DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE MIDDLE VAAL WATER MANAGEMENT AREA

WP10534

SUB-COMPONENT PRIORITISATION AND INDICATOR REPORT

REPORT NO.: RDM/WMA09/00/CON/RQO/0114

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EXECUTIVE SUMMARY

The Chief Directorate: Resource Directed Measures (RDM) has initiated the development of Resource Quality Objectives (RQO) for the Middle Vaal Water Management Area. The purpose of this study is to implement the RQO determination procedures in the Middle Vaal WMA and in so doing determine the RQOs of the significant resources for presentation to the delegated authority. It is recognised that the process of RQO determination of water resources requires a strongly driven stakeholder engagement and communication component supported and guided by the necessary technical and institutional components.

Establishment of RQOs is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RQOs are defined by the National Water Act as “clear goals relating to the quality of the relevant water resources” (DWAF, 2006). RQOs are descriptive or quantitative, spatial or temporal, and ultimately allows realisation of the catchment vision by giving effect through the gazetting process.

As part of the RQO process the Step 4 of the RQO development process, required the selection of components and the identification of proposed sub-components and indicators for which RQOs should be formulated for water resources within the prioritised resource units of the Middle Vaal WMA.

The step has two key objectives, firstly to identify and prioritise sub-components (viz. habitat, quantity, quality, biota) that maybe important to users or the environment; and secondly to select those sub-components and associated indicators (e.g. flow, salinity, fish, invertebrates etc) for which RQOs and numerical limits should be developed.

There are wide range of sub-components and indicators for which RQOs can be set however it is not practical or necessary to set RQOs for all sub-components in a resource unit. A rationalisation process is required to evaluate and prioritise the sub-components for RQO determination. The process is supported by a decision support tool – the ‘Resource Unit Evaluation Tool’. The application of the tool and this step of the RQO development process bears particular relevance to consideration of impacts and land based activities on the water resources of the Middle Vaal (the threat posed) and to identify which sub-components should be protected to support activities, maintain integrity and ecological functioning.

The Resource Unit Evaluation Tool was applied in the Middle Vaal WMA for rivers and dams using desktop information, local knowledge and detailed understanding of the catchment. The assessment was undertaken in a workshop environment with technical specialists, catchment managers and key stakeholders. The overall priority ratings obtained through application of the RU Evaluation Tool was used to guide the selection of sub-components for RQO determination. Once the sub-components were selected, suitable indicators for monitoring were then identified. The rankings and scorings of the evaluation provided an indication of the priority sub-components. Based on this and expert judgement and knowledge the priority sub-components were selected. The process and outcome of the evaluation assessment and prioritisation per resource unit has been captured in an evaluation information sheet. As part of the process the direction of change of the sub-components were also evaluated. Sub-components for wetlands and groundwater were also selected through independent approaches based on assessment and evaluation of relevant aspects.

The list of sub-components, indicators selected for monitoring and the rationale for consideration (where applicable) for the rivers, dams, wetlands and groundwater in the Middle Vaal WMA are

documented in this report. This prioritisation will form the basis for development of RQOs and numerical limits.

LIST OF ABBREVIATIONS AND ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
Ecospec	Ecological specification
EIS	Ecological importance and sensitivity
EWR	Ecological Water Requirements
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
KOSH	Klerksdorp-Orkney-Stillfontein-Hartebeesfontein
MC	Management Class
NGwQlMP	National Groundwater Quality Monitoring Program
NSBA	National Spatial Biodiversity Assessment
NWA	National Water Act
PES	Presentation Ecological State
RDM	Resource Directed Measures
RQOs	Resource Quality Objectives
RUs	Resource Units
Userspec	User specification
WMA	Water Management Area
WRC	Water Resource Classification

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1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Resource Directed Measures (RDM) has initiated the development of Resource Quality Objectives (RQO) for the Middle Vaal Water Management Area. The purpose of this study is to implement the RQO determination procedures in the Middle Vaal WMA and in so doing determine the RQOs of the significant resources. A resource quality objective has to be determined for a significant water resource, as the means to ensure a desired level of protection. The purpose of the RQOs is to provide limits or boundaries from which it can be deduced whether the resource is being stressed by existing management practices or not.

In determining the RQOs, it is important to recognise that different water resources will require different levels of protection. In addition to achieving the water resource management class, the process will allow due of the consideration of the social and economic needs of competing interests by all who rely on the water resources.

In terms of the National Water Act (NWA) (Act 36 of 1998), the RQO's are based on the Management Class may relate to the following:

- Reserve;
- in-stream flow;
- in-stream and riparian habitat quality;
- water level;
- presence and concentration of substances in the water;
- characteristics and quality of water resource;
- characteristics and distribution of aquatic biota; and
- regulation of in-stream or land-based activities affecting water quality.

The setting of the RQOs is best carried out through establishing a vision for the WMA. The RQOs for the different water resources within the WMA are then established as management tools towards achieving the overall vision.

The RQOs encompass four sub-components of the resource quality:

- Water quantity;
- Water quality;
- Habitat integrity; and
- Biotic characteristics.

RQOs may be descriptive or quantitative and may account for quality over time and/or distance.

As part of the RQO process the first step was to delineate the units of analysis and define Resource Units (RUs). Each integrated unit of analysis (IUA) represents a homogenous catchment area of similar impacts which must be considered in the determination of RQOs. A RU on the other hand is a section of a water resource within an IUA that is sufficiently ecologically distinct to warrant its own specification. The IUA delineation of the Middle Vaal WMA was done as

part of the water resource classification process, through which 8 IUAs have been delineated. The IUAs delineated form the basis for the RQO determination process. Through this study the resource units for the water resources in Middle Vaal WMA were delineated and prioritised. In terms of the various components and considerations assessed for RU delineation and prioritisation and based on the understanding and expert knowledge of the Middle Vaal WMA, the results of the delineation and prioritisation process are as follows:

- Thirty one surface water resource RUs were delineated and 28 have been prioritised;
- Six dam RUs were delineated and prioritised;
- Three groundwater priority areas were identified (Dolomite aquifer systems) however the selection of the units for groundwater RQO determination are still to be confirmed;
- The general groundwater areas have been described (Ventersdorp/Karoo Aquifer systems)
- Fifty wetlands/wetland clusters have been prioritised in the WMA.

The next step of the RQO determination process is to prioritise sub-components for RQO determination and select indicators for monitoring (Figure 1).

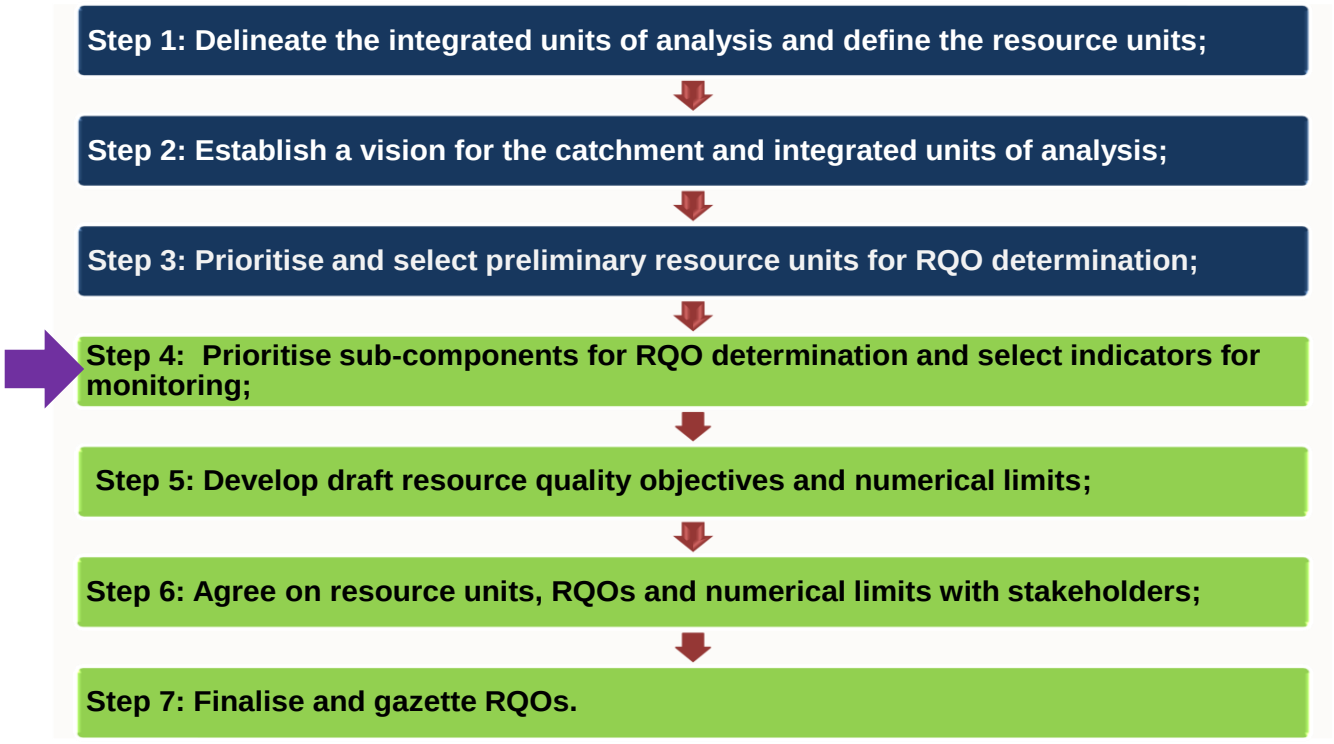

Figure 1: RQO determination process

1.2 STUDY AREA

The study area for the RQO study is the Middle Vaal WMA (WMA 9) which constitutes the middle portion of the Vaal River (Figure 2). The Middle Vaal WMA is part of the integrated Vaal River System and falls within the C drainage region of South Africa. The Middle Vaal WMA covers a catchment area of 52 563 km^2, and includes parts of the Free State and North-West Provinces. The Vaal River is the only main river in the WMA. It flows in a westerly direction from the Upper Vaal WMA, to be joined by the Koekemoerspruit, Skoonspruit, Rhenoster, Vals and Vet rivers as main tributaries, before flowing into the Lower Vaal WMA and then into the Orange River..

There are several dams that have been developed *viz.* Bloemhof Dam on the Vaal River, Allemanskraal Dam on the Sand River, Erfenis Dam on the Vet River, and Koppies Dam in the Renoster River.

Present land use in the WMA is characterised by gold mining, extensive dry land cultivation, particularly in the central parts. Irrigation is practised downstream of dams along the main tributaries as well as at locations along the Vaal River. The remainder of the WMA is natural grassland used for livestock farming. The economy in the WMA is mainly based on mining and agriculture as primary production sectors. The largest urban areas are Klerksdorp, Welkom and Kroonstad.

The Middle Vaal WMA comprises eight sub-catchments as listed in Table 1. The WMA consists of the C24, C25, C41, C42, C43, C60 and C70 tertiary catchments (Figure 2).

Table 1: Sub-catchments and related quaternary drainage regions within the Middle Vaal WMA

Primary Catchment	Sub-Catchment Areas	Quartenary Catchments	Average Gross Area (km^2)
C	Renoster	C70A-K	6656
	Vals	C60A-J	7871
	Schoon Spruit	C24C-G	5644
	Middle Vaal	C24A-B, C24H-J, C25A-C	8281
	Bloemhof	C25D-F	4959
	Allemanskraal	C42A-E	3628
	Erfenis	C41A-E	4724
	Sand	C42F-L	3927
	Vet	C41F-J, C43A-D	6873

The Middle Vaal WMA's water quality and flow is mainly controlled by activities that take place in the Upper Vaal WMA. The Middle Vaal WMA is dependent on the Upper Vaal WMA for meeting the bulk water requirements of its mining, industrial and urban sectors. Large quantities of water are transferred into the WMA to augment local water resources. These upstream activities include releases from the Vaal Dam and Vaal River Barrage, waste water treatment works discharges, urban runoff and gold mining activities on the Witwatersrand. In the Middle Vaal WMA discharges and decants from gold mining activities in the Mooi and Koekemoer Spruits have an impact on the continued salinity build up in the Vaal River. These impacts are subject to many catchment studies.

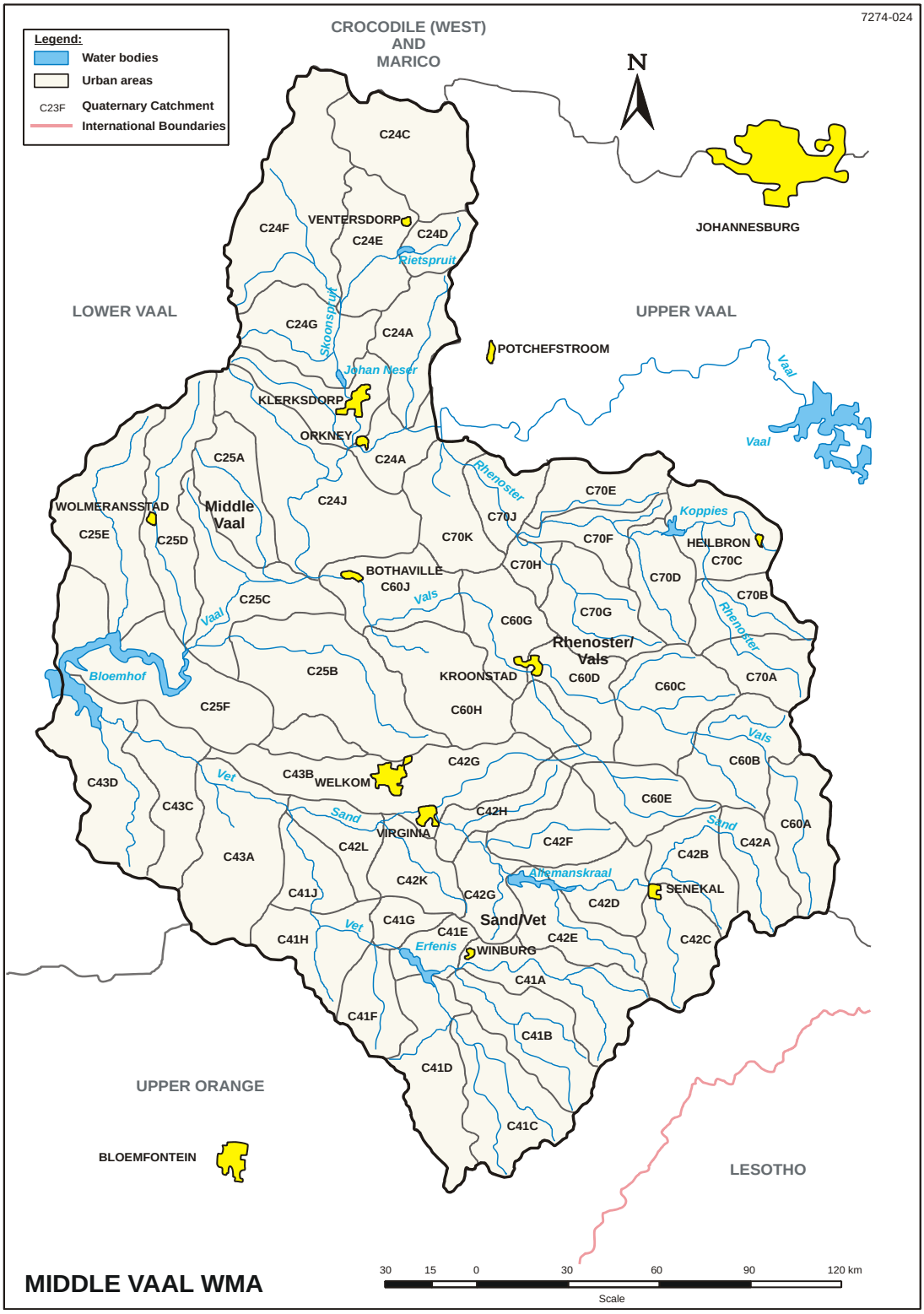

Figure 2: General layout of the Middle Vaal WMA

Management of water quality and quantity in the Middle Vaal WMA is therefore integrally linked to both the Upper and Lower Vaal WMAs. Water quality issues of concern in the Middle Vaal WMA are related to salinity, eutrophication and public health. The closure of mines may have further water quality impacts. High concentrations of TDS have been identified in the Middle Vaal River

which is impacting on water use in the catchment. Eutrophication as the other key water quality problem in the Middle Vaal River is highlighted by the hypertrophic status of the middle reaches of the Vaal River from the Vaal Barrage to Bloemhof Dam.

Two dolomite aquifer systems, the Ventersdorp-Grootpan DWA and the Klerksdorp-Orkney-Stillfontein-Hartebeesfontein (KOSH), are present in the upper reaches of the Schoonspruit and Mid Vaal sub-catchments (*viz*, C24C, C24E, C24F and C24A and C24B). These dolomite water resources are extensively used for irrigation (Schoonspruit groundwater and surface water systems) and impacted by mining activities in the KOSH area. Several studies have reviewed the status of these systems pre-2004; although recent impacts due to drought conditions and mining activities may not be well incorporated into the total hydrological context. Groundwater in the remaining part of the Mid Vaal Catchment is related to Karoo type aquifer systems which may have been impacted on a localized scale due to poor management of the quantities and qualities.

1.3 PRIORITISATION OF SUB-COMPONENTS AND SELECTION OF INDICATORS SUB-TASK

The selection of components and the identification of proposed sub-components and indicators for which RQOs forms part of Task 4 of the RQO determination process. The step has two key objectives, firstly to identify and prioritise sub-components (*viz.* habitat, quantity, quality, biota) that maybe important to users or the environment; and secondly to select those sub-components and associated indicators (e.g. flow, salinity, fish, invertebrates etc) for which RQOs and numerical limits should be developed.

In this study RQOs for rivers, groundwater, dams and wetland resources will be determined. To generate RQOs for these resources the existing seven step procedure methodology available from DWA (2011) has been expanded on to include dam and wetland methodologies.

There are wide range of sub-components and indicators for which RQOs can be set however it is not practical or necessary to set RQOs for all sub-components in a resource unit. A rationalisation process is required to evaluate and prioritise the sub-components for RQO determination. The process is supported by a decision support tool – the 'Resource Unit Evaluation Tool'. The application of the tool and this step of the RQO development process bears particular relevance to consideration of impacts and land based activities on the water resources of the Middle Vaal (the threat posed) and to identify which sub-components should be protected to support activities, maintain integrity and ecological functioning.

This report details the process of prioritising sub-components for RQO determination and selection of indicators for monitoring.

2 DELINEATION OF THE INTEGRATED UNITS OF ANALYSIS (IUAS)

The Water Resource Classification (WRC) and the confirmation of the Ecological Reserve for the Middle Vaal WMA were completed in 2012. Through this study the IUAs for the WMA were delineated and the EWR sites and river nodes were specified. These outputs form the classification study form the basis for the RQO determination process, and primarily for the RU definition.

In terms of the Middle Vaal WRC study, eight IUAs were delineated (DWA, 2012). These are listed in Table 2 and shown in Figure 3. The IUAs form the boundaries for RU delineation. A biophysical node may encompass one or more RUs. A biophysical node is an outcome of the classification process at which a desired ecological category (nested ecological category) for each river reach upstream of the node has been provided.

Table 2: IUAs delineated for the Middle Vaal WMA

IUA (Middle Vaal)	Catchment area	Quaternary catchment
MA	Renoster River	C70A – C70K
MB	Vals River	C60A-C60J
MC	Schoonspruit River	C24C – C24H and C24 A
MD1	Upper Sand River	C42A – C42E
MD2	Lower Sand River	C42F- C42L
ME1	Upper Vet River	C41A – C41E
ME2	Lower Vet River	C41F – C41J and C43A – C43D
MF	Vaal River from Renoster confluence to Bloemhof Dam	C24B, C24J, C25A –C25F

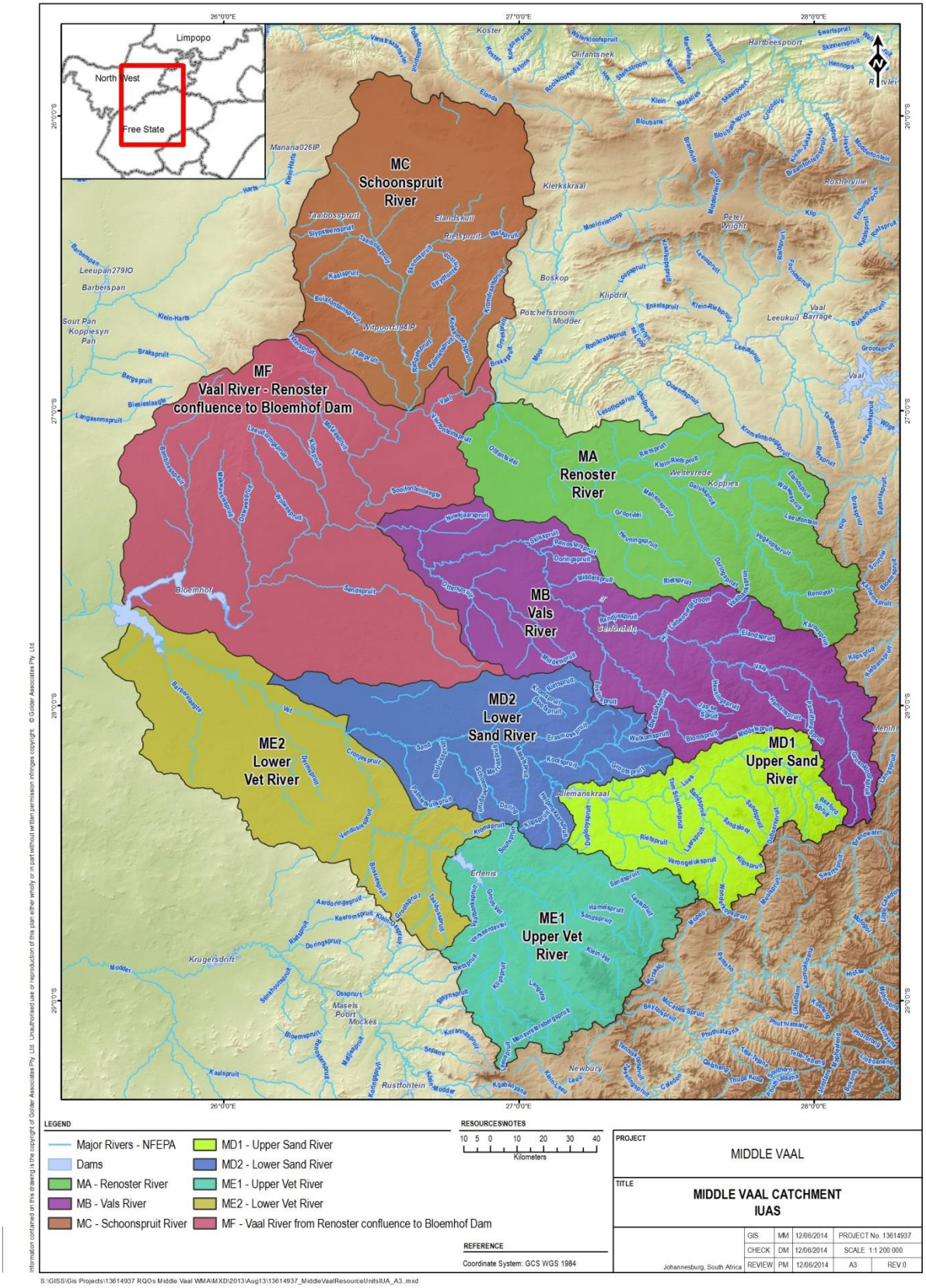

Figure 3: IUAs delineated in the Middle Vaal WMA

3 RESOURCE UNITS

The process followed in terms of IUA delineation and prioritisation was that described in the RQO Determination Guideline (DWA, February 2011). Delineation and prioritisation of RUs is required as it would not be appropriate to set the same RQOs for all water resources in a catchment.

Thirty one river and six dam RUs in the Middle Vaal WMA have been delineated. The RUs are shown in Figure 4 below and listed Table 3.

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

Based on the priority ratings obtained through application of the RU prioritisation tool, these rankings and weightings were used to select the priority RUs for RQO determination. The evaluation of the RU priority ratings for selection were done at a desktop level and discussed and confirmed at the stakeholder engagement workshops for the Middle Vaal WMA RQO study held in Klerksdorp and Welkom over 25 and 26 September 2013 respectively. The scores for all criteria are combined into a priority rating which scores the RUs relative to each other. This provides an integrated measure to inform the selection of RU.

Thirty one surface water resource RUs were delineated and 28 have been prioritised; six dam RUs were delineated and prioritised; three groundwater priority areas were prioritised (Dolomite aquifer systems). The general groundwater areas have been described (Ventersdorp/Karoo Aquifer systems) and fifty wetlands/wetland clusters have been prioritised in the WMA. The results are tabulated in Table 3 below and shown in Figure 6 and Figure 7.

Based on the evaluation process twenty eight river RUs and six dam RUs were prioritised. These are shown in Figure 5. Three RUs were not selected. These include the most upstream catchments (headwaters) in the Renoster River catchment (R1), Vals River catchment (V1) and Upper Sand catchment (US1).

Table 3: RUs Delineated for the Middle Vaal WMA

RU	Delineation	Quartenary Catchment
IUA 8: VAAL RIVER		
VB1.1	Vaal River mainstem: Vermaasdrift to upstream Schoon spruit confluence	C24B
VB1.2	Vaal River mainstem: From the Schoonspruit confluence to just upstream Vals River confluence	C24J
VB1.3	Vaal River mainstem: From Vals River confluence to Bloemhof Dam	C25C, C25F
VB2	Tributary catchments (Vierfonteinspruit and 24J –south of Vaal River)	C24B, C24J
VB3	Ysterspruit, Matjiespruit, Klipspruit, Wolwespruit and Makwassiespruit tributary catchments	C24J, C25A, C25C, C25D
VB4	Sandspruit tributary catchment	C25C, C25B, C25F, C43B
VB5	Bamboespruit tributary catchment	C25E
VB6	Bloemhof Dam	C25E, C25F, C43D
TRIBUTARIES		
IUA 1: RENOSTER RIVER		
R1*	From origin to Vaalbankspruit and Vegkopspruit tributary confluences	C70A, C70B
R2	Downstream Vaalbankspruit tributary confluences to Koppies Dam	C70C
R3	Koppies Dam	C70C
R4	Downstream Koppies Dam to confluence with the Heuningspruit	C70E, C70D, C70F, C70G, C70H
R5	Downstream Heuningspruit confluence to confluence with the Vaal River	C70J, C70K
IUA 2: VALS RIVER		
V1*	Origin of Vals River to Pauciflora Spruit confluence	C60A
V2	Downstream Pauciflor Spruit confluence to Kroonstad	C60B, C60C, C60D, C60E, C60F
V3	Serfontein Dam	C60D
V4	Middelspruit tributary catchment	C60H
V5	From the Kroonval weir to the Vaal River confluence	C60G, C60J
IUA 3: SCHOONSPRUIT		
SK1	From origin of Koekemoerspruit to confluence with Vaal River	C24A, C24B
SK2	Schoonspruit eye	C24C
SK3	Taaibospruit tributary catchment	C24F
SK4	From Schoonspruit eye to Kaalspruit confluence	C24D, C24E
SK5	Kaalspruit and Buisfonteinspruit tributary catchment	C24G
SK6	Johan Neser Dam (Kklerksdorp Dam)	C24G
SK7	From Johan Neser Dam to confluence with the Vaal River	C24H
IUA 4: UPPER SAND RIVER		
US1*	Origin of Sand River to confluence of the Klipspruit	C42A, C42B, C42C
US2	Downstream Klipspruit confluence to Allemanskraal Dam	C42D, C42E
US3	Allemanskraal Dam	C42E
IUA 5: LOWER SAND RIVER		

RU	Delineation	Quartenary Catchment
LS1	Allemanskraal Dam to Merriespruit confluence	C42F, C42G, C42H,
LS2	Rietspruit tributary catchment	C42J
LS3	Downstream Rietspruit confluence to confluence with the Vet River	C42K, C42L, C43B
IUA 6: UPPER VET RIVER		
UV1	Klein Vet and Laaispruit tributary catchments	C41A, C41B
UV2	Origin of Vet River and Leeuspruit tributary catchment to Erfenis Dam	C41C, C41D
UV3	Soutspruit tributary catchment	C41E
UV4	Erfenis Dam	C41E
IU7 : LOWER VET RIVER		
LV1	Erfernis Dam to confluence with Sand River	C41F, C41G, C41H, C41J
LV2	Downstream Sand River confluence to Bloemhof Dam	C43A, C43C, C43D
SELECTED GROUNDWATER PRIORITY UNITS		
Dolimitic RU G1 (RU SK2; SK3)	The demarcation of the quartenary catchment covers the whole dolomite aquifer unit.	C24F, C24C
Dolimitic RU G2 (RU SK3; RU SK4)	The groundwater unit falls within the quartenary catchment boundaries.	C24C, C24F, C24E
Dolimitic RU G3 (RU SK1)	The dolomite aquifer systems fall within the boundaries of the quartenary catchment and can be included in the surface water RU.	C24A, C24B
General: Ventersdorp/Karoo Aquifers	To be included in the RUs as demarcated for the surface water resources	
PRIORITY WETLANDS/WETLAND CLUSTERS		
SK1	Pan	C24A
SK2	Pan cluster to the north of Vetpan and Klippan	C24C
	Vetpan and Klippan	
	Rietpan pan and wetland complex	
	Schoonspruit eye and upper section of the Skoonspruit peatland	
SK3	Grootpan	C24F
	Pan cluster to the north of Coligny	
	Floodplain of the Taaibosspruit	
	Lower Kaalspruit	
	Lower section – floodplain of the Skoonspruit	
SK4	Two pans to the northwest of Ventersdorp	C24D, C24E
	Lower section of the Skoonspruit peatland	
	Skoonspruit wetland system	
SK5	Floodplain of the lower Skoonspruit	C24G
R4	Floodplain of the middle reaches of the Renosterrivier, Heuningspruit, Grootvlei, central and lower reaches of the Mahemspruit, and middle to lower reaches of the Rietspruit	C70E, C70D, C70F, C70G, C70H
	Unchannelled valley bottom wetland of the Rietspruit tributary of the Heuningspruit and a tributary of the Heuningspruit	
R5	Channelled and unchannelled valley bottom wetland adjacent to Viljoenskroon	C70J, C70K
	Unchannelled valley bottom wetland on the farm Roodepoort	

RU	Delineation	Quartenary Catchment
	Northern section of Swartpan	
	Leeupan	
	Vaneedespan	
	Groot Rietpan	
V4	Channelled valley bottom wetland in the middle reaches of the Otterspruit and its tributaries	C60H
	Pan cluster associated with the middle reaches of the Otterspruit	
	Unchannelled valley bottom wetland in a tributary of the Otterspruit	
V5	Valley bottom and hillslope seepage wetlands of Hertzogsvlei	C60G, C60J
	Southern section of Swartpan	
VB4	Upper reaches of the Sandspruit (immediately north of Kutloanong)	C25C, C25B, C25F, C43B
	Pan cluster around Wesselbron including Volstruispan to the north	
	Graspan	
	Mahemspan	
LS3	Ganspan and remaining pans that form the southern part of the Wesselbron pan complex	C42K, C42L, C43B
	Wetland system along the Mahemspruit	
	Flamingo Pan	
	Stinkpan	
	Witpan	
LV2	Brakpan	C43A, C43C, C43D
	Floodplain of the Vetrivier	
	Bultfontein pan and saltworks	
	Pan cluster to the south of Bultfontein	
VB5	Pan cluster along the watershed divide to the west of the Bamboesspruit	C25E
*	Surface water RUs not prioritised	

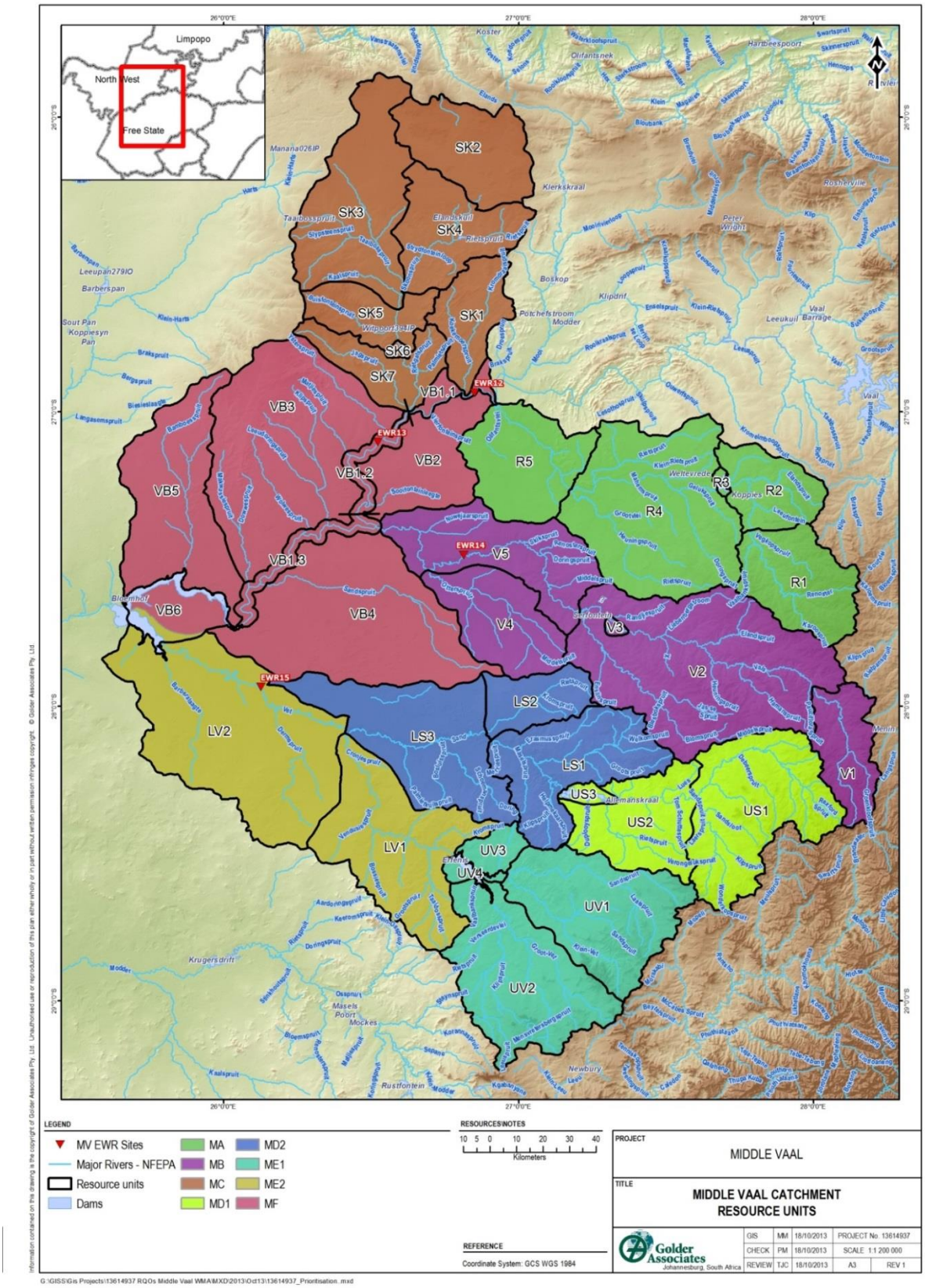

Figure 4: RUs delineated in the Middle Vaal WMA

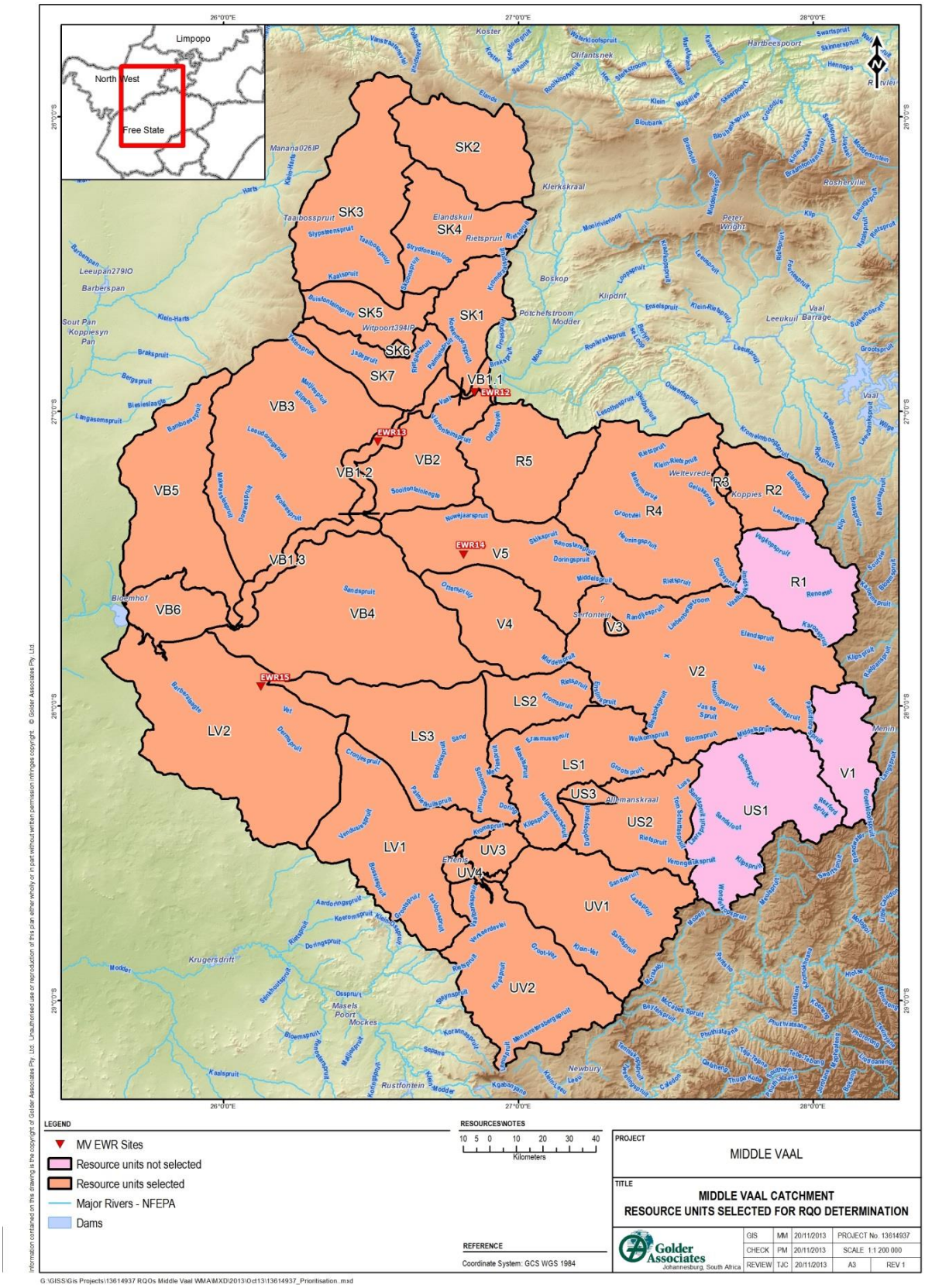

Figure 5: RUs prioritised and selected for RQO determination in the Middle Vaal

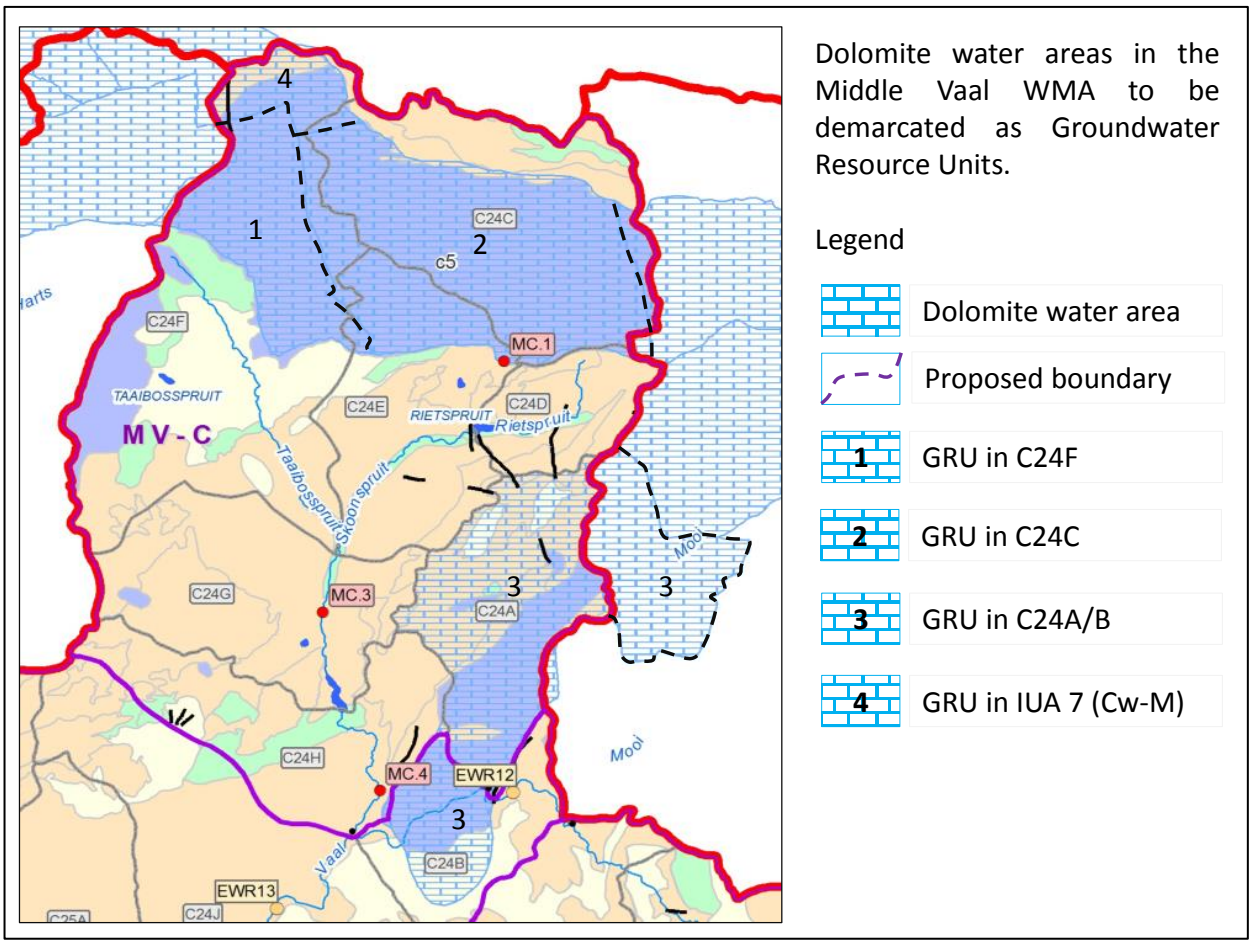

Figure 6: Groundwater priority areas (Dolomitic aquifer systems) identified in the Middle Vaal WMA

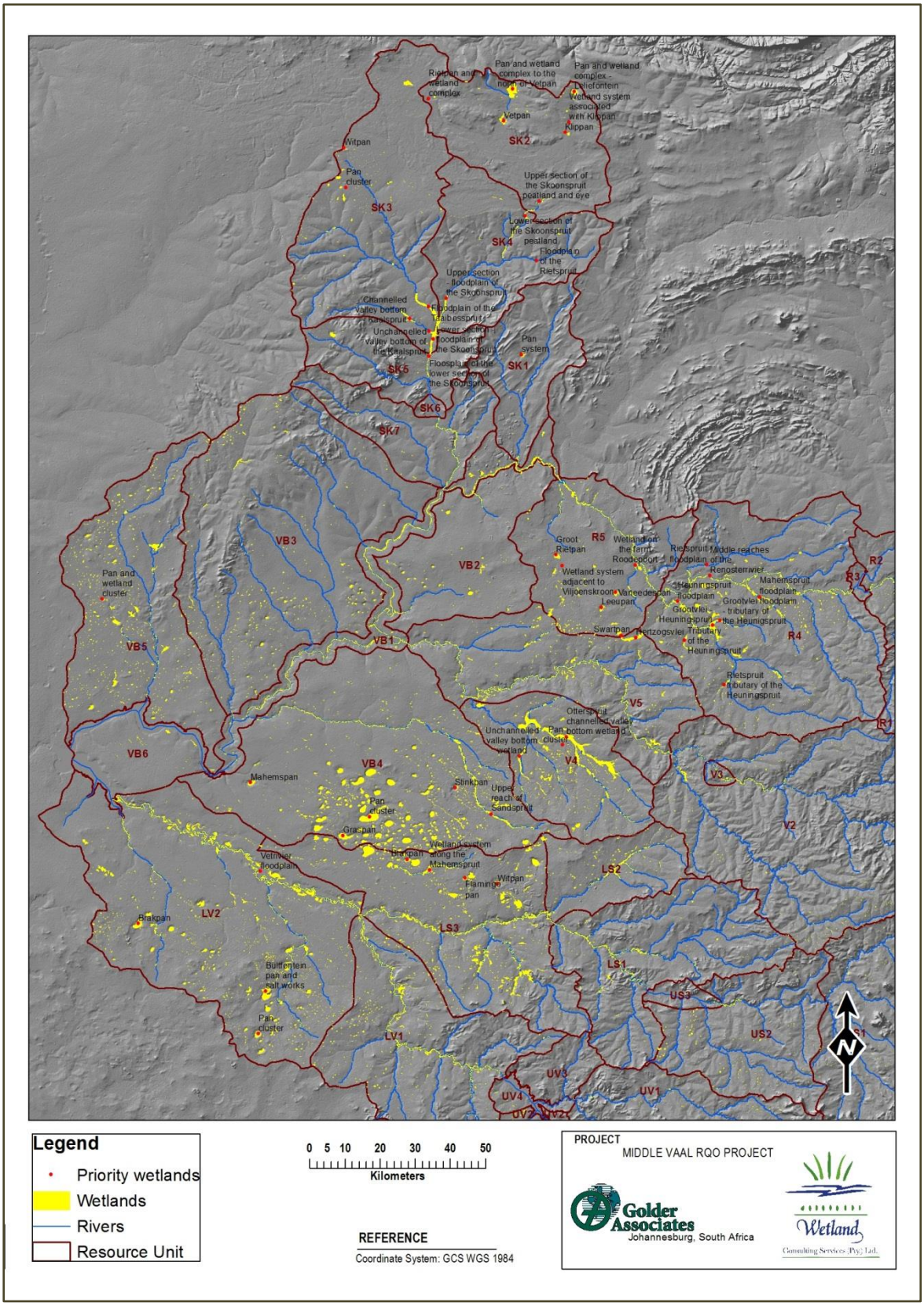

Figure 7: Wetlands/wetland clusters prioritised in the Middle Vaal WMA

4 APPROACH TO PRIORITISATION OF SUB-COMPONENTS AND SELECTION OF INDICATORS

Once the RUs were delineated and prioritised the next step of the RQO determination process was to prioritise sub-components for RQO determination and select indicators for monitoring. This step of the RQO procedure step allows for a process of rationalisation in order to determine what RQOs should be formulated for water resources within the prioritised resource units of the Middle Vaal WMA *i.e.* sub-components that may be important to either the users or the environment are prioritised. This step also requires consideration of the impacts of land based activities on the water resource.

Sub-components include the following:

- Quantity
    - Low Flows
    - High Flows
- Quality
    - Nutrients
    - Salts
    - Systems variables
    - Toxics
    - Pathogens
- Habitat
    - Instream habitat
    - Riparian habitat
- Biota
    - Fish
    - Aquatic and riparian plant species
    - Mammals
    - Birds
    - Amphibians and reptiles
    - Periphyton
    - Aquatic invertebrates
    - Diatoms

The four water resource components addressed for the Middle Vaal WMA included rivers, dams, groundwater and wetland resources.

4.1 River and Dam Component

The rationalisation process for sub-component prioritisation and indicator selection is based on a decision support tool that has been developed to guide and support the process. The 'Resource Unit Evaluation Tool' incorporates decision analyses approach to assess impacting activities, user requirements and protection of the resource.

The four aspects that were assessed/evaluated per RU include:

- Identification and assessment of the impact of current and anticipated future use on water resource components;
- Identification of requirements of important user groups;
- Selection of sub-components for RQO determination; and
- Establishment of the desired direction of change for selected sub-components.

4.1.1 Resource Evaluation Tool

As described above the Resource Evaluation Tool incorporates four aspects that are assessed, rated, scored and weighted to arrive at the prioritised sub-components. The aspects and their sub-steps are described in Table 4 below.

Table 4: Aspects and sub-steps evaluated in Resource Evaluation Tool (DWA, 2011)

Aspect	Sub-step	Consideration/Evaluation
Identify and assess the impact of current and anticipated future use on water resource components: The first aspect in prioritising sub-components for RQO determination involves building an understanding of current impacts and future pressures on the RU using available data and specialist knowledge. This sub-step was undertaken using the 'Impacting activities' worksheet in the river Resource Unit Evaluation Tool	**Assess the importance of activities in driving resource change**	Consideration is given to current users (existing and authorised water use) and anticipated future use (within next 5 years) within and upstream of the RU being evaluated. Those activities which were considered to have a considerable impact are rated as very important users irrespective of their contribution to the economy. The economic contribution of activities was then assessed in terms of their contribution to GDP, the number of jobs that they provide and whether they are a strategic water user. A brief description and rationale for the rating assigned to each user is provided.
	Determine the anticipated level of impact on each sub-component	Each of the listed activities (*e.g.* irrigated agriculture, urban areas, rehabilitation, *etc*.) has the potential to impact the components and sub-components of the water resource in a variety of different ways. The purpose of this sub-step is to identify those sub-components which are threatened as a result of high levels of impact as such sub-components should be prioritised over those sub-components which are experiencing a low level of impact. The assessment was based on the scale, location and intensity of the current and future activities in the Resource Unit and/or catchment.
	Determine the cumulative level of impact on each sub-component	The purpose of this step was to identify the cumulative effect of all of the impacting activities on each sub-component. Cumulative effects are commonly understood as the impacts which combine

Aspect	Sub-step	Consideration/Evaluation
		from different activities and which result in significant change, which is larger than the individual impacts. Based on a review of impact scores, a 'cumulative level of impact' score for each sub-component was selected using the impact rating guidelines. This information was used to automatically determine an Impact Class for each sub-component.
	Determine the anticipated consequences of the impacting activities on each sub-component	Once an understanding of key impacts driving current and future impacts to the RU was assessed, this was used to help inform an assessment of the anticipated consequences of impacting activities on water resource quality. This is expressed as a projected trajectory of change for each sub-component and is informed by the 'cumulative level of impact' score.
Identify requirements of important user groups: The second aspect in prioritising sub-components for RQO determination entails identifying which groups are using the resource, classifying the importance of these groups and determining which sub-components are important to them. This sub-step was undertaken using the 'User requirements' worksheet in the river Resource Unit Evaluation Tool.	**Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types**	The purpose of this sub-step is to identify water users that need to be considered when setting RQOs. The relative importance of user groups was therefore assessed and recorded with a supporting rationale in the river Resource Unit Evaluation Tool.
	Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities	The purpose this sub-step is to determine which sub-components are important and / or of concern to different user groups. This was determined by rating the importance of sub-components for users who were identified as important or very important and was used to calculate an importance score for each sub-component. This helps to highlight sub-components of primary concern to different user groups, thus reflecting aspects of the water resource that they feel need to be closely monitored.
	Summarise the aspirations of each important user group	Opportunity is provided to summarise relevant aspirations of conservation agencies and users dependent on the water resource. In the case of conservation agencies and users dependent on the water resource, stakeholders highlighted specific components or attributes of the water resource which are of concern to them. These aspirations effectively provide a justification for assigning a particular rating or score in the previous importance assessment.
	Review Present State information	In this step the Present State information is documented for each sub-component. This is used to inform the desired direction of change for users. From a protection perspective, this entailed the collection of Present Ecological State information, while for water resource dependent activities, present state was expressed in terms of 'fitness for use'. When completing the information for the 'protection of the water resource' user group, the Ecological Category was first recorded for each sub-component. The 'fitness for use' category for each sub-component for the 'water resource dependent activities' user group was then be recorded. The current trajectory of change for each component was also estimated. This is informed by the assessment of impacting activities but may be over-written based on more reliable

Aspect	Sub-step	Consideration/Evaluation
		information.
	Propose the desired direction and magnitude of change for each sub-component for important user-groups	For 'water resource dependent activities' and organisations responsible for protecting the natural environment, an assessment of the desired direction of change was undertaken to provide an indication of whether stakeholders would like a particular sub-component of the water resource to be improved or whether some level of degradation may be acceptable. Both the importance ratings for each of the sub-components and present state / fitness for use information was used to guide this assessment.
Selection of sub-components for RQO determination: The purpose of this sub-step is to select key sub-components for RQO determination and identify appropriate indicators to monitor them. This sub-step was undertaken using the 'Indicator Selection' worksheet in the Resource Unit Evaluation Tool.	**Review the Ecosystem and User Prioritisation ratings**	Two prioritisation ratings, one for the ecosystem and the other for users, are then automatically calculated. These prioritisation ratings are based on how important a sub-component is from an ecological or user perspective and whether this sub-component is threatened by anthropogenic activities occurring in the catchment. The overall prioritisation ratings range from very low to very high. Very high ratings highlight those sub-components which are both important from an ecological and/or user perspective and which are threatened by anthropogenic activities. Such sub-components are logical choices for RQO determination.
	Select sub-components and associated indicators for RQO determination	The overall priority ratings are used to guide the selection of sub-components for RQO determination. Sub-components with high scores should be selected first. A rationale for selecting each sub-component was provided. Based on the rationale for sub-component selection, the selection of a sub-component as a 'UserSpec', 'EcoSpec' and/or 'Integrated measure' was documented. Once the sub-components were selected, suitable indicators for were identified. This was informed by the Ecosystem and User Prioritisation rating and the rationale for selecting the indicator is also documented.
Establish the desired direction of change for selected sub-components: Once sub-components and relevant indicators were selected, the level at which RQOs will be set are established. This sub-step was undertaken using	**Where applicable, understand the tradeoffs that have been made between user groups in the Water Resource Classification.**	This sub-step requires investigating any decisions made within the Water Resource Classification in order to establish whether decisions have already been made regarding the future management of selected Resource Units. Water Resource Classification was completed for the Middle Vaal WMA in 2013. The RQO process was aligned with the outcomes of the Water Resource Classification.
	Propose an acceptable direction of Change for each selected sub-component	This sub-step requires discussion and consensus seeking regarding an acceptable direction of change. This must be aligned to the Water resource Classification outcomes and is based on the desired and/anticipated magnitude and direction of change in

Aspect	Sub-step	Consideration/Evaluation
the 'Desired Direction of Change' worksheet in the Resource Unit Evaluation Tool.		the present state/fitness for use of each sub-component for each activity type.
	Align outcomes of each resource unit assessment across the catchment	The purpose of this sub-step is align the proposed direction of change and magnitude of change between Resource Units as management decisions affect downstream water resources, and the proposed direction of change of a component in one Resource Unit may impact on the proposed direction of change of a component in a downstream Resource Unit. Any refinement of the direction of change is captured in the Resource Evaluation Tool.

The Resource Unit Evaluation Tool was applied in the Middle Vaal WMA using desktop information, local knowledge and detailed understanding of the catchment. The assessment was undertaken in a workshop environment with technical specialists, catchment managers and key stakeholders (11-12 February 2014). The overall priority ratings obtained through application of the RU Evaluation Tool was used to guide the selection of sub-components for RQO determination. Once the sub-components were selected, suitable indicators for monitoring were then identified. The rankings and scorings of the evaluation provided an indication of the priority sub-components. Based on this and expert judgement and knowledge the priority sub-components were selected. The process and outcome of the evaluation assessment and prioritisation per resource unit has been captured in an evaluation information sheet. As part of the process the direction of change of the sub-components were also evaluated.

Of the 34 prioritised Resource Units (rivers and dams) in the Middle Vaal, prioritisation of the sub-components were completed for 26 Resource Units at the specialist workshop. The remaining 8 Resource Units were not completed due to time constraints. These were Resource Units in the Renoster and Vals IUAs (4 in each IUA). The sub-component prioritisation for the Renoster and Vals IUAs were then completed at a desktop level by the study team with the guidance and comments from stakeholders who attended the sub-component workshop using the Rivers Resource Unit Evaluation Tool.

4.2 Wetlands

Wetlands in the study area provide a range of services including flood attenuation, stream flow regulation, sediment trapping, erosion control and water quality enhancement services. Maintenance and enhancement of wetland functioning is therefore required to ensure that these key ecosystem services necessary to meet societal and environmental requirements are not undermined or lost at a catchment scale. Prioritisation of sub-components was thus based on no net loss' principles, conservation plans, wetland types (inferred functionality) and species targets.

In terms of biota, and particularly avifauna, importantly African Grass-Owl was recorded in a number of the quarter degree squares in the study area during SABAP1. This species and African Marsh-Harrier are two species heavily reliant on wetlands and their adjacent habitat that they provide. Furthermore the recording of Black Harriers in the area is significant as this species is a winter visitor to the region and has been up-listed to Endangered. It requires areas such as the

Middle Vaal region for overwintering. The many pans/depressions in the region serve as important foraging sites for both species of flamingo and also importantly for Palearctic migrants such as sandpipers before they make the long journey back to Eurasia.

The priority wetlands have a host of Red Data bird species as well as containing threatened wetland vegetation types and threatened ecosystems. Only the two Important Bird Areas (IBAs) and a few other small reserves provide formal protection in the entire region. The priority wetlands identified will be vital in supporting populations of rare and endangered species.

The Wetland Evaluation Tool was used to a limited extent to prioritise sub-components. Rather the evaluation and prioritisation of the sub-components focused primarily on the availability of data. For all prioritised wetlands the sub-components Quality, Quantity and Habitat were selected for RQO development. Biota was included as a sub-component where available species data was availability to support RQO development.

Potential sub-components were discussed and selected and then discussed with DWA and key wetland experts at a workshop held on the 20th and 21st of November 2013 to obtain input on the most appropriate approach to be followed. This was done through an integration of the wetland teams from the Upper and Lower Vaal and Olifants studies. The outcomes from the specialist workshops provided the basis for determining ecosystem services in demand, and under threat at an IUA level. The findings of this process informed the development of regional scale RQOs.

4.3 Groundwater

Step 4 of the RQO Process, "Prioritise Sub-Components for RQO Determination and Select Indicators for Monitoring", has not yet been developed for the groundwater component of the water resource.

The following components were thus assessed in order to identify measurable sub-components and indicators for groundwater:

- Hydrogeological characteristics for example difference between a high yielding karst (dolomites) and moderate to low yielding sedimentary (sandstone and shale) groundwater units thus groundwater management units;
- In terms of local aquifer conditions, e.g. interaction with wetlands, surface water sources, a set of algorithms were applied to specify distances between these areas and potential groundwater abstraction points (*i.e*. borehole/well fields);
- Borehole yield classes (GIS information) were used to select high and low yielding aquifer systems within the demarcated groundwater units. Low yielding aquifers are sensitive to high abstractions, such as the Karoo Supergroup aquifers in the WMA;
- Areas where high groundwater use occurs were noted using the National Groundwater Resources Assessment Phase II information. These values were incorporated to define the potential balance between groundwater recharge and use (based on the stress factor) to obtain future groundwater level trends. The idea is to define an annual groundwater level recession value which can be used as a defined parameter for an aquifer's RQO status in terms of yield sustainability. For the dolomite aquifers, a fixed value of 6m total long-term water level drawdown was specified based on long-term monitoring and observations in the Far West Rand area where ground stability problems were noted after a 6m long-term drawdown. This values is applied nationally for dolomite aquifer systems;

- Groundwater quality. This attribute were obtained from the National geo-hydrological Maps; to provide a background water quality criteria and specifically where toxins (nitrates and fluorides) have a negative impact of the water quality criteria. Where the information from the National Groundwater Quality Monitoring Programme (NGwQlMP) was available, groundwater quality trends and limits (i.e. hydro-chemical constituents such as electrical conductivity, pH, the toxins (nitrate and fluoride) were used to specify a baseline water quality which should be used in the water quality trend analyses (RQO specification); and
- It is however important that groundwater monitoring protocols for quality and quantity be set for the WMA – this will provide the baseline status from where RQO's could be evaluated in future.

For the non-dolomite water areas (here referenced as the Ventersdorp and Karoo rock type groundwater units, the RQO's should be based on basic hydrogeological parameters as observed through baseline groundwater information (1: 500 000 Geohydrological Map/Brochure Series) and groundwater time series monitoring information (viz. National Groundwater Quality Monitoring Programme and detailed water level monitoring records by DWA Regional Offices). These aquifers are generally localised and most of them will discharge into the local surface water drainage systems or support local pans/wetlands; otherwise evapotranspiration losses. The interaction between groundwater and surface run-off needs to be acknowledged as well. Most of these aquifer systems are classified as Minor to Insignificant aquifer types due to relative slow transmission of responses (flow and transport) through the groundwater flow paths, and therefore do not require a high level of investigations in terms of RQO determination. It might, however, be necessary to use land use activities, such as stock feedlots, mining/industries and waste & wastewater treatment facilities as indicators for a higher level of RQO indicators where necessary. Sub-components of these groundwater resource units were limited to areas where groundwater/surface water interaction is dominant based on existing information (wetlands studies and DWA surface water monitoring information).

In terms of indicators, only those hydrogeological indicators that can be observed and evaluated through time series monitoring programmes were considered. In terms of aquifer saturation, the following indicators were considered:

- water levels depths;
- water level gradients/trends; and
- recharge.

In terms of aquifer water quality:

- reference groundwater quality character and status (macro, micro, trace elements);
- presence of suspended substances and other potential pollution already part of the natural/induced transport flow regime;
- hydro-chemical trends and spatial coverage; and
- natural deterioration due to geological reasons.

For the dolomite water areas, the RQO's should be based on the results of indicators observed from special studies (long-term quantity and quality trends, ground stability status, recharge mechanisms, Due to the sporadic occurrence of dolomite eyes in these GRU's, basic

hydrogeological parameters (water level elevations and water quality status/trend) for groundwater depending ecosystems in dolomite water areas is probably the most important sub-component criteria and indicator for RQO's. In addition, setting of RQO specifications for the recharge areas of dolomite groundwater units is required and may be upgraded to a level where total protection of such areas may be considered at a resource quality objective.

Several studies have reviewed the status of the dolomite groundwater unit systems; although recent impacts due to drought conditions and mining activities may not be well incorporated into the total hydrological context. The level of assessment of the dolomite groundwater units should therefore be based on recent investigations (e.g. studies undertaken by Anglo Ashanti Gold for the KOSH Dolomite groundwater resource units). It was noted that the KOSH groundwater resource unit monitoring programme is still maintained by the mine; thus valuable data will be available from this programme.

Some long-term monitoring information limitations may exists for the Schoonspruit groundwater resource units and will have to be followed-up with the DWA. This study by DWA (1994) may be regarded as historic already, although a systematic approach was applied to produce a set of management principles, structures and tools which can be used as indicators for RQO determination.

5 PRIORITISATION OUTCOMES

5.1 Rivers and Dams

The list of prioritised sub-components, indicators selected for monitoring, their selection as a user specific measure, ecological specific measure or an integrated measure and the rationale for considering these are indicated in Table 5 below per RU for each of the IUAs. This prioritisation has been used as the basis for developing RQOs and numerical limits.

Table 5: Sub-component Prioritisation for the Resource Units in Middle Vaal WMA

Table 5.1: Sub-component Prioritisation for Integrated Unit of Analysis - MA RENOSTER

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
R2	Low flows		✓		Maintain maintenance low flows as specified at the biophysical node which is important for ecological integrity of resource.	Maintenance flows Drought flows
	Nutrients			✓	Water resource has water quality impacts from the towns in the catchment (sewage effluent. This poses a potential risk.	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate
	Salts	✓			There is a need to monitor baseline for any potential impact from agricultural activities and the towns which could potentially impact on user water quality requirements.	Electrical conductivity
	Pathogens	✓			Need to maintain fitness for use for recreation. Due to public health concerns, pathogens are important. (upstream impacts).	*Escherichia coli*
	Instream Habitat		✓		Maintenance of instream status (Management Class II) is important (Biophysical nodes)	Rapid Habitat Assessment Method
	Fish		✓		Need to maintain population/ species present as well as present ecological state.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Need to maintain present ecological state.	Macroinvertebrate Response Assessment Index
R3	Low flows		✓		Maintain maintenance low flows as specified at the biophysical node which is important for ecological integrity of resource.	Maintenance flows Drought flows
	Nutrients			✓	Water resource has water quality impacts from the towns in the catchment (sewage effluent). Potential for eutrophication exists.	Dissolved Inorganic Nitrogen
						Orthophosphate
						Phytoplankton
	Salts	✓			Fitness for use for irrigation and recreation and downstream user requirements (acceptable salinity levels) must be maintained.	Electrical conductivity
	Pathogens	✓			Need to maintain fitness for use for recreation. Due to public health concerns, pathogens are important. (upstream impacts)	*Escherichia coli*
	Dam habitat		✓		Dam is an important refuge for fish. Link to upstream species should be maintained.	Health assessment studies and indicator species.
	Fish		✓			

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
	Aquatic birds			✓	Birds in the area must be protected by ensuring the dam habitat remains sustainable in order to supports the birdlife present.	Indicator bird species and population
R4	Low flows			✓	Maintain maintenance low flows as specified at the biophysical node. Flow modification present due to activities in catchment.	Maintenance flows Drought flows
	Nutrients			✓	Water resource has significant water quality impacts. Need to maintain the management class. Baseline monitoring is required.	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate
	Salts			✓	Monitor baseline for any potential impact from agriculture and towns. Need to maintain prescribed ecological category.	Electrical conductivity
R4	System variables			✓	Water resource has significant water quality impacts. Need to maintain instream health to meet management class. Baseline monitoring required.	pH
						Turbidity
	Toxics		✓		Ammonia concentrations pose a threat to river health. The water quality in the river is impacted by wastewater treatment works discharges. Ammonia originates from the sewage works discharges.	Ammonia
	Instream Habitat		✓		Maintenance of present ecological state and management class is important to sustaining ecological integrity of system. River Health Programme site present (biomonitoring done)	Rapid Habitat Assessment Method
	Fish		✓		It is important to maintain population/ species present. River Health Programme site (biomonitoring done) is present.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present. Biomonitoring is done. Maintenance of present ecological state and management class is required.	Macroinvertebrate Response Assessment Index
R5	Low flows		✓		Maintain maintenance low flows as specified at the biophysical node. Important to support aquatic ecosystem.	Maintenance flows Drought flows
	Nutrients			✓	Water resource has significant water quality impacts. Level of nutrients is high	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate
	Salts			✓	Monitor baseline for any potential impact from upstream. Need to maintain management class.	Electrical conductivity
	Toxics		✓		Ammonia concentrations pose a threat to river health. The water quality in the river is impacted by wastewater treatment works discharges (tributary and upstream). Ammonia originates from the sewage works discharges.	Ammonia
	Pathogens	✓			It is important to maintain fitness for use for recreation. Due to public health concerns, pathogens are important. (upstream impacts)	*Escherichia coli*
	System variables			✓	Need to maintain instream health to meet management class. Baseline	pH

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
					monitoring required.	Turbidity
	Instream Habitat		✓		Maintenance of instream status (Management Class II) is important	Rapid Habitat Assessment Method
	Fish		✓		It is important to maintain population/ species present. River Health Programme site is present (biomonitoring done).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present. Biomonitoring is done. Maintenance of present ecological state and management class is required.	Macroinvertebrate Response Assessment Index.
	Aquatic birdlife		✓		The Renoster River feeds into the section of the Vaal River considered and important bird area (SA038 Middle Vaal River). The suitability of this stretch of river for aquatic bird populations must be maintained.	Indicator bird species and population

Table 5.2: Sub-component Prioritisation for Integrated Unit of Analysis – MB VALS

Resource Unit	Sub-component	User specific -ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
V2	Low flows			✓	Maintain maintenance low flows as specified at the biophysical nodes. Need to maintain present ecological state and ensure water supply to the town.	Maintenance flows Drought flows
	Nutrients			✓	Water resource has water quality impacts from the towns in the catchment (sewage effluent). Need to manage nutrient levels.	Dissolved Inorganic Nitrogen; Nitrate & Nitrate
						Orthophosphate
	Salts	✓			Requirement to monitor baseline for any potential impact from agricultural activities and the towns.	Electrical conductivity
	Pathogens	✓			Fitness for use requirements should be met. Due to public health concerns, pathogens are important. There is domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		Maintenance of instream status (Management Class II) is important. River Health programme sire is present. (Biophysical nodes)	Rapid Habitat Assessment Method
	Aquatic Invertebrates		✓		Maintain population/ species present. River Health programme site (biomonitoring done)	Macroinvertebrate Response Assessment Index, South African Scoring System 5
	Diatoms		✓		Poor water quality identified in terms of river health assessment. Need to improve nutrient levels to support aquatic health.	Specific Pollution Index
	Fish		✓		It is important to maintain population/ species present. River Health Programme site (biomonitoring done) is present.	Fish Response Assessment Index (FRAI)
V3	Low flows		✓		Maintain maintenance low flows as specified at the downstream biophysical node.	Maintenance flows
	Nutrients			✓	Water resource has water quality impacts from the town and agricultural activity in the catchment.	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
					Potential for eutrophication.	Chlorophyll-*a*
	Salts	✓			Fitness for use for recreation and downstream use water quality requirements (domestic water supply) must be met.(acceptable salinity levels)	Electrical conductivity
	Pathogens	✓			Fitness for use requirements should be met. Due to public health concerns, pathogens are important. There is domestic use of the water resource.	*Escherichia coli*
	Fish		✓		Dam is an important refuge for fish. Forms a link to upstream species. Need to maintain present ecological state.	Health assessment surveys and indicator species.
V4	Low flows			✓	Important to maintain present ecological state. (lower reach is a B category)	Maintenance flows Drought flows
	Nutrients	✓			Water resource has water quality impacts from agricultural activity. Need to maintain present ecological state. Baseline monitoring required.	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate
	Salts	✓			Monitor baseline for any potential impact from agriculture. Important to maintain present ecological state.	Electrical conductivity
V4	Instream Habitat	✓			Maintain instream status. River Health Programme site (biomonitoring done) is present. (Biophysical nodes)	Rapid Habitat Assessment Method
	Fish	✓			It is important to maintain population/ species present. River Health Programme site (biomonitoring done) is present.	Fish Response Assessment Index (FRAI) must be utilized.
	Aquatic Invertebrates	✓			Maintain population/ species present. River Health programme site (biomonitoring done)	Macroinvertebrate Response Assessment Index, South African Scoring System 5
V5	Low flows			✓	Must maintain ecological specifications at EWR 14.	Maintenance flows Drought flows
	High Flows			✓	Must maintain ecological specifications at EWR 14.	High flows
	Nutrients			✓	Water resource has water quality impacts from the towns and agricultural activities in the catchment. Nutrients in the water resource a high.	Dissolved Inorganic Nitrogen; Nitrate& Nitrate
						Orthophosphate
						Chlorophyll-*a*
	Salts			✓	Agricultural impacts and the upstream impacts from Kroonstad need to be monitored. Salinity levels are high.	Electrical conductivity
	Pathogens	✓			Fitness for use requirements should be met. Due to public health concerns, pathogens are important. There is domestic use of the water resource.	*Escherichia coli*
	System variables			✓	Need to maintain instream health to meet management class. Baseline monitoring required.	pH
						Turbidity

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
	Instream Habitat		✓		Ecological specifications for EWR site 14 must be implemented. . River Health Programme site is present (biomonitoring done).	Rapid Habitat Assessment Method
	Fish		✓		Ecological specifications for EWR 14 site must be implemented. . River Health Programme site is present (biomonitoring done).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Ecological specifications for EWR 14 site must be implemented. . River Health Programme site is present (biomonitoring done).	Macroinvertebrate Response Assessment Index, South African Scoring System 5

Table 5.3: Sub-component Prioritisation for Integrated Unit of Analysis – MC SCHOONSPRUIT

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
SK1	Low flows			✓	Required for ecosystem functioning and to support the needs of subsistence domestic and agricultural use.	Maintenance flows Drought flows
	Nutrients			✓	The wastewater treatment works discharges impacts on water quality specifically on the nutrient concentrations in the river.	Dissolved Inorganic Nitrogen Orthophosphate Nitrate & Nitrite
	Salts			✓	The water quality in the river is impacted by mine dewatering discharges as well as the seepages from the tailings storage facilities. and pollution control dams. The mine impact on water quality is largely related to salts.	Electrical conductivity Sulphate Magnesium
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. The mine impact on water quality is largely related to toxics such as cyanide and heavy metals. Ammonia originates from the sewage works discharges.	Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			The wastewater treatment works discharges impacts on water quality on the river. It is reported to be compliant. Due to public health concerns, pathogens are important.	*Escherichia coli*
	Instream Habitat		✓		The instream habitat has been degraded and requires improvement.	Rapid Habitat Assessment Method
	Fish			✓	Need to protect fish species present.	Fish Response Assessment Index (FRAI)
	Diatoms		✓		Provides an indication of water quality state - sensitive to pollution. Species-specific sensitivities and tolerances can be used to infer environmental conditions in a habitat.	Specific Pollution Index. Conduct a diatom assessment annually.

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
SK1	Low flows			✓	Conservation of the eye is required, of ecological importance. Prevention of over-abstraction.	Maintenance flows Drought flows
SK2	Nutrients			✓	Agricultural impact is a potential threat.	Nitrate & Nitrite
						Orthophosphate
						Chlorophyll-*a*
	Salts	✓			Important to monitor baseline to determine any potential impact.	Electrical conductivity
	System variables		✓		Detection of any WQ impacts on dolomites. Need to protect dolomites.	pH
	Instream Habitat		✓		Maintain ecosystem habitat - support biota present.	Rapid Habitat Assessment Method
SK3	Low flows		✓		Required for ecosystem functioning. There is a need to specify seasonal flows.	Maintenance flows Drought flows
	Salts			✓	Important to monitor baseline to determine any potential impact.	Electrical conductivity
SK4	Low flows			✓	Flows required to support downstream ecosystem functioning and users	Maintenance flows Drought flows
	Nutrients			✓	The wastewater treatment works discharges and agricultural activities impacts on water quality specifically on the nutrient concentrations in the river.	Dissolved Inorganic Nitrogen
						Orthophosphate
						Nitrate & Nitrite
	Salts			✓	There is an impact of agricultural activity on the water resource.	Electrical conductivity
	Pathogens	✓			The wastewater treatment works discharges impacts on water quality on the river. Due to public health concerns, pathogens are important. There is informal domestic use of the river water and recreational use.	*Escherichia coli*
SK5	Instream Habitat		✓		The instream habitat needs to be maintained to support the biota.	The Rapid Habitat Assessment Method.
	Fish		✓		Need to maintain fish population present. Fish data is available and monitoring has been done.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Need to maintain ecosystem integrity. Supported by River Health Programme.	Macroinvertebrate Response Assessment Index, South African Scoring System 5
	Low flows			✓	Current overuse -of resource through abstraction (agriculture).	Maintenance flows Drought flows
	Nutrients			✓	Land use activities *viz*. agriculture and piggeries are impacting on the water quality of the resource.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
SK5	Salts			✓	To monitor the salinity in the main stem Schoonspruit (alignment of resource units).	Electrical conductivity
	Pathogens			✓	The piggeries impact on water quality on the river. Due to public health concerns, pathogens are important.	*Escherichia coli*
	System variables			✓	Need to understand behaviour of system.	pH
	Instream Habitat		✓		Need to maintain present ecological state.	Rapid Habitat Assessment Method
	Fish		✓		Need to maintain present ecological state.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Need to maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
SK6	Nutrients			✓	Potential for eutrophication exists. Need to manage nutrient levels.	Dissolved Inorganic Nitrogen, Orthophosphate
						Nitrate & Nitrite, Chlorophyll-*a*
	Salts	✓			Fitness for use for irrigation, recreation and downstream use required (acceptable salinity levels).	Electrical conductivity
	Pathogens	✓			Need to maintain fitness for use for recreation. Due to public health concerns, pathogens are important. (upstream impacts)	*Escherichia coli*
	Fish		✓		Dam is an important refuge for fish. Serves as a link to upstream species.	Health assessment surveys and indicator species.
SK7	Low flows			✓	Flows required to support downstream ecosystem functioning and users	Maintenance flows Drought flows
	Nutrients			✓	Water resource has significant water quality impacts. Water quality needs improvement.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Highly impacted by mining, industrial and urban areas in catchment (Jagspruit tributary). Salinity must be improved.	Electrical conductivity
						Sulphate
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. The mine impact on water quality is largely related to toxics such as cyanide and heavy metals. Ammonia originates from the sewage works discharges.	Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			Wastewater discharges and untreated sewage entering the water have a potential public health concern.	*Escherichia coli*
	Instream Habitat		✓		The instream habitat has been degraded and requires improvement.	Rapid Habitat Assessment Method
	Fish		✓		Need to maintain present ecological state. Prevent further deterioration.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Need to maintain present ecological state. Prevent further deterioration.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.

Table 5.4: Sub-component Prioritisation for Integrated Unit of Analysis – MD1 UPPER SAND

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
US2	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Nutrients			✓	The wastewater treatment works discharges from the town impact on water quality specifically on the nutrient levels in the river.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Catchment is impacted by agricultural activities. There is a need to manage salinity levels.	Electrical conductivity
	Toxics		✓		The water quality in the river is impacted by wastewater treatment works discharges. Ammonia as a toxin needs to be monitored.	Ammonia
	Pathogens	✓			The wastewater treatment works discharges impact on water quality on the river. Due to public health concerns, pathogens are important. There is informal domestic use of the river water.	*Escherichia coli*
	Fish		✓		River Health Programme site present - good site - supporting data available. Monitor ecological integrity of system.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present - good site - support data available. Monitor ecological integrity of invertebrates in system. Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
US3	Low flows		✓		Need to maintain maintenance low flows as specified at biophysical node downstream of the dam.	Maintenance flows Drought flows
	Nutrients			✓	The wastewater treatment works discharges from the town upstream impact on the nutrient concentrations in the dam.	Nitrate & Nitrite Orthophosphate Chlorophyll-*a*
	Salts			✓	Catchment is impacted by agricultural activities. There is a need to manage salinity levels.	Electrical conductivity
	System variables			✓	Monitor the water clarity to understand the limiting of algal growth in Dam.	pH
	Pathogens	✓			The upstream of the impacts of the wastewater treatment works discharges need to be determined. Due to recreational activity and domestic use of water pathogens are important from a public health point of view.	*Escherichia coli*
	Fish		✓		Serves as a fish refuge for a number of species. Must be monitored.	Health assessment surveys and indicator species.
	Aquatic Birds		✓		The dam ecosystem supports birdlife in the area. The habitat must be managed to ensure that the bird populations are maintained.	Indicator bird species and population

Table 5. 5: Sub-component Prioritisation for Integrated Unit of Analysis – MD2 LOWER SAND

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
LS1	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Nutrients			✓	Intensive irrigated agriculture, return flows in water resource have a potential significant impact.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Impacts of agriculture are significant. Need to manage salinity levels.	Electrical conductivity
	System Variables			✓	Need to monitor system behaviour.	pH
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		River Health Programme site present - support data available. Monitor ecological integrity of system. Maintain present ecological state.	Rapid Habitat Assessment Method
	Fish		✓		River Health Programme site present. Monitor ecological integrity of system.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present - support data available. Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
LS2	Nutrients			✓	Water resource has significant water quality impacts from the towns and agricultural activities in the catchment.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Highly impacted by mining, industrial and urban areas in catchment.	Electrical conductivity
	System Variables			✓	Need to monitor system behaviour.	pH, Turbidity
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. The mine impact on water quality is largely related to toxics such as heavy metals. Ammonia originates from the sewage works discharges.	A Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		Need to maintain biota - flow/quality in tributary must be managed to support this.	Rapid Habitat Assessment Method
	Fish		✓		Maintain population (species present)	Fish Response Assessment Index (FRAI)

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
LS3	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Nutrients			✓	Towns waste water treatment works discharges and return flows from agriculture have a significant water quality impact.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Impacts of mining need to be monitored.	Electrical conductivity
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. The mine impact on water quality is largely related to toxics such as heavy metals. Ammonia originates from the sewage works discharges.	Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	System Variables			✓	Need to monitor system behaviour.	pH, Turbidity
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		River Health Programme site present.- support data available. Monitor ecological integrity of system (flow/biota). Maintain present ecological state.	Rapid Habitat Assessment Method
	Fish		✓		Need to maintain population/ species present. River Health Programme site present (biomonitoring done).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present (biomonitoring done). Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.

Table 5.6: Sub-component Prioritisation for Integrated Unit of Analysis – ME1 UPPER VET

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
UV1/UV2	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Nutrients			✓	The agricultural activities impact on the nutrient levels in the water resource.	Dissolved Inorganic Nitrogen
						Orthophosphate
						Nitrate & Nitrite
	Salts			✓	Impacted by agricultural activities in the catchment. Need to manage salinity levels.	Electrical conductivity
	System variables			✓	Erosion a problem as a result of agricultural practices.	pH, Turbidity
	Toxics		✓		The water quality in the river is impacted by wastewater treatment works discharges. Ammonia as a potential toxin needs to be monitored.	Ammonia

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		River Health Programme site present - suitable for habitat assessment. Good condition must be maintained.	Rapid Habitat Assessment Method
	Fish		✓		Yellow fish, rock barbels, good populations possibly present. Need to maintain ecological integrity of system.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Habitat exists to support invertebrate communities. River Health Programme site present (biomonitoring - data available). Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
UV3	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Salts			✓	Monitor baseline to maintain ecological status.	Electrical conductivity
	System variables			✓	Need to monitor system behaviour.	pH
	Instream Habitat		✓		Need to maintain good ecological condition.	Rapid Habitat Assessment Method
	Fish		✓		Presence of species as in main stem (Yellow fish). Need to protect species.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Habitat present to support invertebrate communities. Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
UV4	Low flows		✓		Maintain flows required at downstream EWR site and biophysical node (maintenance flows) must be met.	Maintenance flows
	Nutrients			✓	Agricultural activities have a potential impact on the dam. Need to manage nutrient levels.	Dissolved Inorganic Nitrogen; Nitrate & Nitrite, Orthophosphate, Chlorophyll-*a*
	Salts			✓	There is a need to monitor salts to track upstream impacts.	Electrical conductivity
	System variables			✓	Monitor the water clarity to understand the limiting of algal growth in Dam. Measure pH to understand behaviour.	pH
	Pathogens	✓			Due to recreational activity pathogens are important from a public health point of view.	*Escherichia coli*
	Dam Habitat			✓	Need to manage habitat and ecosystem and water requirements of users.	Habitat Assessment
	Fish		✓		Serves as a refuge for a number of fish species. Must be monitored	Health assessment surveys and indicator species.

Table 5.7: Sub-component Prioritisation for Integrated Unit of Analysis – ME2 LOWER VET

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
LV1	Low flows		✓		Maintain maintenance low flows as specified at biophysical node.	Maintenance flows Drought flows
	Nutrients			✓	Agricultural impacts are present. Nutrients need to be monitored.	Dissolved Inorganic Nitrogen, Orthophosphate, Nitrate & Nitrite
	Salts			✓	Salinity levels must not be allowed to deteriorate due to impacts of agricultural activities in the catchment.	Electrical conductivity
	System Variables			✓	Need to monitor system behaviour	pH
	Toxics		✓		A wastewater treatment works is present in the catchment. Need to protect aquatic biota against the impact of the presence of toxins such as ammonia.	Ammonia
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		The instream status must be maintained.	Rapid Habitat Assessment Method
	Fish		✓		Need to maintain population/ species present. River Health Programme site present (biomonitoring done).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present (biomonitoring done). Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
LV2	Low flows		✓		Must maintain ecological specifications at EWR 15.	Maintenance flows Drought flows
	High flows		✓		Must maintain ecological specifications at EWR 15.	High flows
	Nutrients			✓	Significant agricultural impacts are present in the catchment. Nutrient levels must be managed.	Dissolved Inorganic Nitrogen , Nitrate & Nitrite., Orthophosphate
	Salts			✓	Salinity levels from agricultural impacts and the upstream impacts from the Sand River need to be monitored.	Electrical conductivity, Sulphate, Chloride
	System Variables			✓	Need to monitor system behaviour	pH
	Toxics			✓	Mining impacts from the Sand River and the impacts of ammonia from the wastewater treatment works are a potential threat.	Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			Fitness for use requirements. Due to public health concerns, pathogens are important. There is informal domestic use of the water resource.	*Escherichia coli*
	Instream Habitat		✓		Ecological specifications for EWR site 15 must be implemented.	Rapid Habitat Assessment Method

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
	Riparian Habitat		✓		Ecological specifications for EWR site 15 must be implemented.	Vegetation Response Assessment Index
	Fish		✓		Ecological specifications for EWR site 15 must be implemented.	Fish Response Assessment Index (FRAI)

Table 5.8: Sub-component Prioritisation for Integrated Unit of Analysis – MF VAAL RIVER

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
VB 1.1	Low flows		✓		Must maintain ecological specifications at EWR 12. Need to implement Reserve.	Maintenance flows Drought flows
	High flows	✓			Must maintain ecological specifications at EWR 12. Need to implement Reserve. Potential impact on infrastructure along River (property, water supply infrastructure). Need to implement EWR specifications.	Maintenance flows
	Nutrients			✓	The wastewater treatment works discharges (in the catchment and from Upper Vaal) impact on water quality specifically on the nutrient concentrations in the river. Water hyacinth a key issue, nuisance macrophytes - need to be managed.	Dissolved Inorganic Nitrogen, Nitrate & Nitrite Orthophosphate , Chlorophyll-*a*
	Salts			✓	High degree of salinisation (impact of Upper Vaal. Need to maintain fitness for use. Dilution rule in place)	Electrical conductivity, Total Dissolved Solids Sulphate Magnesium
	System variables		✓		User requirements -need to maintain fitness for use.	pH
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. Toxics need to be monitored.	Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			The wastewater treatment works discharges impact on water quality on the river. Due to public health concerns, pathogens are important. There is informal domestic use of the river water, recreation, bulk water supply.	*Escherichia coli*
	Instream Habitat		✓		Ecological specifications for EWR site 12 must be implemented.	Rapid Habitat Assessment Method
	Riparian Habitat		✓		Ecological specifications for EWR site 12 must be implemented.	Vegetation Response Assessment Index
	Fish		✓		Ecological specifications for EWR site 12 must be implemented.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Ecological specifications for EWR site 12 must be implemented.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
VB1.1	Aquatic Birds		✓		The section of the Vaal River considered and important bird area (SA038 Middle Vaal River). The suitability of this stretch of river for aquatic bird populations must be maintained.	Indicator bird species and population
	Diatoms		✓		Provides an indication of water quality state - sensitive to pollution. Species-specific sensitivities and tolerances can be used to infer environmental conditions in a habitat.	Specific Pollution Index.
VB 1.2/ VB 1.3	Low flows		✓		Must maintain ecological specifications at EWR 13. Need to implement Reserve.	Maintenance flows Drought flows
	High flows	✓			Must maintain ecological specifications at EWR 13. Potential impact on infrastructure along River (property, water supply infrastructure). Need to implement EWR specifications.	Maintenance flows
	Nutrients			✓	The wastewater treatment works discharges (in the catchment and from Upper Vaal) impact on water quality specifically on the nutrient concentrations in the river. Water hyacinth a key issue, nuisance macrophytes - need to be managed.	Dissolved Inorganic Nitrogen, Nitrate & Nitrite, Orthophosphate, Chlorophyll-*a*
	Salts			✓	High degree of salinisation (impact of Upper Vaal. Need to maintain fitness for use. Dilution rule in place).	Electrical conductivity, Total Dissolved Solids, Sulphate, Magnesium
	System variables	✓			User requirements -need to maintain fitness for use.	pH
	Toxics			✓	The water quality in the river is impacted by mining activities and wastewater treatment works discharges. Toxics need to be monitored.	Cyanide (free) , Aluminium, Manganese, Iron, Uranium, Ammonia
	Pathogens	✓			The wastewater treatment works discharges impact on water quality on the river. Due to public health concerns, pathogens are important. There is informal domestic use of the river water, recreation, bulk water supply.	Escherichia coli
	Instream Habitat		✓		Ecological specifications for EWR site 13 must be implemented.	Rapid Habitat Assessment Method
	Riparian Habitat		✓		Ecological specifications for EWR site 13 must be implemented.	Vegetation Response Assessment Index
	Fish		✓		Yellowfish conservation area. Need to implement EWR ecological specifications.	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Ecological specifications for EWR site 13 must be implemented.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
	Diatoms		✓		Provides an indication of water quality state - sensitive to pollution. Species-specific sensitivities and tolerances can be used to infer environmental conditions in a habitat.	Specific Pollution Index.

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
VB2	Salts			✓	Impact of coal mining activities potentially increasing salinisation river.	Electrical conductivity
	System variables			✓	Need to monitor to obtain an indication of the impact of the mining. Protect against deterioration.	pH
	Toxics			✓	The water quality in the river is impacted by mining activities. Toxics need to be monitored.	Aluminium, Manganese, Iron
VB3	Low flows			✓	Maintenance low flows are required to maintain ecological integrity.	Maintenance flows Drought flows
	Nutrients		✓		The wastewater treatment works discharges impact on water quality specifically on the nutrient concentrations. Nutrient levels must be managed.	Dissolved Inorganic Nitrogen, Nitrate & Nitrite, Orthophosphate, Chlorophyll-*a*
	Salts	✓			Agricultural and mining activities in catchments are impacting on water resources. Salinity levels must be managed.	Electrical conductivity
	System Variables			✓	Mining activities are resulting in high suspended solids.	pH, Turbidity
	Pathogens	✓			The wastewater treatment works discharges impact on water quality on the river. Due to public health concerns, pathogens are important. There is informal domestic use of the river water.	*Escherichia coli*
	Instream Habitat			✓	Significant modification of bed and banks by diamond mining (specifically in Makwassie catchment). The present ecological state must be maintained to maintain the ecological health of the tributaries.	Rapid Habitat Assessment Method
	Riparian Habitat			✓	Significant modification of bed and banks has occurred due to diamond mining (specifically in Makwassie catchment). The present ecological state must be maintained to maintain the ecological health of the tributaries.	Vegetation Response Assessment Index
	Fish		✓		All species including Yellowfish – Tributaries confluences are an important refuge for main stem species (Vaal River species).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		River Health Programme site present (biomonitoring done). Maintain present ecological state.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
VB4	Nutrients			✓	Potential impact from agricultural activities and informal settlements. There is a need to ensure that the resource does not deteriorate with respect to nutrients.	Orthophosphate, Nitrate & Nitrite
	Salts			✓	Agricultural activity in catchment is impacting on water resources. Salinity levels must be managed.	Electrical conductivity

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
VB4	Instream Habitat		✓		Present ecological state and ecological integrity of water resource must be maintained. (Hydrology of stream: Highveld tributaries - pools)	Rapid Habitat Assessment Method
	Fish		✓		Need to protect fish species present (possibly Barbus).	Fish Response Assessment Index (FRAI)
	Aquatic Invertebrates		✓		Need to maintain ecological integrity of invertebrate community.	Macroinvertebrate Response Assessment Index, South African Scoring System 5.
VB5	Nutrients			✓	Potential impact from agricultural activities and informal settlements. There is a need to ensure that the resource does not deteriorate with respect to nutrients.	Dissolved Inorganic Nitrogen
						Orthophosphate
						Nitrate & Nitrite
	Salts			✓	Agricultural and diamond mining activities are impacting on water resources. Salinity levels must be managed.	Electrical conductivity, sulphate
	System variables			✓	Impacts of mining and agriculture must be monitored. Need to understand behaviour of system.	pH
	Instream Habitat		✓		Significant bed, banks modification due to diamond mining is impacting on ecological integrity of system. The habitat must be improved.	Rapid Habitat Assessment Method
	Riparian Habitat		✓		Significant bed, banks modification due to diamond mining is impacting on ecological integrity of system. The habitat must be improved.	Vegetation Response Assessment Index
	Fish		✓		Species present in tributary serve as a source population in Bloemhof Dam. In stream species will improve if habitat improves.	Fish Response Assessment Index (FRAI)
VB6	Low flows		✓		The maintenance flows required at the downstream EWR site 16 must be implemented to sustain prescribed ecological condition.	Maintenance flows
	Nutrients			✓	Hypertrophic state is present in the dam. Important to manage nutrient levels.	Dissolved Inorganic Nitrogen, Nitrate & Nitrite
						Orthophosphate
						Chlorophyll-*a*
	Salts			✓	High degree of salinisation in Middle Vaal River (impact of Upper Vaal WMA). Need to maintain fitness for use water quality requirements of use. Dilution rule in place. Need to manage salinity levels at acceptable levels to support downstream Lower Vaal River.	Electrical conductivity, Total Dissolved Solids
						Sulphate, Sodium, Chloride
	System variables			✓	Need to monitor system behaviour to maintain fitness for use.	pH
	Pathogens	✓			Need to maintain fitness for use for recreational and domestic users.	*Escherichia coli*
	Dam Habitat			✓	Need to manage habitat and ecosystem and water requirements of users.	Habitat Assessment
	Fish			✓	Serves as a refuge for a number of fish species. Must be monitored	Health assessment surveys and indicator species.

Resource Unit	Sub-component	User specific-ation	Ecological specific-ation	Integrated Measure	Rationale	Indicator
VB6	Aquatic Birds			✓	The dam ecosystem supports birdlife in the area. The habitat must be managed to ensure that the bird populations are maintained.	Indicator bird species and population

5.2 Wetlands

Selection of subcomponents for prioritised wetland ecosystems was based on an evaluation of no net loss' principles, conservation plans, wetland types (inferred functionality) and species targets. A summary of the sub-components selected per priority wetland and IUA is presented in **Table 6.**

Table 6: Summary of subcomponents and indicators selected for prioritized wetlands

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MA Renoster	**Floodplain of the middle reaches of the Renosterrivier, Heuningspruit, Grootvlei, central and lower reaches of the Mahemspruit, and middle to lower reaches of the Rietspruit (wetland Freshwater Ecosystem Priority Areas or parts that are Freshwater Ecosystem Priority Areas)**	**R4**	**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Ecosystem structure and function, ecosystem services, particularly regulating and supporting services for the downstream river including the riparian and instream habitats.
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as both flamingo species.	Floodplain systems are likely to provide an important refuge for Red Data Listed birds.
MA Renoster	**Unchannelled valley bottom wetland of the Rietspruit tributary of the Heuningspruit and a tributary of the Heuningspruit (wetland Freshwater Ecosystem Priority Areas)**	**R4**	**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as both flamingo species.	These wetland systems are likely to provide an important refuge for Red Data Listed birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MA Renoster	Leeupan, Vaneedespan, Groot Rietpan and the wetland Freshwater Ecosystem Priority Area Swartpan (northern section)	R5	Quantity	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Biota	Presence of endangered bird species such as Black Stork, Yellow-billed Stork and African Marsh-Harrier. Presence of both important species such as flamingos and African Grass-Owl	The pans are likely to provide an important refuge for Red Data Birds.
MA Renoster	Channelled and unchannelled valley bottom wetland adjacent to Viljoenskroon	R5	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	Water quality sampling of key cations and anions.	Increased levels of sewage pollution in the system.
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Sections of this wetland system have been extensively canalized. In addition, some sections of the wetland have also been cultivated. These impacts have compromised the wetland systems ecosystem structure and functioning.
MA Renoster	Unchannelled valley bottom wetland on the farm Roodepoort (wetland Freshwater Ecosystem Priority Area)	R5	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as African Marsh-Harrier. Presence of important species such as Greater and Lesser Flamingo.	The wetland system is likely to provide an important refuge for Red Data Birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MB Vals	Pan and associated wetland cluster along the middle reaches of the Otterspruit	V4	Quantity	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans.	
			Biota	Presence of important bird species such as Blue Crane and both flamingo species.	The pans and associated hillslope seepage wetlands are likely to support viable populations of Red Data Listed birds.
MB Vals	Channelled valley bottom wetland in the middle reaches of the Otterspruit and its tributaries (wetland Freshwater Ecosystem Priority Areas)	V4	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	The integrity of wetland hydrology can be affected by alterations in the catchment that affects the quantity and timing of inputs, which in turn affects the distribution and retention patterns within the wetland system itself.
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Ensure that the ecosystem structure and function are maintained and that there is ongoing supply of ecosystem services, particularly regulating and supporting services for the downstream river including the riparian and instream habitats.
			Biota	Presence of important bird species such as Blue Crane and both Flamingo species.	The wetland system is likely to support viable populations of Red Data Listed birds.
MB Vals	Unchannelled valley bottom wetland in a tributary of the Otterspruit (wetland Freshwater Ecosystem Priority Area)	V4	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measures.	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of important bird species such as Blue Crane and both flamingo species.	The wetland system is likely to support viable populations of Red Data Listed birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MB Vals	Swartpan (southern section) - (wetland Freshwater Ecosystem Priority Area)	V5	Quantity	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	The pan system and associated wetland habitat is likely to support viable populations of Red Data Listed birds.
			Biota	Presence of endangered bird species such as Black Stork and Yellow-billed Stork. Presence of important bird species such as Greater Flamingo.	
MB Vals	Valley bottom and hillslope seepage wetlands of Hertzogsvlei (wetland Freshwater Ecosystem Priority Area)	V5	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	The integrity of wetland hydrology can be affected by alterations in the catchment that affects the quantity and timing of inputs, which in turn affects the distribution and retention patterns within the wetland system itself.
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Management of the wetland is important to ensure that the ecosystem structure and function are maintained and that there is ongoing supply of ecosystem services, particularly regulating and supporting services for the downstream river including the riparian and instream habitats.
			Biota	Presence of endangered bird species such as Black Stork and Yellow-billed Stork. Presence of important bird species such as Greater Flamingo.	The wetland system is likely to support viable populations of Red Data Listed birds.
MC Schoon-spruit	Pan	SK1	Quantity	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan system.	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Biota	Presence of endangered bird species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important bird species such as Blue Crane and both flamingo species.	The pan system and associated wetland habitat is likely to support populations of Red Data Listed birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MC Schoon-spruit	**Pan and wetland systems associated with these pans including the pans at Leliefontein and north of Vetpan and the wetland Freshwater Ecosystem Priority Areas including Vetpan, Klippan and Rietpan**	**SK2**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Biota	Presence of endangered bird species such as Black Stork, Yellow-billed Stork, African Marsh-Harrier. Presence of important bird species such as Blue Crane and both flamingo species.	The pan systems and associated wetland habitat are likely to provide a refuge for Red Data Listed birds such as Black Stork, Yellow-billed Stork, Greater Flamingo, Lesser Flamingo, African Marsh-Harrier, Blue Crane, Black-winged Pratincole, White-bellied Korhaan and Chestnut-banded Plover.
MC Schoon-spruit	**The Schoonspruit eye and the wetland Freshwater Ecosystem Priority Area which includes the upper section of the Skoonspruit (Schoonspruit) peatland**	**SK2**	**Quantity**	Water supply to the system using dryness of peat as an indicator. Abstraction permits.	
				Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
				Abstraction	
MC Schoon-spruit	**The Schoonspruit eye and the wetland Freshwater Ecosystem Priority Area which includes the upper section of the Skoonspruit (Schoonspruit) peatland**	**SK2**	**Quantity**	Abstraction/ Boreholes	
			Quality	Nitrate levels	
				Deteriorating water quality	
			Habitat	Riparian vegetation. Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
				Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as both flamingo species.	The wetland system is likely to support viable populations of Red Data Listed birds.
MC Schoon-spruit	**The wetland Freshwater Ecosystem Priority Areas including Witpan and the pan cluster north of Coligny**	**SK3**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Quality	Water quality sampling of key cations and anions.	There is a risk of toxic accumulation of contaminants in the pans as a result of catchment related agricultural practices.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
			Biota (Pans only)	Number of observed Greater Flamingo and Lesser Flamingo present annually. Reporting rate or total numbers counted annually.	The pan systems are likely to support viable populations of the Red Data Listed Greater Flamingo and Lesser Flamingo.
MC Schoon-spruit	**Floodplain of the Taaibosspruit and lower section of the Skoonspruit (wetland Freshwater Ecosystem Priority Areas)**	**SK3**	**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measures	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
	Channelled valley bottom wetland of the middle Kaalspruit		**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	The integrity of wetland hydrology can be affected by alterations in the catchment that affects the quantity and timing of inputs, which in turn affects the distribution and retention patterns within the wetland system itself.
			Quality	River Resource Quality Objective's indicator/measures	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Important to ensure that the ecosystem structure and function are maintained and that there is ongoing supply of ecosystem services, particularly regulating and supporting services for the downstream river including the riparian and instream habitats.
MC Schoon-spruit	**Unchannelled valley bottom wetland of the lower Kaalspruit**	**SK3**	**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measures	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota (Excluding pan system mentioned above)	Presence of endangered species such as Yellow-billed Stork. Presence of important species such as Blue Crane, White-bellied Korhaan and both flamingo species.	The wetland system is likely to support populations of Red Data Listed birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MC Schoon-spruit	Lower section of the Schoonspruit peatland (wetland Freshwater Ecosystem Priority Area)	SK4	Quantity	Water supply to the system using dryness of peat as an indicator. Abstraction permits.	Maintenance of water inputs to the wetland is critical for peat formation and to prevent oxidation.
				Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
				Abstraction/Water volume measurements	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Maintain current extent of riparian vegetation. Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
				Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as both flamingo species.	The wetland system is likely to support viable populations of Red Data Listed birds.
MC Schoon-spruit	Floodplain of the Rietspruit and the wetland Freshwater Ecosystem Priority Area including the upper section of the floodplain of the Skoonspruit	SK4	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as Blue Crane and both flamingo species.	The wetland system is likely to support viable populations of Red Data Listed birds.
MC Schoon-spruit	Floodplain of the lower Skoonspruit (wetland Freshwater Ecosystem Priority Area)	SK5	Quantity	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered bird species such as Yellow-billed Stork. Presence of important species such as Blue Crane and both flamingo species.	The wetland system is likely to support populations of Red Data Listed birds.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MD2 Lower Sand	**Ganspan and remaining pans that form the southern part of the Wesselbron pan complex/cluster (most are wetland Freshwater Ecosystem Priority Areas)**	**LS3**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Biota	Presence of endangered species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important species such as African Grass-Owl and both flamingo species.	The pan systems and associated wetland habitat are likely to support viable populations of Red Data Listed birds.
MD2 Lower Sand	**Wetland system along the Mahemspruit and associated pans including Brakpan (wetland Freshwater Ecosystem Priority Areas)**	**LS3**	**Quantity**	Water distribution & retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2). Wet-Health not applicable to Pans.	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2). Wet-Health not applicable to Pans.	
			Biota	Presence of endangered species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important species such as African Grass-Owl and both flamingo species.	The pan systems and associated wetland habitat are likely to support viable populations of Red Data Listed birds.
MD2 Lower Sand	**Flamingo Pan, Stinkpan and Witpan**	**LS3**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Quality	Water quality sampling of key cations and anions.	The systems are threatened and currently impacted by sewage pollution from the adjacent sewage plants. There is a growing risk of eutrophication caused by increased nutrient inputs from the discharge as well as the surrounding land use and urban developments in and around the pan catchments.

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MD2 Lower Sand	**Flamingo Pan, Stinkpan and Witpan**	**LS3**	**Habitat**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	Sections of these pans and pan catchments have been impacted by infrastructure and sewage water inputs. These impacts have compromised the pan systems ecosystem structure and functioning and resulted in changes in wetland vegetation and biota.
			Biota	Presence of endangered species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important species such as African Grass-Owl and both flamingo species.	The pan systems and associated wetland habitat are likely to support viable populations of Red Data Listed birds.
ME2 Lower Vet	**Brakpan and pan cluster to the south of Bultfontein (most are wetland Freshwater Ecosystem Priority Areas)**	**LV2**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems	
			Biota	Presence of endangered species such as Black Stork. Presence of important species such as Blue Crane and both flamingo species.	The pan systems are likely to support viable populations of Red Data Listed birds.
ME2 Lower Vet	**Bultfontein pan and salt works**	**LV2**	**Quality**	Water quality sampling of key cations and anions.	
			Biota	Number of observed Greater and Lesser Flamingo present annually. Reporting rate or total numbers counted annually.	The pan system is likely to support populations of Red Data Listed birds.
	Floodplain of the Vet River (wetland Freshwater Ecosystem Priority Area)	**LV2**	**Quantity**	Water distribution and retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	Management of the wetland is important to ensure that the ecosystem structure and function are maintained and that there is ongoing supply of ecosystem services, particularly regulating and supporting services for the downstream river including the riparian and instream habitats.
			Biota	Presence of endangered species such as Black Harrier. Presence of important species such as Blue Crane.	The floodplain system is likely to support viable populations of Red Data Listed birds

IUA	Wetlands	Resource Unit	Sub-component	Indicator/measure	Rationale/Consideration
MF Vaal River from Renoster to Bloemhof Dam	**Pan cluster around Wesselbron including Volstruispan, Graspan and Mahemspan (wetland Freshwater Ecosystem Priority Areas)**	**VB4**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	Developments and/or land-use practices or activities in and adjacent to the pan basin, including in the pan catchment, and wetlands and the wetland catchments associated with the pan systems, that will lead to the deterioration in the current condition of the pan and wetland systems and alteration of the associated habitats should be avoided.
			Biota	Presence of endangered species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important species such as African Grass-Owl and both flamingo species.	The pan systems and associated wetland habitat are likely to support viable populations of Red Data Listed birds
MF Vaal River from Renoster to Bloemhof Dam	**Unchannelled valley bottom wetland in the upper reaches of the Sandspruit immediately north of Kutloanong (wetland Freshwater Ecosystem Priority Area)**	**VB4**	**Quantity**	Water distribution & retention patterns score. Water distribution and retention assessment, hydrology module of Wet-Health (Level 2).	
			Quality	River Resource Quality Objective's indicator/measure	
			Habitat	Wetland vegetation score. Vegetation module of Wet-Health (Level 2).	
			Biota	Presence of endangered species such as Yellow-billed Stork and African Marsh-Harrier. Presence of important species such as African Grass-Owl, Blue Crane and both flamingo species.	The wetland system likely to support viable populations of Red Data Listed birds
MF Vaal River from Renoster to Bloemhof Dam	**Pan cluster along the watershed divide to the west of the Bamboesspruit (some are wetland Freshwater Ecosystem Priority Areas)**	**VB5**	**Quantity**	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Quality	Water quality sampling of key cations and anions.	
			Habitat	Wet-Health not applicable to Pans. A new Present Ecological State assessment tool must be developed for pan systems.	
			Biota	Presence of endangered species such as Yellow-billed Stork. Presence of important species such as Blue Crane and both flamingo species.	The pan systems are likely to support viable populations of Red Data Listed birds.

5.3 Groundwater

Selection of subcomponents for groundwater resource units was based on the measurable parameters including Quantity (Abstraction), Aquifer Water Level, Water Quality and Protection Zones (related to a localised borehole as a means of protecting the basic human needs and the ecological Reserve). A summary of the sub-components selected per groundwater resource unit and IUA is presented in Table 7.

Table 7: Summary of subcomponents and indicators selected for Groundwater Resource Units

IUA	Ground-water unit	RU	Sub-component	Indicator/ Measure	Consideration
MC – Schoon-spruit	RU G1	SK3	Quantity	Water Level - Depth to groundwater level from ground elevation. Time series water level monitoring (Monthly)	Based on water level declines and appearances of sinkholes in the Far West Rand by the Council for Geosciences.
				Abstraction - Abstraction Volume (Q) Time series water level monitoring (Monthly)	High abstractions within the 500m zone could impact on the surface water resource
			Quality	Nutrients - Nitrate	Pristine conditions occurs. Need to maintain good quality.
				Salts - Electrical Conductivity	
			Protection Zone	Radius of influence (r)	The zone around a borehole must be protected against potential impacts.
				Distance from river (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features
				Distance from wetland (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features.
MC – Schoon-spruit	RU - G2	SK 2, SK 4	Quantity	Water Level - Depth to groundwater level Time series water level monitoring (Monthly)	Based on water level declines and appearances of sinkholes in the Far West Rand. Schoonspruit Eye must be protected.
			Quantity	Abstraction - Abstraction rate (Q) Continuous Flow measurement at Eye	Water balance assessed during a hydrogeological study of the area and long-term observations of eye discharges.
			Quality	Nutrients - Nitrate Bi-annual monitoring	Prevent deterioration of water quality. Must support needs of water users.
				Salts - Electrical Conductivity	
			Protection Zone	Radius of influence (r)	The zone around a borehole must be protected against potential impacts.
				Distance from river (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features
				Distance from wetland (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features.

IUA	Ground-water unit	RU	Sub-component	Indicator/ Measure	Consideration
MC – Schoon-spruit	**RU – G3**	**SK 1**	**Protection Zone**	Radius of influence (r)	The zone around a borehole must be protected against potential impacts.
				Distance from river (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features
				Distance from wetland (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features.
MC – Schoon-spruit; MF – Vaal; MA - Renoster	**Venters-dorp aquifers**	**VB 3, VB 5, SK 5, SK 6, SK 7 and R5**	**Quantity**	Water Level (metres below ground level) Water level (wl) recession rate Water use monitoring dataset	Groundwater level trends indicate the impact on groundwater saturations levels and once assessed it can be used to manage groundwater abstraction on an annual interval. This information is crucial for resource modelling.
			Quality	Nutrients – Nitrate (as Nitrogen) Annual water quality analysis	Prevent deterioration of water quality. Must support needs of water users.
				Electrical conductivity and specific macro elements for domestic use; Electrical Conductivity and Sodium Adsorption Ratio for Irrigation water use. Annual water quality analysis.	
				Toxics: specific trace metal constituents. Annual water quality analyses must be undertaken.	
			Protection Zones .	Microbial Radius (r) Annual water quality analysis	Groundwater quality must be for use and boreholes must be protected from microbial pollution
				Radius of influence (r)	The zone around a borehole must be protected against potential impacts.
				Distance from river (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features
				Distance from wetland (W)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features.

IUA	Ground-water unit	RU	Sub-component	Indicator/ Measure	Consideration
MA - Renoster, MB - Vals, MD1 - Upper Sand, MD2 - Lower Sand, ME1- Upper Vet, ME2 - Lower Vet, MF - Vaal to Bloemhof Dam	**Karoo aquifers**	**UV1, UV2, UV3, UV4, LV1, LV2, US2, US3, LS1, LS2, LS3, V2, V3, V4, V5, R2, R3, R4, R5, VB4, VB2, VB6**	**Quantity**	Water Level (m below ground level) Water level (wl) recession rate Water use monitoring dataset	Groundwater level trends indicate the impact on groundwater saturations levels and once assessed it can be used to manage groundwater abstraction on an annual interval. This information is crucial for resource modelling.
				Abstraction rate Q (mm/km^2/a) and recharge (mm/km^2/a). (Refer to Groundwater Resources Assessment Phase II or more recent updated recharge estimation in mm/km^2/a). Estimate local Stress Index, SI(%): SI(%)=Use (Q)/Recharge	
MA - Renoster, MB - Vals, MD1 - Upper Sand, MD2 - Lower Sand, ME1- Upper Vet, ME2 - Lower Vet, MF - Vaal to Bloemhof Dam	**Karoo aquifers**	**UV1, UV2, UV3, UV4, LV1, LV2, US2, US3, LS1, LS2, LS3, V2, V3, V4, V5, R2, R3, R4, R5, VB4, VB2, VB6**	**Quality**	Nutrients: Nitrate (as Nitrogen) Annual water quality analysis	Prevent deterioration of water quality. Must support needs of water users.
				Salts: Electrical conductivity and specific macro elements for all domestic use. Electrical Conductivity and Sodium Adsorption Ratio for Irrigation waters. Annual water quality analysis.	
				Toxics: Specific trace metal constituents Annual water quality analyses must be undertaken.	
			Protection Zones	Microbial Radius (r)	Groundwater quality must be for use and boreholes must be protected from microbial pollution
				Radius of influence (r):	The zone around a borehole must be protected against potential impacts.
				Distance from river (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features
				Distance from wetland (L)	To protect ecological systems that are groundwater fed, it is important to maintain the groundwater gradient to these features.

6 CONCLUSION

The previous sections detail the results of the prioritisation process for rivers, dams, wetlands and groundwater for the selection of proposed sub-components and indicators for the Middle Vaal WMA. This has been determined through the evaluation of available information and various considerations based on the understanding and expert knowledge of the Middle Vaal WMA. The process was supported by the input of specialists and stakeholders in the catchment area.

RQOs and numerical limits for the prioritised and selected rivers, dams and groundwater RUs and wetlands/wetland clusters will be determined as the next step of the process (Steps 5 of the RQO process) for the sub-components and indicators that have been prioritised above.

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