: EWRs needed to maintain the ESBC ecological category per IUA

IUA	Catchment area	Ecological Category (ESBC)	EWR needed to maintain ESBC ($10^6 m^3$)
1	Upper Olifants River catchment	D	22.5
2	Wilge River catchment area	C	57.8
3	Selons River area including Loskop Dam	C	108.9
4	Elands River catchment area	D	10.8
5	Middle Olifants up to Flag Boshielo Dam	D	92.3
6	Steelpoort River catchment	D	26
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D	124.2
8	Spekboom catchment	C	34.1
9	Ohrigstad River catchment area	D	17.3
10	Lower Olifants	C	315
11	Ga-Selati River area	D	18.1
12	Lower Olifants within Kruger National Park	C	269.7
13	Blyde River catchment area	A/B	114.8

4.2.1 Extrapolation and EWRs for river nodes

The information available from Comprehensive and Rapid Reserve determinations has been used for extrapolation to all the identified rivers nodes. Table 9 lists all the rivers nodes with the EWR sites that were used for extrapolation. The eco-region level 2 information as well as discussions with specialists were used as a guide during this process.

The rule and summary tables and the long term EWR time series as generated with the Desktop Reserve Model in SPATSIM was used during ESBC scenario establishment and will also be used in Step 5 of the WRCS process.

The PES and REC information from the desktop study, the re-assessment of the comprehensive

EWR sites, existing EWR sites and the additional rapid studies were used as the basis for extrapolation as indicated.

Table 9: River nodes and associated EWR sites used for extrapolation

IUA	Node no	Quaternary catchment	Nodes	EWR sites used for extrapolation
1 Upper Olifants River catchment	HN1	B11A, B11B	Olifants	OLI-EWR1
	HN2	B11C	Piekespruit	OLI-EWR1
	HN3	B11D	Dwars-indie-Wegspruit	OLI-EWR1
	HN5	B11E	Blesbokspruit	OLI-EWR1
	HN8	B11G	Noupoortspruit	NOU-EWR1
	HN13	B11L	Olifants	EWR1
	HN14	B12A	Boschmansfontein	OLI-EWR1
	HN17	B12C	Klein Olifants	OLI-EWR1
	HN20	B12D	Klein Olifants	EWR3
2 Wilge River catchment area	HN28	B20G	Saalboomspruit	EWR4
	HN30	B20H	Wilge	EWR4
	HN31	B20J	Wilge	EWR4
3 Selons River area including Loskop Dam	HN32	B12E	Doringboomspruit	EWR3
	HN33	B12E	Keeromspruit	EWR3
	HN34	B12E	Klein Olifants	EWR3
	HN35	B32A	Kranspoortspruit	OLI-EWR3
	HN36	B32A	Boekenhoutloop	OLI-EWR3
	HN37	B32A	Olifants	EWR2
	HN38	B32B, B32C	Selons, Klipspruit,Kruis	OLI-EWR3
	HN40	B32C	Olifants	EWR5
4 Elands River catchment area	HN41	B31A, B, C	Elands, Hartbeesspruit	EWR6
	HN42	B31D	Enkeldoringspruit	EWR6
	HN43	B31F	Elands	EWR6
	HN44	B31G	Kameel	EWR6
	HN45	B31G	Elands	EWR6
	HN46	B31G	Elands	EWR6
5 Middle Olifants up to Flag Boshielo Dam	HN48	B32E, B32F	Bloed, Doringpoortloop, Diepkloof and Bloed	OLI-EWR3
	HN50	B32D	Olifants	EWR5
	HN51	B51B	Puleng	No extrapolation sites. Use Desktop requirements
	HN53	B51D, B51E	Olifants	EWR7
6 Steelpoort River	HN54	B41A	Grootspruit, Langspruit, Lakenvleispruit and Kleinspruit	OLI-EWR2
	HN55	B41B	Steelpoort	OLI-EWR2

IUA	Node no	Quaternary catchment	Nodes	EWR sites used for extrapolation
catchment	HN56	B41C	Masala, Tonteldoos and Vlugkraal)	OLI-EWR2
	HN57	B41D, B41E	Steelpoort (inflow to De Hoop Dam)	OLI-EWR2
	HN58	B41F	Draaikraalspruit	OLI-EWR4
	HN59	B41F	Klip	OLI-EWR4
	HN60	B41G	Kraalspruit	OLI-EWR2
	HN63	B41H	Dwars	DWA-EWR1
	HN64	B41H	Steelpoort	EWR9
	HN66	B41J, B41K	Steelpoort	EWR10
7 Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	HN67	B51F	Nkumpi	No extrapolation sites. Use Desktop requirements
	HN68	B51G	Olifants	EWR7
	HN69	B52E	Palangwe	No extrapolation sites. Use Desktop requirements
	HN70	B52F	Hlakaro	No extrapolation sites. Use Desktop requirements
	HN71	B52J	Mphogodima	No extrapolation sites. Use Desktop requirements
	HN72	B52A, E, G, J	Olifants	EWR7
8 Spekboom catchment	HN74	B42B	Dorpspruit	OLI-EWR9
	HN77	B42D	Spekboom	OLI-EWR6
	HN80	B42G	Rooiwalhoek-se-Loop	OLI-EWR5
	HN81	B42G	Watervals	OLI-EWR5
	HN82	B42H	Spekboom	OLI-EWR5
9 Ohrigstad River catchment area	HN83	B60E, B60F	Kranskloofspruit, Mantshibi, Ohrigstad	OLI-EWR6
	HN84	B60G	Vyehoek	OLI-EWR6
	HN85	B60H	Ohrigstad	OLI-EWR8
	HN86	B60H	Ohrigstad	OLI-EWR8
10 Lower Olifants	HN87	B60J	Sandspruit, Rietspruit and Qunduhlu	EWR12
	HN88	B60J	Blyde	EWR12
	HN89	B60J	Blyde	EWR12
	HN90	B71A	Paardevlei	No extrapolation sites. Use Desktop requirements
	HN91	B71A	Tongwane	No extrapolation sites. Use Desktop requirements

IUA	Node no	Quaternary catchment	Nodes	EWR sites used for extrapolation
	HN92	B71B	Olifants	EWR8
	HN93	B71C	Mohlapitse	No extrapolation sites. Use Desktop requirements
	HN94	B71D	Kgotswane	No extrapolation sites. Use Desktop requirements
	HN95	B71D, B71F	Olifants	EWR8
	HN96	B71G, H, J	Olifants	EWR11
	HN97	B72A	Makhutswi, Moungwane and Malomanye	EWR14a
	HN98	B72C	Olifants	EWR11
11 Ga-Selati River area	HN101	B72H	Ga-Selati	EWR14a
	HN102	B72J	Molatle	EWR14a
	HN103	B72K	Ga-Selati	EWR14b
	HN104	B72K	Ga-Selati	EWR14b
12 Lower Olifants within Kruger National Park	HN105	B72D	Olifants	EWR13
	HN106	B73A	Klaserie	OLI-EWR7
	HN107	B73B	Klaserie	OLI-EWR7
	HN108	B73C	Tsiri	OLI-EWR7
	HN109	B73C	Tshutshi	OLI-EWR7
	HN110	B73D	Nhlaralumi, Machaton, Nyameni and Thlaralumi	OLI-EWR7
	HN112	B73F	Timbavati	OLI-EWR7
	HN113	B73G	Timbavati, Shisakashonghondo	OLI-EWR7
	HN114	B73G, B73H	Olifants	EWR16
	HN115	B73J	Hlahleni	OLI-EWR7
	HN116	B73J	Olifants	EWR16
13 Blyde River catchment area	HN117	B60A	Blyde	TRE-EWR1
	HN118	B60B	Lisbon, Heddelspruit and Watervalspruit	TRE-EWR1
	HN119	B60B	Blyde	TRE-EWR1
	HN120	B60C	Treur	TRE-EWR1
	HN121	B60D	Blyde	TRE-EWR1

4.3 The Hydrological Modelling – The Water Resources Yield Model (WRYM)

4.3.1 Background and setup

The Water Resources Yield Model (WRYM) that was used as part of the development of the Olifants Reconciliation Strategy was obtained and used as the base from which the ESBC was constructed.

The following are some of the specific considerations that were included in the setup for the ESBC scenario:

- Present day water use for irrigation, mining, domestic, rural and afforestation as provided in the water requirements and water resources report that forms part of the reconciliation strategy;
- De Hoop Dam was included;
- Raised Flag Boshielo Dam was included;
- Compensation releases from Flag Boshielo Dam, De Hoop Dam and Phalaborwa Barrage;
- Water court orders from Witbank, Middelburg and Loskop Dams; and
- All the major dams in the system were included.

4.3.2 System schematic – Major nodes/points

Detailed schematic diagrams were obtained from the study team responsible for the development of the Olifants Water Supply System Reconciliation Strategy and this was used as the basis for changing, checking and evaluation of the ESBC. The following major nodes were included as part of the setup per IUA:

- All major dams as well as combined farm dams and irrigation areas; and
- Ecological requirements for all the EWR sites as listed in Table 8.

Appendix B provides some detail of the schematic diagram for the system. The detailed system diagrams are available as part of the Olifants Water Supply System Reconciliation Strategy Study.

4.3.3 Model Runs

The WRYM was run with present day (2010) water requirements and the EWR requirements as determined using the approach described in section 4.2.

This provides the basis for the evaluation of the impact of the implementation of ESBC on the resulting water balance for the Olifants WMA and to determine the economic consequences of these.

The results for this run are provided in Section 5 of this report.

4.4 The ESBC Scenario – Scenario 1

The ESBC defines this lowest theoretical level of protection required for the sustainable use of the water resources of a catchment. It is not the target scenario but informs the minimal protection level required constructed as a starting point for the hydrological analysis of the water resource system.

A scenario is used to understand different ways that future events might unfold. Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition. Analysis thereof gives the ability to compare the implications of one scenario against another, with the ultimate aim to make a selection of the preferred scenario.

Having established the ecological categories (ECs) required for the sustainable use of the water resources in the Olifants WMA. This ESBC scenario (PES scenario) was tested in the yield model with the following parameters:

ESBC Scenario (PES Scenario)	Water Requirements	EWR
1	2010 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows

This current level of development modelled for the Olifants WMA included the present day (2010) water requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' ((DWA, 2011).

5 RESULTS OF THE YIELD ANALYSIS

The yield model for the Olifants WMA was setup and run with the ESBC scenario as described in Section 4.3. The assessment allowed for evaluation of the yield that would result in the catchment with the EWRs required for maintaining the PES ecological category. The outputs of the yield analysis provided the water balance (surpluses/deficits) per IUA by implementation of the ESBC scenario. The planning scenarios for the WMA are also considered at this point to understand the availability of water.

The yield analysis results per IUA with the ESBC scenario indicate varying degrees of water surpluses and deficits in each IUA. The results of the simulation for the ESBC are listed in Table 10. The Olifants WMA has an overall water deficit of 159 million m^3/a with implementation of the ESBC scenario.

Table 10: Water balance per IUA in the Olifants WMA for the ESBC scenario

IUA	Catchment	A *Water User Requirements (million m^3/a)	B Yield (million m^3/a)	EWR (million m^3/a)	D Water Balance (million m^3/a)
1	Upper Olifants River catchment	122	87	22.5	(35)
2	Wilge River catchment area	45	71.5	57.8	26.5
3	Selons River area including Loskop Dam	46	192	108.9	146
4	Elands River catchment area	16	45.7	10.8	29.7
5	Middle Olifants up to Flag Boshielo Dam	249	76	92.3	(173)
6	Steelpoort River catchment	42	119	26	77
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	13	10	124.2	(3)
8	Spekboom catchment	37	124.6	34.1	87.6
9	Ohrigstad River catchment area	49	30	17.3	(19)
10	Lower Olifants	141	159	315	18
11	Ga-Selati River area	32	10	18.1	(22)
12	Lower Olifants within Kruger National Park	63	59	**269.7#**	(4)
13	Blyde River catchment area	18	0	114.8	(18)
	TOTAL	**873**	**983.8**		**110.8**
OLIFANTS WMA WATER BALANCE (Volume of water required to meet the EWR - – flow at IUA 12#)		**Column B – (A + 269.7)**			**(159)** (deficit)

*Water user requirements includes that of the irrigation, domestic, industrial, mining, power generation and forestry sectors within the Olifants WMA.

#IUA 12 is the most downstream IUA in the WMA and 269.7 million m^3/a is the total volume required in the lower reaches of the Olifants River to maintain an ecological logical category of C before it reaches Mozambique.

The yield analysis indicates that IUAs 1, 5, 7, 9, 11, 12 and 13 have a water deficit with the implementation of the ESBC scenario.

The simulation also highlights that there are surpluses in some of the IUAs. These surpluses are used to support the deficits in the downstream IUAs. For instance the surplus in IUA 3, Selons River area including Loskop Dam, is the water available from Loskop Dam which is used to supply the irrigation requirements in Middle Olifants up to Flag Boshielo Dam IUA (IUA 5). The overall balance shows that the Olifants WMA has a deficit of 159 million m^3/a.

The reconciliation strategy identified a number of interventions to achieve a balance in the Olifants WMA. The interventions included:

- Removal of alien vegetation and unlawful water use;
- Water conservation and demand management in urban and irrigated areas;
- Compulsory licensing;
- Development of groundwater resources;
- Trading water rights;
- Transfer of water into the Olifants WMA from the Vaal River System;
- Transfer of treated sewage effluent from the Apies-Pienaars River;
- Construction of further dams on the Olifants; and
- Use of excess mine water.

A feasibility study has not yet been undertaken to compare the interventions so that a go forward option can be selected. This level of analysis is not part of the scope of the Olifants Classification Study. For the purpose of this study, above listed reconciliation water supply options will be used to meet the water deficit. The marginal costs per option as outlined in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) will be used as input to the economic analysis.

6 THE ALTERNATE CATCHMENT CONFIGURATION SCENARIOS

Having established the ESBC (detailed above), the classification process requires that additional catchment scenarios are configured for the IUAs within the WMA to assess the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible and achievable in terms of a MC.

At the study Project Steering Committee of 08 November 2011 and the subsequent Technical Task Group meeting of 31 January 2012, the stakeholders in the WMA confirmed acceptance of the ESBC scenario (Scenario 1) and proposed the following additional catchment scenarios to be evaluated for the Olifants WMA as part of the scenario analysis:

- **Scenario 2**: RDM Scenario (Recommended ecological categories) with 2010 water requirements;
- **Scenario 3**: Maximum Use Scenario (Ecological category of D throughout the system- Class III) with 2010 water requirements;
- **Scenario 4**: ESBC scenario (PES scenario) with 2035 high water requirements; and
- **Scenarios 5**: Scenario 2 with 2035 high water requirements.

The catchment configuration scenarios to be assessed are listed in Table 11.

Table 11: Alternate catchment configuration scenarios

Scenario	Water Requirements	EWR
2	2010 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows
3	2010 Water Requirements as per Reconciliation Strategy	Class III throughout the system (EWR D Category)
4	2035 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
5	2035 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows

The catchment configuration scenarios listed above will be assessed as the starter scenarios as part the evaluation step (Task 5) of the process to determine their social, economic and ecological implications to the Olifants WMA. These various configurations will be investigated the consequences of each will be communicated to stakeholders in the WMA to facilitate the decision making process on the recommended scenario.

7 CONCLUSIONS

The ESBC scenario (Scenario 1) was established using the PES of the water resources as the base ecological category. The results of the yield analysis of the ESBC scenario indicates that the water balance of the Olifants WMA will be in deficit by 159 million m^3/a by the implementation of this configuration.

This configuration of ecological categories (PES) ensures that a sustainable level of ecosystem functioning is maintained in the Olifants WMA (current water use scenario). The ESBC does provide a sustainable level of protection, and is adequate to form the basis for the assessment of other scenarios.

Consideration of any lower ecological categories (all D categories) although reducing the water deficit, it will result in a deterioration in the PES. Consideration of all other higher ecological categories and catchment configurations scenarios will result in a larger water deficit in the Olifants WMA. The water resource system would have to provide for the required volume of water needed to maintain the various scenario configurations. The evaluation going forward will therefore require a decision on the interventions required to achieve this reconciliation. For this study the interventions identified in the Reconciliation Strategy will be assessed. The costs of the options will be included in the socio-economic assessment.

Step 5 of the WRCS process will interrogate these aspects as part of the evaluation of the scenarios. The consultation process that follows with stakeholders will then provide direction on the recommended scenario and proposed classes that this configuration will translate into.

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APPENDIX A

FRESHWATER ECOSYSTEM PRIORITY AREAS (FEPAS) IN THE OLIFANTS WMA

List of FEPAs in the Olifants WMA with associated sub-node PES

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
1	289	FEPA: Fish sp	Hydrocynus vittatus	B73J	A
2	292	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B71C	B
	292	FEPA: Fish sp	Barbus lineomaculatus	B71C	B
	292	FEPA: Fish sp	Opsaridium peringueyi	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B71C	B
	292	FEPA: Wetland ecosystem type	Lowveld Group 7_Channelled valley-bottom wetland	B71C	B
3	309	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lowland river	B52F/B52G	C
	309	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B52F/B52G	C
	309	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Channelled valley-bottom wetland	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Unchannelled valley-bottom wetland	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 7_Floodplain wetland	B52F/B52G	C
4	313	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Mountain stream	B51F	C
	313	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Upper foothill	B51F	C
5	315	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B52J	C
6	317	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Upper foothill	B51F	C
7	320	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B52J	C
	320	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B52J	C
8	323	FEPA: Fish sp	Hydrocynus vittatus	B73J	A
	323	FEPA: Number of wetland clusters	1 WetCluster FEPA	B73J	A
	323	FEPA: River ecosystem type	Ephemeral - Lebombo Uplands - Lower foothill	B73J	A
	323	FEPA: River ecosystem type	Ephemeral - Lebombo Uplands - Upper foothill	B73J	A

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	323	FEPA: Wetland ecosystem type	Lowveld Group 4_Depression	B73J	A
9	347	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B52J	C
	347	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B52J	C
10	361	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	361	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	361	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
11	367	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	367	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	367	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
12	368	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	368	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	368	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
13	378	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B71D	B
	378	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B71D	B
14	381	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	381	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	381	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
15	391	FEPA: River ecosystem type	Ephemeral - Lowveld - Lower foothill	B73F	B
	391	FEPA: River ecosystem type	Ephemeral - Lowveld - Upper foothill	B73F	B
16	404	FEPA: Fish sp	Hydrocynus vittatus	B73G	B
	404	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B73G	B
17	424	FEPA: Fish sp	Barbus lineomaculatus	B60J	B
	424	FEPA: Fish sp	Opsaridium peringueyi	B60J	B
	424	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B60J	B
	424	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B60J	B
18	444	FEPA: Fish sp	Barbus lineomaculatus	B60J	B
	444	FEPA: Fish sp	Opsaridium peringueyi	B60J	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B60J	B
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Mountain stream	B60J	B
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B60J	B
19	461	FEPA: Fish sp	Opsaridium peringueyi	B73A	B/C
	461	FEPA: Number of wetland clusters	1 WetCluster FEPA	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Mountain stream	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Channelled valley-bottom wetland	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Depression	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Flat	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Seep	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Unchannelled valley-bottom wetland	B73A	B/C
20	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Lower foothill	B41K	D
	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B41K	D
	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B41K	D
21	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Lower foothill	B51B	B
	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Mountain stream	B51B	B
	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Upper foothill	B51B	B
22	525	FEPA: Fish sp	Barbus lineomaculatus	B60D	B
	525	FEPA: Fish sp	Opsaridium peringueyi	B60D	B
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60D	B
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60D	B
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60D	B
23	566	FEPA: Fish sp	Barbus anoplus	B60B	B
	566	FEPA: Fish sp	Barbus lineomaculatus	B60B	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	566	FEPA: Fish sp	Barbus treurensis	B60B	B
	566	FEPA: Fish sp	Opsaridium peringueyi	B60B	B
	566	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Channelled valley-bottom wetland	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Depression	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Unchannelled valley-bottom wetland	B60B	B
24	581	FEPA: Fish sp	Barbus anoplus	B60C	B
	581	FEPA: Fish sp	Barbus lineomaculatus	B60C	B
	581	FEPA: Fish sp	Barbus treurensis	B60C	B
	581	FEPA: Fish sp	Opsaridium peringueyi	B60C	B
	581	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60C	B
	581	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Channelled valley-bottom wetland	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Flat	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Seep	B60C	B
25	626	FEPA: Fish sp	Barbus lineomaculatus	B41J	D
	626	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B41J	D
	626	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41J	D
26	650	FEPA: Fish sp	Barbus anoplus	B60B	B
	650	FEPA: Fish sp	Barbus lineomaculatus	B60B	B
	650	FEPA: Fish sp	Barbus treurensis	B60B	B
	650	FEPA: Fish sp	Opsaridium peringueyi	B60B	B
	650	FEPA: Number of wetland clusters	1 WetCluster FEPA	B60B	B
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60B	B
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains -	B60B	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
			Mountain stream		
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Depression	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Flat	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Seep	B60B	B
27	653	FEPA: Fish sp	Amphilius natalensis	B60A	C
	653	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B60A	C
	653	FEPA: Fish sp	Barbus anoplus	B60A	C
	653	FEPA: Fish sp	Barbus lineomaculatus	B60A	C
	653	FEPA: Fish sp	Barbus treurensis	B60A	C
	653	FEPA: Fish sp	Opsaridium peringueyi	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60A	C
28	667	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B60E/B60F	C
	667	FEPA: Fish sp	Barbus lineomaculatus	B60E/B60F	C
	667	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B60E/B60F	C
	667	FEPA: Fish sp	Opsaridium peringueyi	B60E/B60F	C
	667	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60E/B60F	C
	667	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60E/B60F	C
29	674	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	674	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	674	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
30	685	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	685	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41G	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
	685	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Channelled valley-bottom wetland	B41G	B
	685	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41G	B
31	699	FEPA: Fish sp	Opsaridium peringueyi	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	C
32	705	FEPA: Fish sp	Barbus lineomaculatus	B42D/E	C
	705	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	705	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42D/E	C
	705	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42D/E	C
33	721	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
34	725	FEPA: Fish sp	Barbus lineomaculatus	B42D/E	C
	725	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	725	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42D/E	C
	725	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42D/E	C
35	726	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	726	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	726	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
36	734	FEPA: Fish sp	Barbus anoplus	B42G	B
	734	FEPA: Fish sp	Barbus lineomaculatus	B42G	B
	734	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42G	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	734	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42G	B
37	743	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32F	C
	743	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32F	C
38	762	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B42D/E	C
39	777	FEPA: Fish sp	Opsaridium peringueyi	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41D	C
40	788	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	788	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B42D/E	C
	788	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B42D/E	C
41	848	FEPA: Fish sp	Barbus anoplus	B41F	B
	848	FEPA: Fish sp	Opsaridium peringueyi	B41F	B
	848	FEPA: Number of wetland clusters	2 WetCluster FEPAs	B41F	B
	848	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	B
	848	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Depression	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Seep	B41F	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Valleyhead seep	B41F	B
42	851	FEPA: Fish sp	Opsaridium peringueyi	B41F	B
	851	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Depression	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Seep	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Valleyhead seep	B41F	B
43	862	FEPA: Fish sp	Opsaridium peringueyi	B41C	C
	862	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B41C	C
	862	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41C	C
44	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lowland river	B32H	D
	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32H	D
	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32H	D
45	905	FEPA: Fish sp	Barbus anoplus	B41B	D
	905	FEPA: Fish sp	Opsaridium peringueyi	B41B	D
	905	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41B	D
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41B	D

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41B	D
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Unchannelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41B	D
46	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lower foothill	B32A	B
	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32A	B
	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32A	B
47	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41A	C
	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41A	C
	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41A	C
48	1005	FEPA: Fish sp	Opsaridium peringueyi	B41A	C
	1005	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41A	C
	1005	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lower foothill	B41A	C
	1005	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Unchannelled valley-bottom wetland	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Valleyhead seep	B41A	C

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
49	1047	FEPA: Fish sp	Barbus anoplus	B41A	C
	1047	FEPA: Fish sp	Opsaridium peringueyi	B41A	C
	1047	FEPA: River ecosystem type	Permanent/Seasonal - Highveld - Mountain stream	B41A	C
	1047	FEPA: River ecosystem type	Permanent/Seasonal - Highveld - Upper foothill	B41A	C
Higher ecological protection included in ESBC scenario as required by FEPA					

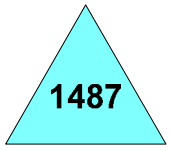
APPENDIX B

OLIFANTS RIVER SYSTEM YIELD MODEL SCHEMATICS

Yield model system schematics:

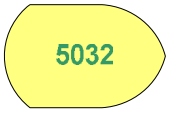
Key:

Nodes

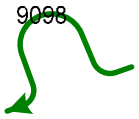


Dams

Inflow from catchment

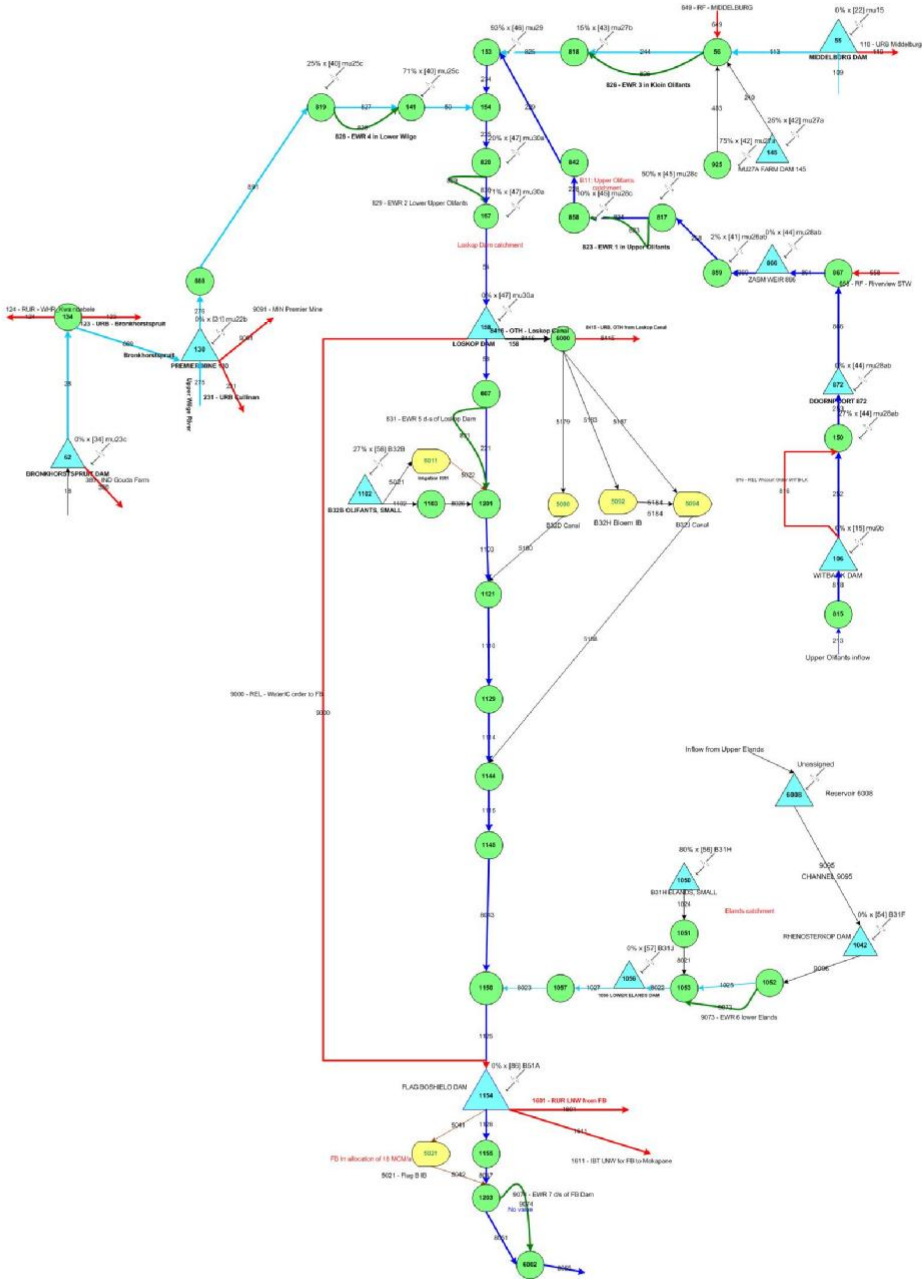


Irrigation



EWR

Yield Model System Schematic for IUAs 1 to 5



Yield Model System Schematic for IUAs 6 to 13