DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems Management

DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE UPPER ORANGE RIVER CATCHMENT

WATER RESOURCE CLASSES REPORT
WP 11422

Study Report No.

RDM/WMA13/00/CON/CLA/0225

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Reports as part of this project:

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4.0	RDM/WMA13/00/CON/CLA/0324	Linking the Socio-Economic and Ecological Value and Condition of the Water Resources Report
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7.0	RDM/WMA13/00/CON/CLA/0125	Scenarios and Consequences Report
8.0	**RDM/WMA13/00/CON/CLA/0225**	**Water Resource Classes Report**

TERMINOLOGY AND ABBREVIATIONS

Acronym	Description
BHN	Basic Human Needs
BYC	Borehole yield class
CD: WEM	Chief Directorate: Water Ecosystems Management
DCVB	Discontinuously Channelled Valley-Bottom
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FIFHA	Fish Invertebrate Flow Habitat Assessment Model
FMP	Flow Management Plan
FP	Floodplain
FRAI	Fish Response Assessment Index
GDP	Gross Domestic Product
GRU	Groundwater Resource Unit
HGM	Hydrogeomorphic
HSS	Hillslope Seep
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
MAP	Mean Annual Precipitation
MIRAI	Macroinvertebrate Response Assessment Index
Mm/a	Millimetres per annum

Acronym	Description
Mm^3	Million cubic metres
Mm^3/a	Million cubic metres per annum
m^3/s	Cubic metres per second
Na-Cl	Sodium chloride
NVD	Vioolsdrift/ Noordoewer Dam
ORS	Orange River System
PES	Present Ecological Sate
QC	Quaternary catchment
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RDM	Resource Directed Measures
SANBI	South African National Biodiversity Institute
SWSA	Strategic Water Source Area
TEC	Target Ecological Category
WARMS	Water Use Authorisation and Registration System
UCVB	Unchannelled Valley-Bottom
VB	Valley-Bottom
WMA	Water Management Area
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRU	Wetland Resource Unit
WRYM	Water Resource Yield Model
%	Percentage

EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems Management (WEM) of the Department of Water and Sanitation (DWS) is presently undertaking a study to determine Water Resource Classes and associated Resource Quality Objectives in the Upper Orange River catchment which falls within the Vaal-Orange Water Management Area (WMA 04).

The main objective of this study is to coordinate the implementation of the determination of water resource classes and associated resource quality objectives for all significant water resources in the Upper Orange River catchment within the Vaal-Orange Water Management Area (WMA04) in accordance with the Water Resource Classification System (WRCS)(DWA, 2010) and determine the associated RQOs for the prioritised units. This is aimed at facilitating the management and regulation of water resources to ensure efficient and sustainable use, a balance between protection and use, while maintaining ecological integrity and specifically maintaining or improving the present ecological state (PES) of the water resources, in the Upper Orange River catchment.

To date as part of the classification component of the project the following reports have been completed and have informed this report:

- Status Quo and delineation of Integrated Units of Analysis and Resource Units Report, RDM/WMA13/00/CON/CLA/0224
- Linking the Socio-Economic and Ecological Value and Condition of the Water Resources Report, RDM/WMA13/00/CON/CLA/0324,
- Ecological Water Requirements Report, RDM/WMA13/00/CON/CLA/0524, and
- Scenarios and Consequences Report, RDM/WMA13/00/CON/CLA/0125

The purpose of this report is to present and describe the rationale for the proposed water resource classes for the identified IUAs in the Upper Orange River catchments based on the outcomes of the scenario evaluation process and recommendations. The water resource classes presented in this report will be incorporated into the classification component of the Integrated Water Resource Management (IWRM) template which will be presented to the Minister for consideration. The results of this classification step will inform the RQO process being undertaken in parallel, to determine RQOs at a higher level of protection for these systems.

A summary of the Recommended Ecological Category (REC) which is the Ecologically Sustainable Base Case (ESBC) described in the Scenarios and Consequences Report (RDM/WMA13/00/CON/CLA/0125) and the proposed Target Ecological Category are shown in Table ES-1, highlighting that IUA 5 and IUA10, show a decrease in ecological category.

Table ES-1: Summary of REC and TEC at the hydronodes per IUA

Integrated Units of Analysis		EWR site (hydronode)	River	REC (ESBC)	TEC
1	**Golden Gate**	UO_EWR01_R	Little Caledon	**B/C**	**B/C**
2	**Caledon/ Leeu River**	UO_EWR01_I	Middle Caledon	**D**	**D**
3	**Caledon River**	UO_EWR04_I	Lower Caledon	**C/D**	**C/D**
4	**Kraai River**	UO_EWR08_I	Lower Kraai	**B/C**	**B/C**
5	**Upper Orange River**	UO_EWR02_I	Sterkspruit	**C/D**	**D**
		UO_EWR03_I	Upper Orange	**D**	**D**
6	**Gariep Dam**	No EWR site	No REC/ TEC has been set for this stretch of river as it is a sacrificial zone between the two dams with extremely artificial flows, making it impractical to set EWR		
7	**Seekoei River**	UO_EWR05_I	Seekoei	**C**	**C**
8	**Vanderkloof Dam**	UO_EWR10_I	Lower Orange Marksdrift	**C**	**C**
9	**Upper Modder River**	UO_EWR07_I	Upper Modder	**C/D**	**C/D**
10	**Modder-Riet Rivers**	UO_EWR06_I	Upper Riet	**C**	**C**
		UO_EWR09_I	Lower Riet	**B/C**	

Considering the scenarios evaluated and consequences and trade-offs, and using the approach set out in the water resource classification system guidelines which recommend that the water resource classes are determined considering the ecological categories of the biophysical nodes in an IUA, the following water resources classes are proposed (Table ES-2 and Figure ES-1)

Table ES-2: Proposed Water Resources Classes

Integrated Units of Analysis		Proposed Water Resource Class
1	**Golden Gate**	II
2	**Caledon/ Leeu River**	III
3	**Caledon River**	III
4	**Kraai River**	II
5	**Upper Orange River**	III
6	**Gariep Dam**	III
7	**Seekoei River**	II

Integrated Units of Analysis		Proposed Water Resource Class
8	**Vanderkloof Dam**	III
9	**Upper Modder River**	III
10	**Modder-Riet Rivers**	III

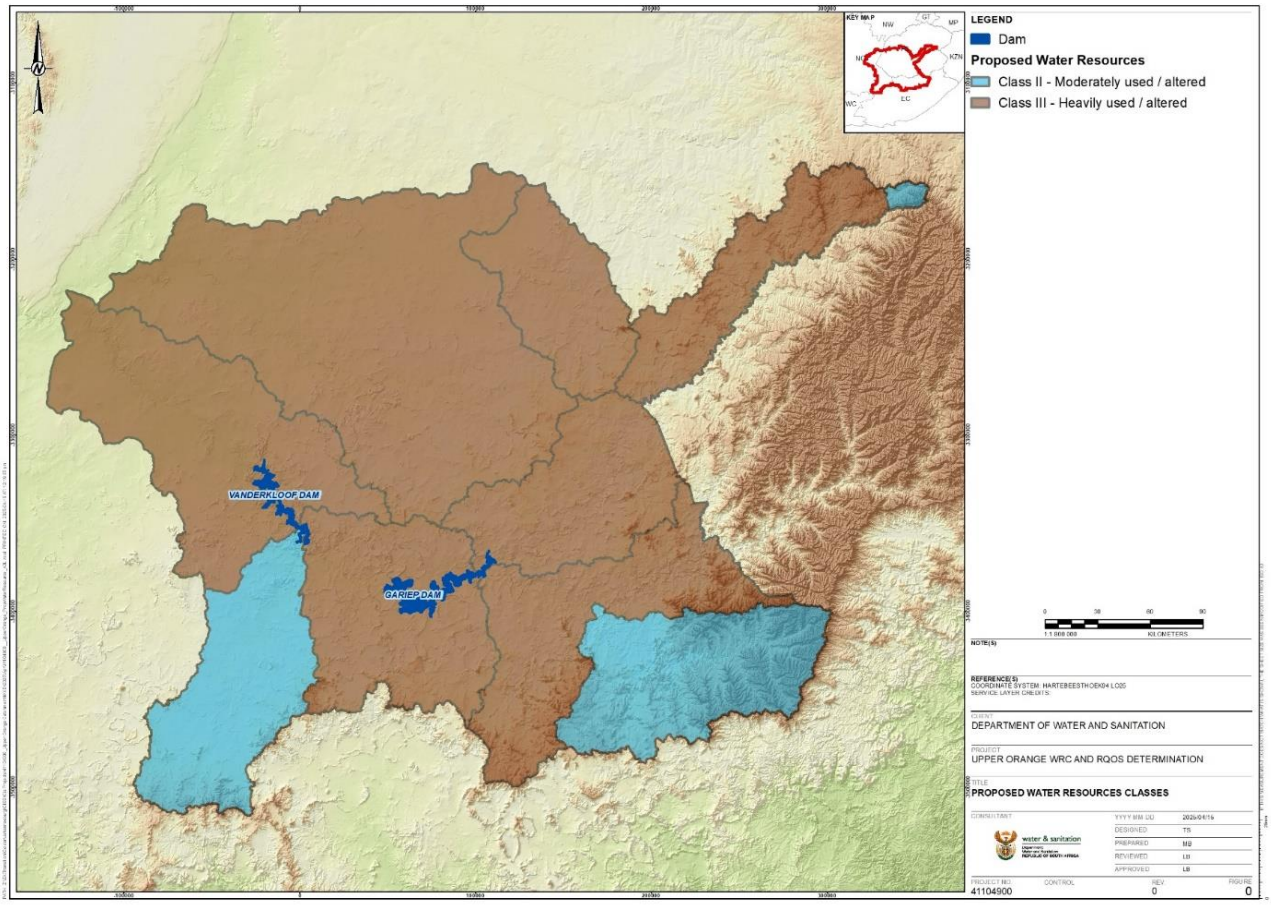

Figure ES-1: Proposed Water Resources Classes per IUA

The groundwater resource classification included groundwater usage (calculated stress index), groundwater quality status/ characteristics and aquifer vulnerability index, with the following results:

Integrated Unit of Analysis (IUA)	**Groundwater Resource Unit**	**Groundwater Quantity Class (Index)**	**Groundwater Quality Class (Index)**	**Aquifer Vulnerability Class (Index)**	**Final Groundwater Resource Classification[1] (Index)**	**Proposed Groundwater Resource Classification per IUA**
IUA 1 & 2	GRU 2.0	1	1	2	1	CLASS 1 (Ideal-Good)
UIA 3	GRU 3.0	2	1	3	2	CLASS 2 (Marginal)
UIA 4	GRU 4.0	2	1	2	2	CLASS 2 (Marginal)
UIA 5	GRU 5.1	1	1	2	1	CLASS 1 (Ideal-Good)
	GRU 5.2	2	2	1	2	CLASS 2 (Marginal)
UIA 6	GRU 6.0	2	1	2	2	CLASS 2 (Marginal)
UIA 7	GRU 7.1	1	1	3	1	CLASS 1 (Ideal-Good)
	GRU 7.2	1	1	3	1	CLASS 1 (Ideal-Good)
UIA 8	GRU 8.1	1	1	2	1	CLASS 1 (Ideal-Good)
	GRU 8.2	1	2	1	1	CLASS 1 (Ideal-Good)
	GRU 8.3	1	2	1	1	CLASS 1 (Ideal-Good)
UIA 9	GRU 9.1	2	2	1	2	CLASS 2 (Marginal)
	GRU 9.2	3	3	1	3	CLASS 3 (FAIR TO POOR)
UIA 10	GRU 10.1	2	1	1	2	CLASS 2 (Marginal)
	GRU 10.2	2	1	1	2	CLASS 2 (Marginal)
	GRU 10.3	1	2	1	1	CLASS 1 (Ideal-Good)

Notes:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

Insignificant: 0.0-0.1 L/s;

Low: 0.1-0.5 L/s;

Moderate: 0.5-2.0 L/s;

High: 2.0-5.0 L.s; and

Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions.

Recommendations made for each IUA will be taken forward for consideration during the RQO process.

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1 INTRODUCTION

1.1. Background

The Chief Directorate: Water Ecosystems Management (CD: WEM) initiated the study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Upper Orange River Catchment (Figure 1) which falls within the Vaal-Orange Water Management Area (WMA 04).

Water Resource Classification, the Reserve and Resource Quality Objectives (RQOs) are protection-based measures that make up Resource Directed Measures (RDM), the protection principles contained in Chapter 3 of the National Water Act (Act No. 36 of 1998). Resource Directed Measures are intended to ensure comprehensive protection of all water resources. Protection relates to the quantity and quality (overall health) of the water resource. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical, and affordable. Once the water resource class and the Reserve have been established, RQOs are determined to give effect to those water resource classes and the Reserve. The DWS has progressively set water resource classes for all significant water resource systems in South Africa to ensure their protection and sustainable use, and the Orange River System (ORS) is the last system that requires classification and setting of RQOs.

The Upper and Lower Orange River catchment studies are being undertaken separately, however in parallel, with continuous liaison. This was particularly important for the outcomes of the scenarios assessment and trade-off analysis component of the study where what happens in the upper catchment can have an impact on the lower catchment and vice versa.

1.2. Study Objective

The main objective of this study is to coordinate the implementation of the determination of water resource classes and associated resource quality objectives for all significant water resources in the Upper Orange River catchment within the Vaal-Orange Water Management Area (WMA04) as described in the revised reconfiguration that was gazetted as part of the National Water Resources Strategy 3 (NWRS3) under Gazette Notice 49225, dated 1 September 2023, in accordance with the Water Resource Classification System (WRCS)(DWA, 2010).

This is aimed at facilitating the management and regulation of water resources to ensure efficient and sustainable use, a balance between protection and use, while maintaining ecological integrity and specifically maintaining or improving the present ecological state (PES) of the water resources, in the Upper Orange River catchment.

Appropriate integration with water resource planning and management processes, as well as cooperation among stakeholders, will be key success factors in setting the water resource classes and RQOs. The outcomes of the process will result in the protection framework for the catchment that will guide actions, interventions, and needs, to ensure a sustainable water resource system that is able to balance water use and protection.

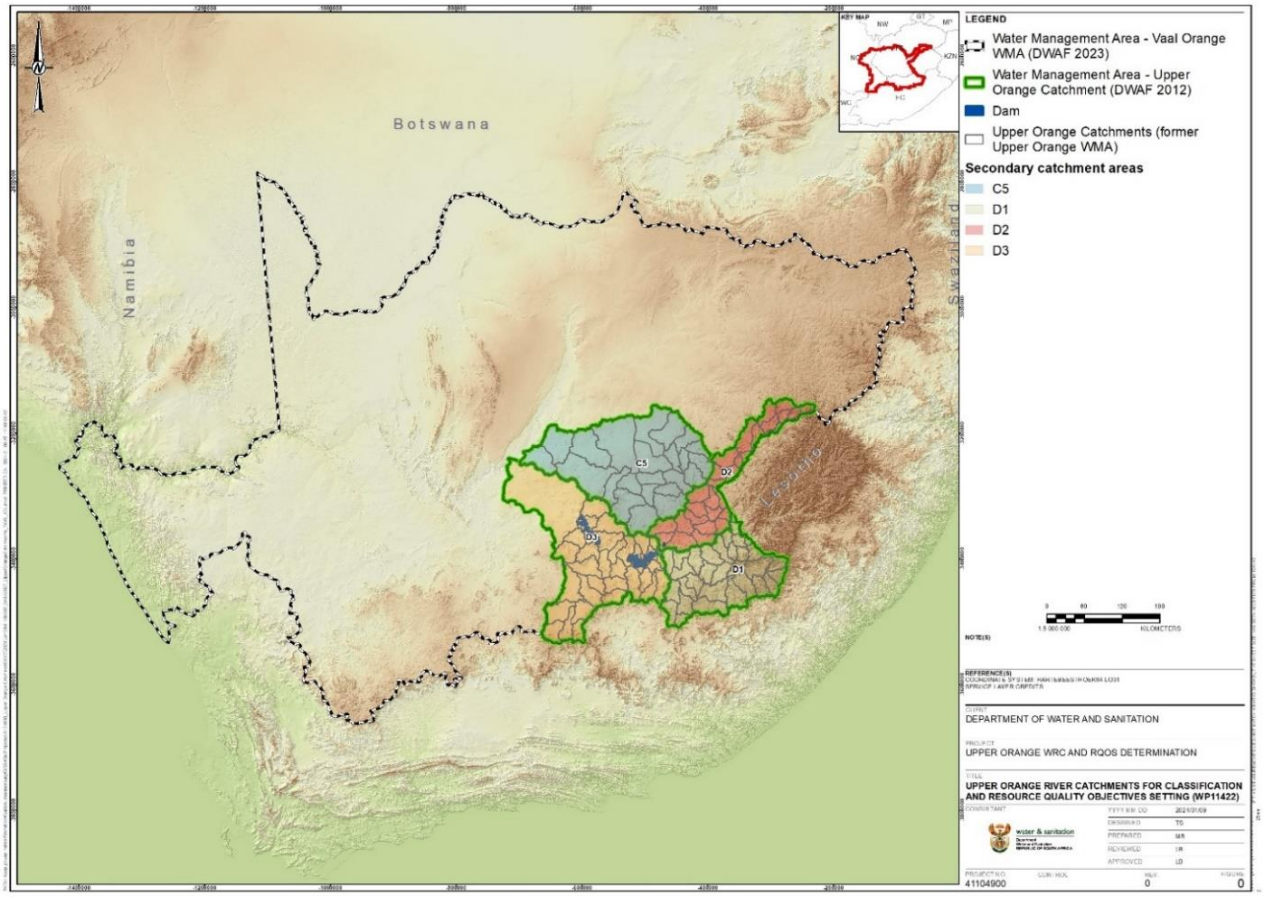

Figure 1: Upper Orange River catchment within Vaal-Orange Water Management Area (WMA04) in South Africa

The classification process includes the 7 steps illustrated in Figure 2, with the associated reports being relevant.

In terms of this process, the approach undertaken by the study team for implementation has included the following:

- As part of the status quo assessment of the Upper Orange River Catchment, the catchment was delineated into ten Integrated Units of Analysis which are described further in Section 4.2.
- The Ecological Water Requirements quantification was based on the 2024 Reserve determination study conducted for the Upper Orange River catchment (DWS, 2023).

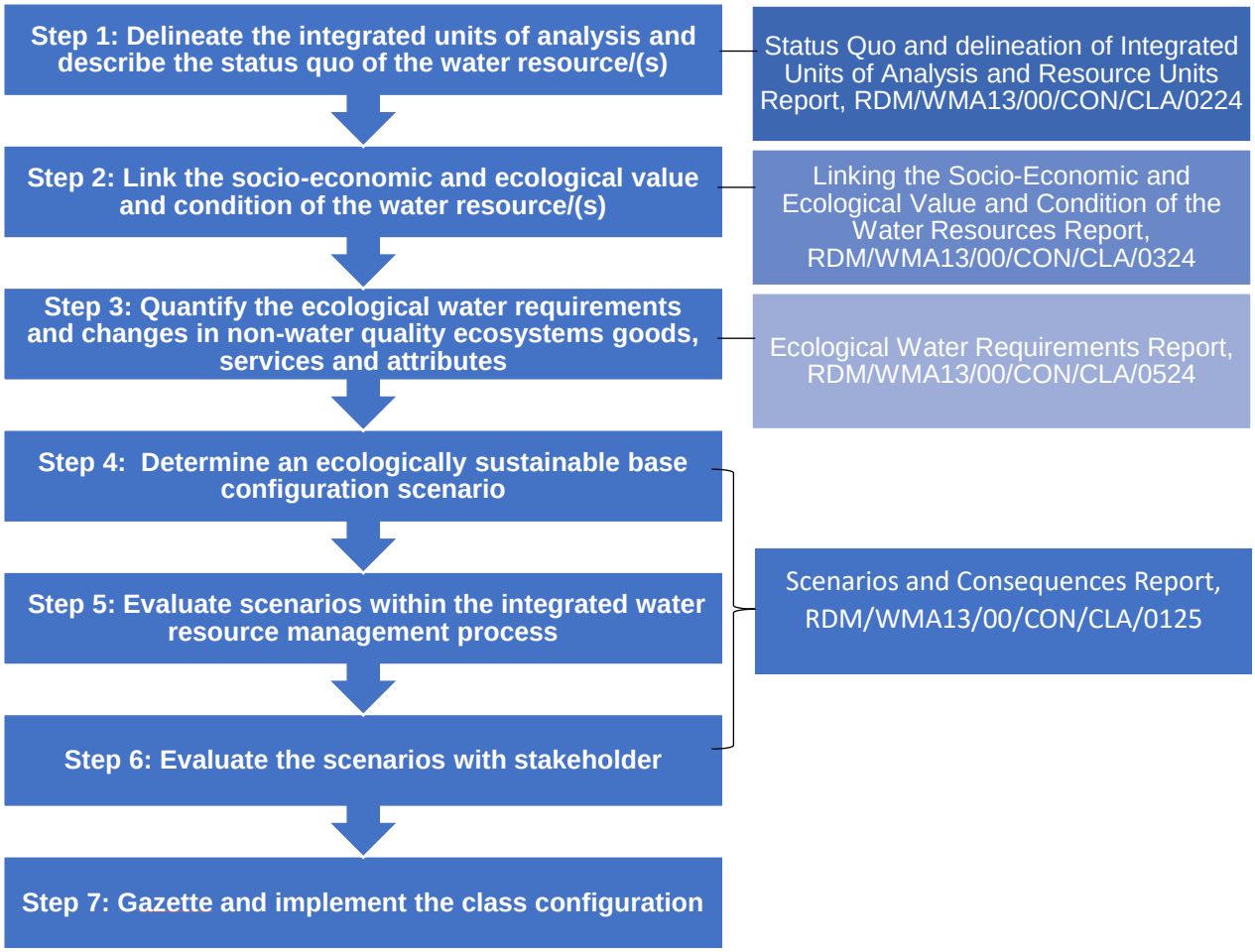

Figure 2: Study process followed for classification of water resources in the Upper Orange River catchment and associated outputs

- The Ecologically Sustainable Base Case (ESBC) scenario, which could permit the maximum water use scenario, requires that the base condition for each water resource is at minimum established as either a D category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However, where the ecological condition requires it, a higher ecological category needs to be set. The ESBC scenario is established once this base condition is hydrologically and ecologically tested to ensure that it is feasible and can be achieved. In other words, the results will reflect whether the catchment water balance would be in surplus or deficit by implementing a D category EWR. In terms of the Upper Orange River catchment, the D ecological category was not selected as the default ESBC. Rather the selected ecological category per IUA is the Present Ecological State (PES). Additional to the establishment of the ESBC, the Recommended Ecological Category (REC) was also determined as an alternate scenario at the nodes.
- The scenarios analysis included of the following proposed scenarios:

  - Current scenario (2025) including the key current infrastructure developments in the Orange River System
  - Future development scenarios
  - A medium-term scenario (2040), and
  - A long-term scenario (2060).
- Water Resources Planning Model (WRPM) analysis and adjustment
- Reporting of ecological consequences and IUA- level ecological condition using the Fish Invertebrate Flow Habitat Assessment (FIFHA) model. It is important to note that the FIFHA model has limitations in that there is only one metric, flow, while the FRAI/ MIRAI models consider all 3 metrics (habitat, water quality and flow), thus these limitations are also noted in Upper Orange.
- Assessment of water quality implications using load assessment and impacts.
- Description of the macro-economic implications
- Evaluation of the overall scenario implications for the Upper Orange River catchment in alignment with the Lower Orange River catchment
- Selection of a subset of recommended scenarios as set out in the Scenarios and Consequences Report, RDM/WMA13/00/CON/CLA/0125.
- The IUA water resource classes associated with these scenarios are presented in this report. The approach applied to determining the proposed water resource class for each of the IUAs was to follow the guidelines of the WRCS (DWA, 2007).

1.3. Purpose of this Report

The purpose of this report is to present and describe the rationale for the proposed water resource classes for the identified IUAs in the Upper Orange River catchments based on the outcomes of the scenario evaluation process and recommendations.

The water resource classes presented in this report will be incorporated into the classification component of the Integrated Water Resource Management (IWRM) template which will be presented to the Minister for consideration.

The results of this classification step will inform the RQO process being undertaken in parallel, to determine RQOs at a higher level of protection for these systems.

1.4. Study area

The Upper Orange River catchment comprises four sub-catchments (Figure 3) stretching across the Northern Cape, Free State and Eastern Cape provinces and across three ecoregions, the Eastern Escarpment Mountains, Nama Karoo and Highveld:

- The Caledon River from its headwaters and its tributaries to the Gariep Dam (Secondary catchment D2)

- The Orange River from the Lesotho Border to the Gariep Dam, including the main tributaries namely Kornetspruit, Sterkspruit, Stormbergspruit and Brandwaterspruit, and the Kraai River catchment (D1 secondary catchment), and
- The Orange River from the Gariep Dam, through Vanderkloof Dam to Marksdrift weir, just before the confluence with the Vaal River, including the Seekoei River in the south (D3 secondary catchment), and
- The Modder-Riet River (main tributaries of the Vaal River system) in the north (C5 secondary catchment). Although the Modder/Riet rivers are tributaries to the Vaal River, this catchment and related sub-systems are seen as part of the Orange River System due to transfers and support from the Orange to the Modder/Riet catchment.

Table 1: Sub-catchment areas of the Upper Orange River catchment

Secondary Catchment	Tertiary Catchment	Quaternary catchments	Main River/(s)	Catchment area(1) (km²)	
				Gross	Net
C5	C51	C51A – H, C51J - M	Fouriespruit, Ruisterspruit, Ospoortspruit, Kromellemboogspruit, Rietspruit	17 449	12 166
	C52	C52A – H, C52J - L	Wildebeesspruit, Sepane, Osspruit, Modder River	17 366	8 572
D1	D12	D12A - F	Winnaarspruit, Kromspruit, Wilgespruit	2 967	2 967
	D13	D13A – H; D13J - M	Bell, Langkloofspruit, Dierspruit, Wasbankspruit, Holspruit, Skulpspruit, Kraai River	9 354	9 354
	D14	D14A – H, D14J and K	Orange River	6 145	6 145
	D15	Portions of D15G and H	Makhaleng (lower reaches shared with Lesotho), Unnamed tributaries	846	846
	D18	Portion of D18L and K	Tele (shared with Lesotho), Blikana	1 545	1 545
D2	D21	D21D, D21E, D21F, D21G, portion of D21A and D21H	Caledon River Little Caledon	1 659	1 659
	D22	D22A, D22B, portions of D22C and D22D,	Meulspruit, Brandwater/ Groot,	4 369	4 369

Secondary Catchment	Tertiary Catchment	Quaternary catchments	Main River/(s)	Catchment area[(1)] (km^2)	
				Gross	Net
		D22G, portions of D22H and D22J	Rantsho; Mopeli		
	D23	Portion of D23A, E, F and G; D23C, D23D, D23H, D23J	Montsoane, Maseng, Tsoaning Leeu River, Rietspruit	4 910	4 910
	D24	D24A – G, D24H, D24J - L	Witspruit, Wilgeboomspruit, Grahamstadspruit, Slykspruit, Edon River, Skulpspruit	6 614	6 614
D3	D31	D31A - E	Berg River, Orange River,	4 910	4 396
	D32	D32A – H, D32J and K	Seekoei River	9 081	9 081
	D33	D33A – D33K	Orange River	9 598	3 404
	D34	D34A - G	Orange River	5 020	5 020
	D35	D35A – H, D35J and K	Brandspruit, Brakspruit, Bossiespruit, Suurbergspruit, Orange River	5 638	5 638

[1]WR2012 data

The Caledon River (also called the Mohokare River along the Lesotho/ South Africa border) forms the north-western boundary of Lesotho with South Africa and is the first major tributary of the Orange River with their confluence in the upper reaches of the Gariep Dam. Other large tributaries that contribute to the flow in the Upper Orange River catchment are the Makhaleng (although only the lower reaches within South Africa) and Kraai Rivers. Although the Seekoei River has a large catchment, the runoff is very low as it forms part of the drier Karoo area.

The Modder and Riet Rivers, tributaries of the Vaal River are also part of the study area due to the interconnectedness of these systems through water transfers.

The main storage dams in the Upper Orange River catchments are Gariep and Vanderkloof dams on the Orange River. Smaller dams in the study area are Welbedacht Dam in the Caledon River, Jozanas Hoek Dam on the Sterkspruit, Rustfontein, Mockes, and Krugersdrift Dams in the Modder River with the Tierpoort and Kalkfontein Dams in the Riet River. The Gariep Dam, Vanderkloof Dam, Orange-Fish Tunnel, Orange Vaal transfer canal and Orange-Riet Canal system are all part of the Orange River Project.

Groundwater occurrences in the Upper Orange River catchment occurs predominantly as shallow (<65 m thick) aquifer systems in the Karoo Supergroup sedimentary sequence (as primary rock formation). In most of the water management area, secondary Karoo Dolerite intrusions in the form of (i) sub-vertical dikes and (ii) semi-horizontal sills are present which enhances the yield potential of the primary aquifer system. In a few cases, specific aquifer yield potentials can be significantly enhanced by occasional flooding of local surface water drainages, especially where these drainages are mature, and alluvial sedimentation has developed overlying the Karoo rocks.

There are seven wetland types, often in wetland complexes: flats, floodplains, depression wetlands, unchanneled valley-bottom wetlands, seeps, and channelled valley bottom wetlands. There are several high-altitude wetland complexes that are characterised by unique vegetation assemblages.

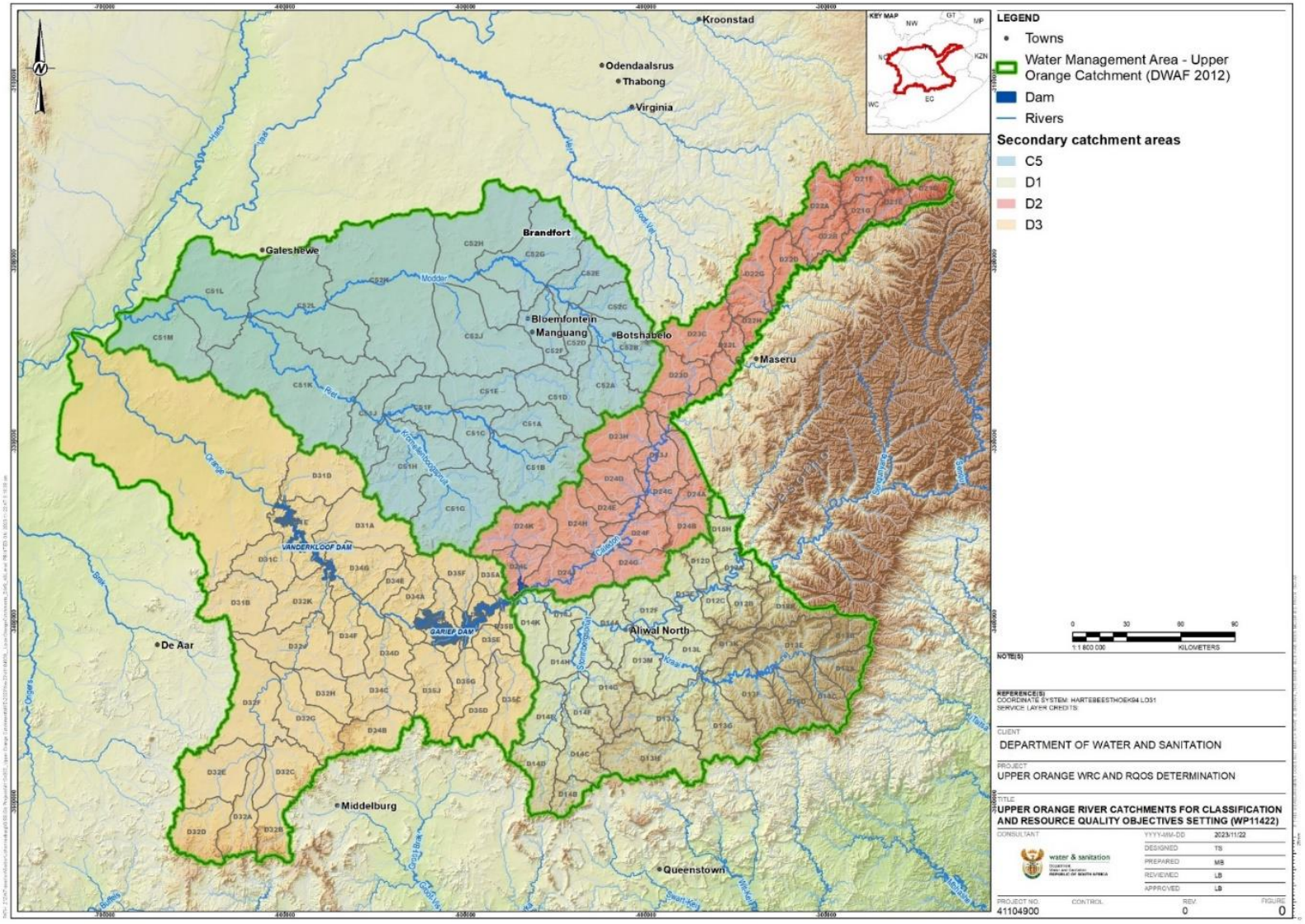

Figure 3: Upper Orange River sub-catchments

2 SUMMARY OF THE SCENARIOS AND CONSEQUENCES FOR THE UPPER ORANGE RIVER CATCHMENTS

Table 2 summarises the scenarios that were evaluated. Details of the approach followed, and the outcomes are included in Report: Scenarios and Consequences Report, RDM/WMA13/00/CON/CLA/0125. summarises the ecological and socio-economic consequences.

Table 2: Summary of the scenarios evaluated

Scenario ID	Scenario Name	Time slice / development level	Interventions included [1]	Operations
0	Natural	N/A	None	N/A
1a	Present day without EWRs	2020	As per present day (excl. LHWP2).	Supply to users prioritised
1b	Present day with EWRs	2020	As per present day (excl. LHWP2)	EWR prioritised
1c [2]	Present day with adjusted EWRs	2020 - 2028	Preliminary EWRs to align with ORS yield impact for lower Orange. River management plan	Short-term or phasing in option (until system is augmented).
2a	Medium term without EWRs	2040	LHWP2-Polihali, Vioolsdrift (size option 2 – 700 million m^3), Gariep to Bloem pipeline	Supply to users prioritised
2b	Medium term with EWRs	2040	LHWP2-Polihali, Vioolsdrift (size option 2 – 700 million m^3), Gariep to Bloem pipeline	EWR prioritised
2.1a	Medium term alternative without EWRs	2040	LHWP2-Polihali, Vioolsdrift (size option 3 – 2800 million m^3), Gariep to Bloem pipeline	Supply to users prioritised
2.1b	Medium term alternative with EWR	2040	LHWP2-Polihali, Vioolsdrift (size option 3 -2800 million m^3), Gariep to Bloem pipeline	EWR prioritised
3a	Long term without EWRs	2060	LHWP2-Polihali, Vioolsdrift (size option 2), Gariep to Bloem pipeline, with Verbeeldingskraal,	Supply to users prioritised
3b	Medium term with EWRs	2060	LHWP2-Polihali, Vioolsdrift (size option 2), Gariep to Bloem pipeline, with Verbeeldingskraal	EWR prioritised
3.1a [3]	Long term alternative 1 without EWRs	2060	LHWP2-Polihali, Vioolsdrift (Size option 2), Gariep to Bloem pipeline, Verbeeldingskraal and Makhaleng Dam	Supply to users prioritised
3.1b [3]	Long term alternative 1 with EWRs	2060	LHWP2-Polihali, Vioolsdrift (Size option 2), Gariep to Bloem pipeline, Verbeeldingskraal and Makhaleng Dam	EWR prioritised
3.2a	Long term alternative 1 without EWRs	2060	LHWP2-Polihali, Vioolsdrift (Size option 1), Gariep to Bloem pipeline, Boskraai Dam and Makhaleng Dam	Supply to users prioritised
3.2b	Long term alternative 1 with EWRs	2060	LHWP2-Polihali, Vioolsdrift (Size option 1), Gariep to Bloem pipeline, Boskraai Dam and Makhaleng Dam	EWR prioritised
3.3a [4]	Long term alternative 3 without EWRs		LHWP2-Polihali, Vioolsdrift (size option 4 – 1200 million m^3), Gariep to Bloem pipeline, with Verbeeldingskraal,	Supply to users prioritised

Scenario ID	Scenario Name	Time slice / development level	Interventions included [1]	Operations
3.3b [4]	Long term alternative 1 with EWRs		LHWP2-Polihali, Vioolsdrift (size option 4 – 1200 million m^3), Gariep to Bloem pipeline, with Verbeeldingskraal,	EWR prioritised

Notes:

[1] The intervention options align with the large dam development options presented in Table 3 of the Scenarios and Consequences Report, Report Number: RDM/WMA13/00/CON/CLA/0125*.*

[2] Scenario 1c will be run and tested as a part of the implementation of the EWRs, once the trade-offs have been confirmed based on the longer-term realities and projections. This will be an interim scenario aimed at trying to mitigate possible short-term issues until the larger interventions are implemented and is thus an implementation focused matter.

[3] This scenario includes additional consumptive water use through a transfer to Botswana and greater local water use for irrigation. It is thus not directly comparable with Scenario 3a, but still an important scenario to assess with the increased levels of catchment development and use.

[4] A larger size of Vioolsdrift/ Noordoewer Dam (NVD) was tested of 1 200 Mm^3 rather than the 2 800 Mm^3 as the feasibility study already raised concerns of the larger dam on the estuary, and the 2800 size has been included in Scenario 2.1.

Table 3: Summary of the ecological and social consequences for the REC and showing the Target Ecological Category (TEC)

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
1	**Golden Gate**	UO_EWR01_R	Little Caledon	**B/C**	**B/C**	Flows under present day conditions (Scenario 1a) for the selected indicator species/taxon during the wetter months - support critical habitats at levels reflective of natural flows and exceeded those specified for the REC. ***Insufficient for meeting the REC during drier months***, significant reduction in habitat suitability for the selected indicator species Fish - connectivity for spawning migrations is needed and the spawning habitat must be available. Implementing the EWR improves the system by ensuring flows during the drier months are better and match the habitat needs of macroinvertebrates with specific flow preferences. Water quality impacts. ***Overall, implementing the EWR is recommended to ensure flows remain adequate and ecological balance is maintained***.	No changes in the volumes of water supplied within the IUA with the implementation of the EWR flows and there are no resulting economic trade-offs for the present day, medium term or long-term scenarios
2	**Caledon/ Leeu River**	UO_EWR01_I	Middle Caledon	**D**	**D**	Scenario flows, with or without EWR, generally align with the flow preferences of the indicator species/taxon. Although a ***stronger positive response when EWR is implemented***. The proposed weirs reduce instream continuity and cause instream modifications, particularly affecting fish and impeding flow. Despite these impacts, the ***flows remain sufficient to meet the overall REC of a D***. It is crucial to highlight that water quality is the primary driver in this reach, coupled with limited habitat availability. Fine silts passing through the system remain a concern, as they clog the gills of both fish and macroinvertebrates. Additionally, the proposed weirs may trap coarse materials like gravel, which are vital habitats for biotic communities.	Very small changes in the volumes of water supplied within the IUA with the implementation of the EWR flows for both urban (domestic/mine) and irrigation users, however these would not result in any significant economic trade-offs in the present day, medium term or long-term scenarios.

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
3	**Caledon River**	UO_EWR04_I	Lower Caledon	**C/D**	**C/D**	Scenario flows, with or without EWR, generally align with the flow preferences of the indicator species/taxon. Biota shows a ***stronger positive response when EWR is implemented***. The proposed weirs reduce instream continuity and cause instream modifications, particularly affecting fish (migration and embedded spawning habitat) and impeding flow. Despite these impacts, the flows remain sufficient to meet the overall REC of a C/D. It is crucial to highlight that water quality is the primary driver in this reach, coupled with limited habitat availability. Fine silts passing through the system remain a concern, as they clog the gills of both fish and macroinvertebrates. Additionally, the proposed weirs may trap coarse materials like gravel, which are vital habitats for biotic communities.	When the EWR is implemented, there will be an impact on the agricultural sector with less water available for irrigation with associated economic trade-offs.
4	**Kraai River**	UO_EWR08_I	Lower Kraai	**B/C**	**B/C**	Flows under present-day conditions (Scenario 1a) during wetter months support critical habitats for the selected indicator species required for the REC of a B/C. Present-day flows during drier months fall short of achieving the REC of a B/C, leading to a significant reduction in habitat suitability. Implementing the EWR under the current scenario (Scenario 1b) improves conditions by providing flows in both seasons that better align with the habitat needs of biota with specific flow preferences. ***If the Boskraai Dam is constructed in the future without implementing the EWR, flow requirements during both seasons will not be met for fish or macroinvertebrates***, raising serious ecological concerns. To ensure adequate flows and maintain ecological balance under either scenario (present or future), implementing the EWR is strongly recommended. If this is not feasible and trade-offs are required, an Alien Invasive Plant (AIP) eradication programme should be prioritised. Extensive AIP	Implementing the EWR in this IUA will have an impact on the irrigation sector. The impacts to the agricultural economy because of potential supply deficits to irrigation users is seen in the present day, medium- and long-term scenarios.

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
						infestations along the Kraai's riparian zone currently reduce baseflows. Over time, eradication efforts could help restore some baseflows, potentially improving flow and thus biotic responses.	
5	**Upper Orange River**	UO_EWR02_I	Sterkspruit	**C/D**	**D**	Flows under present-day (Scenario 1) and future (Scenario 2) conditions, with or without EWR implementation, are insufficient for fish and macroinvertebrates during the dry season and for fish during the wet season, primarily due to limited releases from Jozana's Hoek Dam. These deficits negatively impact critical habitats despite the presence of suitable biotopes. Indicator fish species respond to Scenario 1b and 2b flows with a rating of "D," falling short of the REC of a C/D. The flows compromise fish migration and spawning during the critical summer high-flow period. In addition to the flow requirements not being met, both fish and macroinvertebrate health are predominantly influenced by water quality (non-flow driver). The PES of the fish and macroinvertebrate community was rated as D/E (largely to critically modified) and "D" (largely modified) respectively, indicating the significant impact of this non-flow driver on their ecological state. Overall, priority should focus on maintaining suitable conditions during March to support spawning rather than addressing low-flow periods e.g. July.	Implementation of the EWR will have an impact on the irrigation sector. The impacts to the agricultural economy as a result of potential supply deficits to irrigation users is seen only in the present-day scenario. In the medium term and long-term scenarios there are very small changes in supply volumes, with EWR allocation, for irrigation users. These changes in supply volumes represent less than 1% of the total supply volume across the IUA without the implementation of EWR and would not result in any significant economic impacts.
		UO_EWR03_I	Upper Orange	**D**	**D**	Scenario flows, with or without EWR implementation, generally align with the indicator biota flow preferences, even under future dam proposals. Increased flows in months like February contribute to habitat scouring and sediment mobilisation. However, as highlighted by the limitations of FIFHA, the model does not account for poor habitat availability and water quality, which are the primary non-flow drivers of ecological conditions at this	

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
						Upper Orange EWR site. These factors were therefore considered when interpreting the FIFHA results. Although the FIFHA indicates adequate flows for the indicator species/taxon, ecological conditions are likely to remain constrained if the proposed upstream dams (e.g., Verbeeldeingskraal, Pohlihali, and Makhaleng) are constructed. These dams will trap more sediment, particularly coarse material such as gravel, which is critical for biotic habitats. Fine sediments will continue to pass through the system, increasing turbidity, sediment deposition, and embedding of available rocky habitats. These changes clog the gills of biota, restrict riparian zones, encourage the spread of AIP, and degrade biotic responses. This underscores the importance of addressing non-flow drivers, such as improving water quality, to support ecological health effectively.	
7	**Seekoei River**	UO_EWR05_I	Seekoei	**C**	**C**	Scenario flows, with or without EWR implementation, generally align with the flow preferences of the biota. However, biota respond more favourably when the EWR is implemented. Since no changes to the main drivers are proposed, the macroinvertebrate and fish communities are unlikely to change in the absence of developments. Notably, deficits in the system during March (from the 15% to the 90% exceedance levels) result in insufficient flow to meet the EWR. However, as the system is ephemeral and such deficits are expected.	Implementation of the EWR may impact irrigation users - present day, medium term and long-term scenarios.
8	**Vanderkloof Dam**	UO_EWR10_I	Lower Orange Marksdrift	**C**	**C**	Scenario flows, with or without EWR implementation, generally align with the flow preferences of indicator biota, even under future dam proposals. Increased flows during months like February play a key role in habitat scouring and sediment mobilisation. While the FIFHA indicates adequate flows for the indicator species/taxon, ecological conditions are likely to remain constrained if	There are changes to irrigation supply volumes, albeit small in relation to the total supply volumes within the IUA in the present-day scenario and in

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
						proposed upstream dams (e.g., Verbeeldingskraal, Pohlihali, and Makhaleng) are constructed. These dams will trap coarse sediment, such as gravel, which is crucial for biotic habitats, while fine sediments will continue to increase turbidity, sediment deposition, and the embedding of rocky habitats. These changes adversely impact biota by clogging gills (physiological stress impacting on reproduction), narrowing riparian zones, promoting alien invasive plants, and degrading ecological responses. Addressing non-flow drivers, such as improving water quality, is therefore critical in maintaining ecological health. In addition to the above, to protect geomorphology and riparian vegetation, it is essential to implement the floods specified in the Reserve determination study. Failure to do so would have detrimental effects on these ecological components and thus may have a knock-on effect on the biotic component. *Although the scenario flows at this EWR site near Marksdrift are meeting the REC of a Category C. There is a concern regarding the limited bigger floods of approximately 155 and 550m3/s (October to April) that have been removed. This will have a major impact on the geomorphological and riparian vegetation components of the system, which will have a knock-on effect on the instream biota (ecological trade-off). The lack of large floods will be insufficient to effectively scour habitats, mobilise sediments, and transport gravel and reset marginal vegetation, which are critical processes for maintaining ecosystem health. While the results from the FIFHA indicate that the flow requirements for the indicator species or taxa are being met, it is important to acknowledge that the reduced freshet may not fully support key ecological functions. Therefore, careful consideration must be given to the potential impacts of*	the first medium term scenario. When the EWR is implemented, there will be an impact on the agricultural sector with less water available for irrigation

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
						this lower-than-ideal freshet on habitat maintenance and overall river system dynamics.	
9	**Upper Modder River**	UO_EWR07_I	Upper Modder	**C/D**	**C/D**	Scenario flows, with or without EWR implementation, generally align with the flow preferences of the biota. In fact, flows are higher owing to releases from upstream WWTW. However, it is important to note that flow is not the primary driver in this system; water quality is the dominant factor influencing ecological health. This critical aspect is not accounted for in the FIFHA model, which focuses primarily on flow metrics. The poor water quality in the system has a significant impact on biota, affecting their ability to thrive and altering ecological conditions. These impacts include reduced habitat suitability, physiological stress on species, and the potential for long-term degradation of biotic communities. Addressing water quality issues is therefore essential to improve the ecological state of the system, even where flows are deemed adequate.	Changes to irrigation supply volumes, albeit small in relation to the total supply volumes within the IUA in the present-day scenario and in the first medium term scenario. When the EWR is implemented, there will be an impact on the agricultural sector with less water available for irrigation
10	**Modder-Riet Rivers**	UO_EWR06_I	Upper Riet	**C**	**C**	Scenario flows, with or without EWR implementation, generally align with the flow preferences of the biota.	Implementation of the - impact on the irrigation users. The impacts to the agricultural economy because of these potential supply deficits to irrigation users is seen in the present day, medium term and long-term scenarios. When the EWR is implemented, the impact on the agricultural sector will
		UO_EWR09_I	**Lower Riet**	**B/C**[1]		Flows under present-day (Scenario 1) with or without the EWR implemented, do not meet the flow requirements for the specified indicator species/taxon during the wet season (March). The biota's responses in these scenarios fall between categories C's and D's, which do not meet the overall REC of a B/C. However, during the dry season, the indicator biota responds positively to the available flows, indicating that conditions are more favourable during this period. The negative responses observed during the wet season are of particular concern, as they directly affect the migration and spawning movements of the indicator fish	

IUA		EWR Site	River	Ecological Category		Ecological consequences	Socio-economic consequences
				REC (ESBC)	TEC		
						species. The lack of adequate flow cues during this critical period prevents these species from accessing suitable habitats for spawning (physiological responses). Under Scenarios 2 and 3, there is only a slight improvement in biota responses, but they still do not meet the REC of B/C, with most results falling into the C category during the wet season. However, dry season results remain adequate. As a result, there will be a minor ecological trade-off during wet periods, though this impact would be reduced if the TEC were adjusted to a C category. Maintaining overall habitat suitability at this site is crucial, as the upper reaches serve as key refugia for fish species. This will support the long-term ecological health of the system.	be less water available for irrigation

Note 1: *While the Ecostsus was found to be a C, the EWR study (see Report: RDM/WMA13/00/CON/CLA/0524) suggested that a REC of a B/C (close to largely natural most of the time) can be achieved, as long the upstream water quality aspects related to WWTW discharges were improved. It was noted that this should be tested during trade-offs.*

3 APPROACH TO DETERMINATION OF WATER RESOURCE CLASSES IN THE UPPER ORANGE RIVER CATCHMENT

The determination of a class for a water resource represents the first stage in the water resource protection process. The water resource class essentially describes the desired condition of the resource, along with the degree to which it can be utilised. In terms of the water resource classification system, Regulation 810 (Government Gazette No. 33541), the water resource classes will range from minimally to heavily used, as defined:

- ***Class I*** - minimally used and configuration of ecological categories of that water resource minimally altered from its pre-development condition
- ***Class II*** - moderately used and configuration of ecological categories of that water resource moderately altered from its pre-development condition; and
- ***Class III*** - heavily used and configuration of ecological categories of that water resource significantly altered from its pre-development condition.

The implementation of the water resource classification system in the Upper Orange River catchments, has to this point presented recommended scenarios specifying an ecological condition per IUA (ecological categories based on the scenario analysis and evaluation). The final step requires the summarising of this data into an IUA Class.

The water resource classification system guidelines (DWA, 2007) recommend that the water resource classes are determined considering the ecological categories (ECs) of the biophysical nodes in an IUA. Among other methods, the guidelines recommend the application of Table 4 where the percentage of biophysical hydronodes falling into the indicated EC groups determines the IUA's water resource class.

Table 4: Preliminary guidelines for determining the IUA class for a scenario (DWA, 2007)

		Percentage (%) nodes in the IUA falling into the indicated groups				
		A or A/B	B or B/C	C or C/D	D	>D
Class I		60	40	20	1	-
Class II			60	30	5	-
Class III	Either			70	20	-
	Or				100	-

In order to apply the preliminary guidelines of the water resource classification system (Table 4) to arrive at a water resource class, the desired ecological conditions of the water resources in the catchments need to be determined within the context of the integrated water resource management dynamics in the catchment. Various configurations of ecological condition, socioeconomics, water resource availability and water quality were therefore assessed by the scenario evaluation task of the study (DWA, 2007). Results for the scenario analysis are detailed in Report RDM/WMA13/00/CON/CLA/0125.

The recommended scenarios are associated with an ecological condition for the water resources, and this is translated into the water resource class for the IUA.

The PES and REC ecological category representations for each node, which in the case of the Upper Orange River catchments are the EWR sites within an IUA, are summarised into a water resource class for the IUAs within the Upper Orange River catchments. This is presented in Section 4 of the report.

To broadly interpret the preliminary guidelines indicated above, the link between ecological categories and the water resource classes may be defined as follows:

- Class I – Mostly B ecological category water resources and higher
- Class II - Mostly C ecological category water resources; and
- Class III - Mostly D ecological category water resources.

The water resource class categorisation for the Upper Orange River catchment IUAs is based largely on the ecological condition of the main stem rivers and major tributaries.

This report presents the set of ecological categories (% distribution of biophysical nodes) that define the water resource class per IUA that will ultimately guide water resource management and its planning.

4 WATER RESOURCE CLASSES OF THE UPPER ORANGE RIVER CATCHMENTS

4.1 Overview

The Upper Orange River catchment is characterized by several key water resources, including wetlands, strategic water source areas (SWSA), and rivers. Within the catchment, there are notable dams such as the Gariep Dam, Vanderkloof Dam, Mockes Dam, Rustfontein Dam, Krugersdrift Dam, Kalkfontein Dam, and Tierpoort Dam. The main rivers in the area consist of the Orange River, Caledon River, Leeu River, Kraai River, Seekoei River, Modder River, Riet River, and their respective tributaries.

4.2 Integrated Units of Analysis

The study area is the catchment of the Upper Orange River catchment, predominantly in the Free State and Eastern Cape Provines, and a small portion of the Northern Cape Province, and is an integral part of the Vaal-Orange Water Management Area (WMA 04), and the Orange-Senqu River Basin.

To enable improved representation of the water resources and socio-economic situation in the catchment, and to facilitate the determination of water resource classes, Integrated Units of Analysis (IUA) were defined as Step 1 of the classification process and are listed in Table 5 and illustrated in Figure 4. The detailed descriptions and rationale for these IUAs are provided in RDM/WMA13/00/CON/CLA/0224, Status Quo and delineation of Integrated Units of Analysis and Resource Units Report.

Table 5: IUAs delineated in the Upper Orange River Catchment

IUA	Description	Quaternary
1	Golden Gate	D21D and a portion of D21A along South Africa/ Lesotho border
2	Caledon/ Leeu River	D21E, D21F, D21G; portion of D21C; D22A, D22B; portions of D21H and D22C along the SA/ Lesotho border; Portions of D22D, D22G, D22H, D22L, Portion of D23A, D23C, D23D and portion of D23E
3	Caledon River	D23F, D23G, D23H, D23J, D24A, D24B, D24C, D24D, D24E, D24F, D24G, D24H, D24J, D24K and D24L
4	Kraai River	D13A – D13M
5	Upper Orange River	D12A – D12F, D14A – D14K, Portions of D15G, D15H, D18K and D18L
6	Gariep Dam	D34A, D34B, D34C, D34D, D34E, D34F, and D34G, D35A, D35B, D35C, D35D, D35E, D35F, D35J, D35G, D35H, D35K
7	Seekoei River	D32A, D32B, D32C, D32D, D32E, D32F, D32G, D32H, D32J, D32K
8	Vanderkloof Dam	D33A – D33K (along main stem Orange River); D31A – D31E
9	Upper Modder River	C52A, C52B, C52C, C52D, C52E, C52F and C52G
10	Modder/ Riet River	C51A, C51B, C51C, C51D, C51E, C51F, C51G, C51H, C51J, C51K, C51L, C51M, C52H, C52J, C52K and C52L

4.3 Biophysical Nodes

Biophysical nodes represent flow requirements and ecological state relevant for the IUA and are established to account for interactions between ecosystems. Allocation nodes are established to account for specific catchment issues or socio-economic aspects and to serve as modelling points for the scenario evaluation process in a catchment.

The nodes are used to assess the response of upstream water resources to changes in water quality, quantity, and timing (DWA, 2007). Biophysical nodes should be located at interactions between ecosystems and at the end points of eco-system reaches to account for interactions. Allocation nodes should be located at the downstream edge of a reach of interest, as required for modelling and to allow for meaningful trade-offs.

Biophysical nodes have been selected within the study components (river, wetland and groundwater) for analysis. These nodes represent the significant water resources that have a high ecological importance and/ or sensitivity that could be under threat due to its importance for water

resource use and/ or where water use is high and/ or where water quality is impacted. The selected nodes are presented per water resource component.

Biophysical nodes were selected for the significant water resources per IUA to quantify the ecological water requirements (EWR) as part of the Reserve study (DWS, 2023) to inform the scenario analysis, the evaluation of ecological consequences and the determination of the water resource classes.

The biophysical hydronodes per IUA and their level of assessment are listed in Table 6 and illustrated in Figure 4**,** and those used for the scenario evaluation are highlighted in blue. These sites were modelled and used to evaluate the ecological consequences and macroeconomic implications for the defined development scenarios.

Table 6: Biophysical nodes per IUA in the Upper Orange River Catchment

EWR site	Quaternary	River	Latitude	Longitude	Level
IUA 1: Golden Gate					
UO_EWR01_R	D21D	Little Caledon	-28.5578	28.40571	Rapid III
IUA 2: Caledon/ Leeu River					
UO_EWR01_I	D22D	Middle Caledon	-28.9091	27.78492	Intermediate
UO_EWR02_R	D21G	Brandwater (Groot)	-28.68034	28.13993	Rapid III
UO_EWR03_R	D22G	Mopeli	-29.10121	27.57075	Rapid III
UO_EWR01_FV	D22B	Meulspruit	-28.8857	27.83494	Field verification
IUA 3: Caledon River					
UO_EWR04_I	D24G	Lower Caledon	-30.43614	26.29926	Intermediate
UO_EWR10_FV	D24H	Skulpspruit	-30.2344	26.51134	Field verification
UO_EWR09_FV	D24H	Groenspruit	-30.24119	26.5613	Field verification
UO_EWR02_FV	D24C	Witspruit	-30.00826	26.92832	Field verification
UO_EWR16_FV	D24L	Slykspruit	-30.393	26.12093	Field verification
UO_EWR22_FV	D18K	Tele	-30.44859	27.58234	Field verification
UO_EWR23_FV	D12A	Upper Orange	-30.39876	27.34299	Field verification
IUA 4: Kraai River					
UO_EWR04_R	D13E	Upper Kraai	-30.85179	27.77689	Rapid III
UO_EWR08_I	D13M	Lower Kraai	-30.69007	26.74157	Intermediate
UO_EWR04_FV	D13K	Karringmelkspruit	-30.8118	27.2665	Field verification
UO_EWR05_FV	D13A	Bokspruit	-30.8847	27.88456	Field verification
UO_EWR06_FV	D13J	Holspruit	-30.99532	27.05664	Field verification
UO_EWR07_FV	D13C	Sterkspruit, tributary of the Kraai	-30.91762	27.80075	Field verification
UO_EWR08_FV	D13B	Bell	-30.8526	27.78656	Field verification

EWR site	Quaternary	River	Latitude	Longitude	Level
UO_EWR17_FV	D13D	Langkloofspruit	-30.95413	27.60613	Field verification
UO_EWR18_FV	D13G	Wasbankspruit	-31.15554	27.28444	Field verification
IUA 5: Upper Orange River					
UO_EWR03_FV	D12D	Gryskopspruit	-30.33963	27.17688	Field verification
UO_EWR02_I	D12B	Sterkspruit	-30.51784	27.36908	Intermediate
UO_EWR03_I	D12F	Upper Orange	-30.65289	26.82305	Intermediate
UO_EWR24_FV	D15G	Makhaleng	-30.16412	27.39825	Field verification
UO_EWR05_R	D14E	Wonderboomspruit	-31.00526	26.34194	Rapid III
IUA 6: Gariep Dam					
UO_EWR_FMP	D34E	Orange River between Gariep and Vanderkloof dams	-30.50368	25.20057	Hydraulic survey to Inform FMP
IUA 7: Seekoei River					
UO_EWR05_I	D32J	Seekoei	-30.53436	24.9629	Intermediate
IUA 8: Vanderkloof Dam					
UO_EWR10_I	D33K	Lower Orange	-29.16202	23.69594	Intermediate
IUA 9: Upper Modder River					
UO_EWR07_I	C52B	Upper Modder (Sannaspos)	-29.16002	26.57249	Intermediate
UO_EWR06_R	C52H	Middle Modder (Soetdoring)	-28.80719	26.1097	Rapid III
UO_EWR13_FV	C52E	Os-spruit	-28.93917	26.51141	Field verification
UO_EWR14_FV	D31C	Hondeblaf	-30.20514	24.71803	Field verification
IUA10: Modder-Riet River					
UO_EWR06_I	C51F	Upper Riet	-29.53507	25.52457	Intermediate
UO_EWR09_I	C51L	Lower Riet	-29.03842	24.50283	Intermediate
UO_EWR26_FV	C51L	Lower Riet	Not assessed	Not assessed	Field verification (additional)
UO_EWR11_FV	C51A	Fouriespruit	-29.67121	26.07439	Field verification
UO_EWR12_FV	C52F	Renoster	-29.11632	26.3287	Field verification
UO_EWR15_FV	C51G	Tributary of VanZylspruit	-30.0312	25.78646	Field verification
UO_EWR19_FV	C51K	Lower Modder	-28.89166	25.65645	Field verification
UO_EWR20_FV	C51G	Upper Kromellenboog	-30.06628	25.68106	Field verification
UO_EWR21_FV	C51H	Lower Kromellenboog	-29.6536	25.43507	Field verification

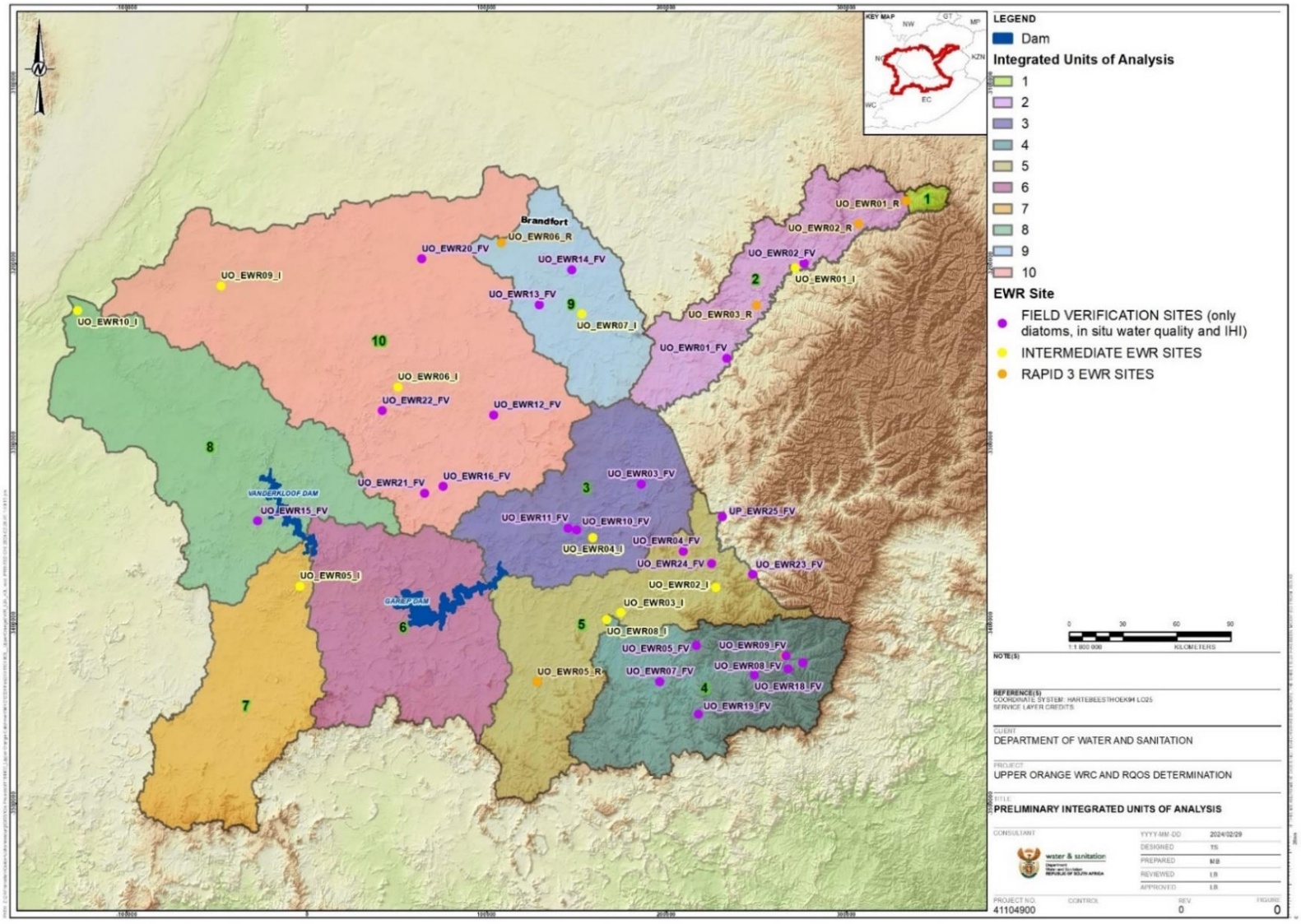

Figure 4: IUAs and associated EWR sites (biophysical nodes)

4.4 Economic development

The main economic contributions in the Upper Orange River catchment are from the tertiary sector in the financial services sector (20%), followed by wholesale and retail trade, catering and accommodation sector (17%). Tourism sector activity in the catchment includes cultural-historic, events (such as sporting and festivals), leisure related activities and agri-tourism.

Manufacturing and construction sectors (secondary sectors) play an important role with the main centres being in the Mangaung Metropolitan Municipality and some of the larger towns within the catchment. Manufacturing is mainly in the light manufacturing and service orientated industries, brick manufacturing, agro-processing and food, beverages and tobacco products.

While agriculture's contribution to Gross Domestic Product (GDP) (4%) is not large it is still one of the key economic activities within the catchment with extensive livestock farming, dryland and irrigation agriculture.

The mining sector is relatively small (1% contribution to GDP) with the main mining activities from alluvial diamond mining, salt works, sand mining and quarrying.

4.5 Tourism Economy

Tourism sector activity in the catchment includes cultural-historic, events (such as sporting and festivals), leisure related activities and agri-tourism. There are several nature reserves, notably, Golden Gate National Park in IUA 1, and around the Gariep and Vanderkloof dams, IUAs 6 and 8.

4.6 Water Use in the Upper Orange River catchments

Table 7 sets out the water use per IUA for the current, medium term (2040) and long-term (2060) scenarios, highlighting the biggest water user as irrigation, which is expected to stay constant over the medium to long-term. IUA 8, Vanderkloof Dam has the highest irrigation water use followed by IUA 5, Upper Orange River and IUA 10, Modder/ Riet.

Domestic use is expected to increase with highest increase in IUA 9 which includes the Mangaung Metropolitan Municipality.

IUAs 6 and 8, Vanderkloof and Gariep dams, also have high volumes set aside for hydropower.

Table 7: Projected average annual water requirements for Upper and Lower Orange (Mm^3/a) per water use sector

IUA		User type	Scenario 1: current	Scenario 2: medium (2024)	Scenario 3 (long-term (2060)
1	Golden Gate	Irrigation	6.23	6.23	6.23
		Domestic	0.60	0.60	0.60
		Total	6.83	6.83	6.83
2	Caledon/ Leeu River	Irrigation	28.92	28.92	28.92
		Domestic	41.30	58.42	72.22
		Total	70.22	87.33	101.14
3	Caledon River	Irrigation	40.26	40.26	40.26
		Domestic	8.01	9.79	10.81
		Total	48.27	50.05	51.07
4	Kraai River	Irrigation	47.06	40.28	47.06
		Domestic	1.20	1.20	1.20
		Total	48.26	41.48	48.26
5	Upper Orange River	Irrigation	218.82	218.82	218.82
		Domestic	20.52	26.73	28.82
		Total	239.34	245.55	247.64
6	Gariep Dam	Irrigation	33.82	33.82	33.82
		Domestic	5.19	5.80	6.73
		Hydro power	70.00	70.00	70.00
		Total	109.01	109.62	110.55
7	Seekoei River	Irrigation	4.15	4.15	4.15
		Domestic	0.00	0.00	0.00
		Total	4.15	4.15	4.15
8	Vanderkloof Dam	Irrigation	255.25	255.25	255.25
		Domestic	2.42	3.26	4.38
		Hydro power	70.00	70.00	70.00

IUA		User type	Scenario 1: current	Scenario 2: medium (2024)	Scenario 3 (long-term (2060)
		Total	327.68	328.52	329.63
9	Upper Modder River	Irrigation	26.46	41.93	41.93
		Domestic	105.23	135.52	171.14
		Total	131.70	177.45	213.07
10	Modder/ Riet River	Irrigation	174.92	174.47	174.47
		Domestic	10.90	12.89	15.57
		Total	185.82	187.36	190.03
Upper Orange Total			***1 171.29***	***1 238.33***	***1 302.37***

4.7 Proposed Water Resources Classes per IUA

Considering the outcomes of the scenarios assessment step and the associated consequences and trade-offs, and the approach described in Section 3, the following table summarises the aggregated PES and REC percentages, with the prosed wate resource classes.

	PES aggregated for EWR Sites per IUA (PES)					REC aggregated for EWR Sites per IUA					
Ecological category	A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	Proposed Class
IUA1			100.00%				100.00%				II
IUA2			25.00%	75.00%			25.00%	25.00%	50.00%		III
IUA3		16.67%	71.43%	16.67%			16.67%	85.71%			III
IUA4		44.44%	44.44%	11.11%			77.78%	22.22%			II
IUA5		20.00%	40.00%	40.00%			20.00%	60.00%	20.00%		III
IUA6						No hydronodes					III
IUA7			100.00%					100.00%			II
IUA8			100.00%					100.00%			III
IUA9		50.00%		50.00%			50.00%	50.00%			III
IUA10		12.50%	75.00%	12.50%			37.50%	50.00%	12.50%		III

Figure 5: Summary of the aggregated PES and REC percentages per ecological category

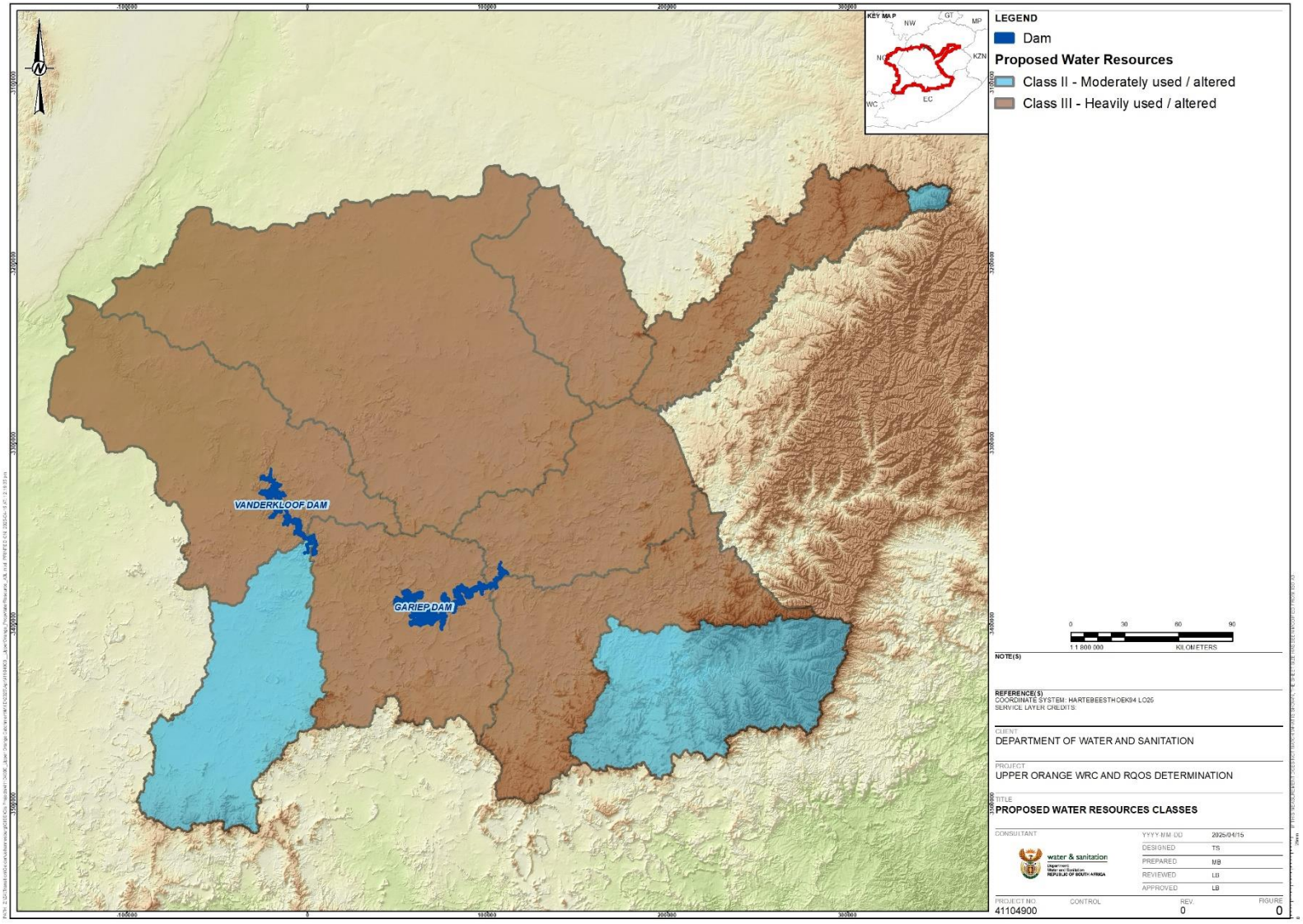

Figure 6: Proposed Water Resource Classes per IUA in the Upper Orange River catchments

5 GROUNDWATER

5.1 Approach to Groundwater Classification

The current assessment of the groundwater quality classification assessment and setting of resource quality objectives for the Upper Orange Catchment has used the 2024 high confidence Reserve determination study (DWS, 2024) which provided a good hydrogeological dataset which was enhanced by a detailed satellite imagery assessment and evaluation of the Department of Water and Sanitation' Water Use Authorisation and Management System (WARMS) dataset to improve on the groundwater use figures that form an important part of this water resource classification phase.

As described in Section 4.2, the Upper Orange River catchment has been delineated into 10 integrated units of analyses for the surface water component, and this delineation was adopted for the groundwater resource units (GRUs). However, some of the IUA's were divided into sub-resource units, resulting in 16 GRUs based on sound groundwater characteristics, i.e., (i) rainfall recharge depths, (ii) aquifer hydraulics, and (iii) aquifer rock formation types.

The groundwater contribution to baseflow in the catchment is significant and therefore represents an important component of the groundwater water balance of the catchment. It was noted that the baseflow figures for a few quaternary catchments were significantly higher than the estimated groundwater recharge figures. After consultation with the project team, it was acknowledged that these specific baseflow figures included shallow groundwater seeping from elevated local wetland systems as part of the shallow interflow drainages in the wetter part of the catchment. The affected GRUs are:

(i) GRU 4 (D13, except -G, H, J, L & M), and

(ii) GRU 5.1 (D12B, D15H & D18K). This phenomenon is not present further west towards the drier parts of the catchment.

Groundwater resources are highly dependent on frequent rainwater recharge – this recharge is presented as either percentage mean annual precipitation (% MAP) or calculated as millimetres per annum (mm/a) and is currently based on long-term average values. The result is thus a calculated value (Mm^3/a) that forms the most important groundwater balance component in assessing the potential of groundwater resources (particularly aquifer systems). In areas where climate variation is more prominent, i.e., >2-years consecutive dry spells with lower rainfall input, it is obvious that the annual groundwater replenishment decreases or may in progressive dry periods/seasons, not happen at all.

Other important aspects of the groundwater balance are the baseflow component required for the EWR and the basic human needs (BHN). These values, combined, represent the Groundwater Reserve that needs to be protected and is a fixed volume (groundwater reserve as Mm^3/a) – except in the case of severe rainfall deficits where the EWR may be naturally impacted.

Groundwater use is the volume of groundwater that is removed from the groundwater systems (various aquifer systems are present in the catchment). The number on boreholes in the catchment are numerous and the water is abstracted for several different uses, i.e., (i) domestic use [households and/or yards], (ii) stock watering, (iii) bulk water supplies (wellfields), (iv) mining [ore processing and/or dewatering], (v) cash crop irrigation schemes [1 to 200 hectares], and (vi) industries. The actual volumes abstracted annually are difficult to calculate as many are diffused abstraction and volumes are not registered in WARMS. Likewise, there is a possibility that the surface water WARMS figures for irrigation water use are to some degree mixed with the groundwater use figures for irrigation. This statement comes from noting significantly high groundwater use figures for irrigation, whilst the satellite image scans of the quaternary catchments do not always indicate significant irrigated lands.

The groundwater resource classification included the following criteria (DWS, 2009):

- **Groundwater Usage** (calculated Stress Index): The SI of each of the quaternary catchment were assessed as this index provided an indication of the groundwater use related to long-term annual groundwater recharge. The calculated indices are an indication of the "allocable volume of groundwater" still available for allocation as a water use once the groundwater reserve (viz., Basic Human Needs at 25L/c/d and Total Water Use (viz., stock water, municipal, irrigation, mining, industrial (+solar plants), population Schedule 1 and Domestic Use) has been updated/recalculated and assessed on Quaternary Catchment scale.
  - The criteria were scaled to a Minimally Used (Class I), Moderately Used (Class II) and Heavily Used (Class III).
- **Groundwater Quality Status/ characteristics**: A water quality classification criterion (Class I: Ideal/Good, Class II: Marginal and Class III: Poor) based on (i) hydrochemical median concentrations, (ii) statistical classification and (iii) identifying specific elevated constituent concentrations like fluoride, nitrate and sodium-chloride combinations (as per water quality ranges proposed for domestic water supplies, WRC, 1998)
  - A Total Dissolved Solids Classification: CI to CIII (<1000, 1001-2400, >2400 mgTDS/L); and.
  - Concentration of Nitrate and Fluoride (both as CI to CIII, <10, 11-20, >20mgN/L and <1.0, 1.1-1.5, >1.5 mgF/L respectively.
  - Acknowledgement of primary salinity in groundwater as a result of the rock-water interaction in the aquifers were part of the mass statistical assessment of the hydrochemistry dataset for the Catchment.
- **Aquifer Vulnerability Index**: The basis for the Vulnerability Indices used in this assessment is the Aquifer Vulnerability [assessment] of South Africa (CSIR, 1999, updated in 2013 by the then Department of Water Affairs) The scales for the vulnerability indices were downscaled to three tier criteria, CI (<60), CII (61-145) and CIII (>145) as Least, Moderate and Most aquifer vulnerability ITO it's "tendency or likelihood for contamination to reach a specific position in

the groundwater system" in the quaternary catchment assessed. The following attributes were included in the aquifer vulnerability assessment:

- Depth to water level (aquifer saturation elevation, metre below ground level)
- Aquifer Recharge (mm/a)
- Aquifer media (rock type in terms of storativity)
- Vadose Zone Impact (soil/sand/clay/regolith/hard rock characteristics above saturated formation including the so)
- Topography (surface run-off criteria); and
- Hydraulic Conductivity (ability of aquifer to transmit water).

5.2 Results

Assessment of the above-mentioned criteria was undertaken for each quaternary catchment in the Upper Orange River catchment. These tables are included per IUA in Section 6 (6.1 to 6.10). and each table lists the groundwater quantity, quality and aquifer vulnerability status and the final proposed water resource classification using a weighted approach: Aquifer Stress Index (60%), Aquifer Quality Index (25%) and Aquifer Vulnerability Index (15%).

5.3 Conclusions of the groundwater classification

The groundwater resource classification results highlight the following important groundwater related aspects:

- Large shallow calcrete aquifer system in IUA 10 (specifically GRU 10.2) need to be protected against over-utilization in the future and groundwater pollution due to agricultural activities associated with irrigating on a shallow aquifer system – specifically nitrate pollution coming from high fertilizer doses.
- Primary groundwater quality is characterised by primary geological conditions, i.e., water-rock interaction that causes elevated salinity (TDS-concentrations) and fluoride concentrations – the latter component occurs over a wide area in GRU 9.2 (IUA 9 and IUA 10 overlapping) where high primary salinity is noted due to the underlying saline rock formations in the Karoo Supergroup Ecca Group Mudrocks.
- Surface water and groundwater interaction in UIA 4 (GRU 4) has been addressed in a separate assessment of the Upper Kraai River catchment – this aspect should be considered for the final RQO Phase of this study. This condition is probably present in portions of the IUA 5 (specifically GRU 5.1).
- This water resource classification assessment discloses that the prominent factor is the groundwater quantity component, and the weight on this was in the order of 60% of the numerical classification method used. Most of the IUAs groundwater quantity classification

falls in the minimally to moderately used categories. The highest ranking for moderately used was still below the proposed 65% Stress Index limit.

- Only one IUA indicates a significant groundwater deficit, i.e., GRU 9.2 – this is directly based on the WARMS water use dataset.
- Quaternary catchments that are highly impacted based on their groundwater use (Qn) are quaternary catchments C52J and C52K (Petrusburg Area – Kalkveld Region), areas with a high degree of cash crop irrigations (pivot systems). These groundwater resources are characterised by large shallow calcrete (secondary fractured limestone rock formation) aquifer systems with a high rainfall recharge potential. This aquifer system should be managed in a controlled water balance manner and as it is a shallow depth, it is regarded as highly vulnerable to land use pollution – specifically agricultural pollution (nitrates from fertilized overdosing). It is also important to note that Petrusburg is solely reliant on groundwater for domestic use.
- The groundwater conditions on the western perimeter of the catchment, i.e. IUAs 7 and 8 in the drier part of the catchment, are specifically highlighted by the high aquifer vulnerability index (most vulnerable) that is very likely related to a combination of lower rainfall and aquifer water quality. For example, elevated salinity (sodium-chloride) is noted in the groundwater quality dataset of GRU 7.1 (IUA 7) and GRU 8.3 (IUA 8).

This water resource classification is based on long-term hydrogeological observations; however, the scenario testing has revealed that the rainfall index is the most important component of the groundwater resource potential. A proposed -25% on the long-term average rainfall depth scenario has shown that the stress index increases significantly and most of the IUA's groundwater quantity classification drops. The quantity classification is regarded as the most important as it drives the groundwater quality refreshment as well. Without reasonable intermittent aquifer water refreshment, the groundwater quality could deteriorate to levels where special water treatment will be required for domestic water supply schemes.

6 DESCRIPTION OF THE INTEGRATED UNITS OF ANALYSIS AND ASSOCIATED WATER RESOURCE CLASS

6.1 IUA 1: Golden Gate

IUA Description

IUA 1 falls only into quat D21D and a portion of D21A and lies within Dihlabeng Local Municipality in the Free State province, The IUA delineation is illustrated in Figure 7, showing the quaternary catchments. Clarens is the main town. Most of the area within this IUA falls into the protected area of the Golden Gate National Park with other protected areas including Eureka Nature Reserve, De Ark Game Ranch, Mount Horeb Estate and Clarens Private Nature Reserve adjacent to the town of Clarens. The population is estimated as 7,976 (Stats SA Census 2011 adjusted).

The main water resources in this IUA include the Caledon River forming the border with Lesotho and the Little Caledon River that runs through the IUA. Therea are no big dams on the mainstem river or tributaries. The IUA falls within the agriculture and tourism socio-economic zone, with tourism being the key economic activity within this IUA.

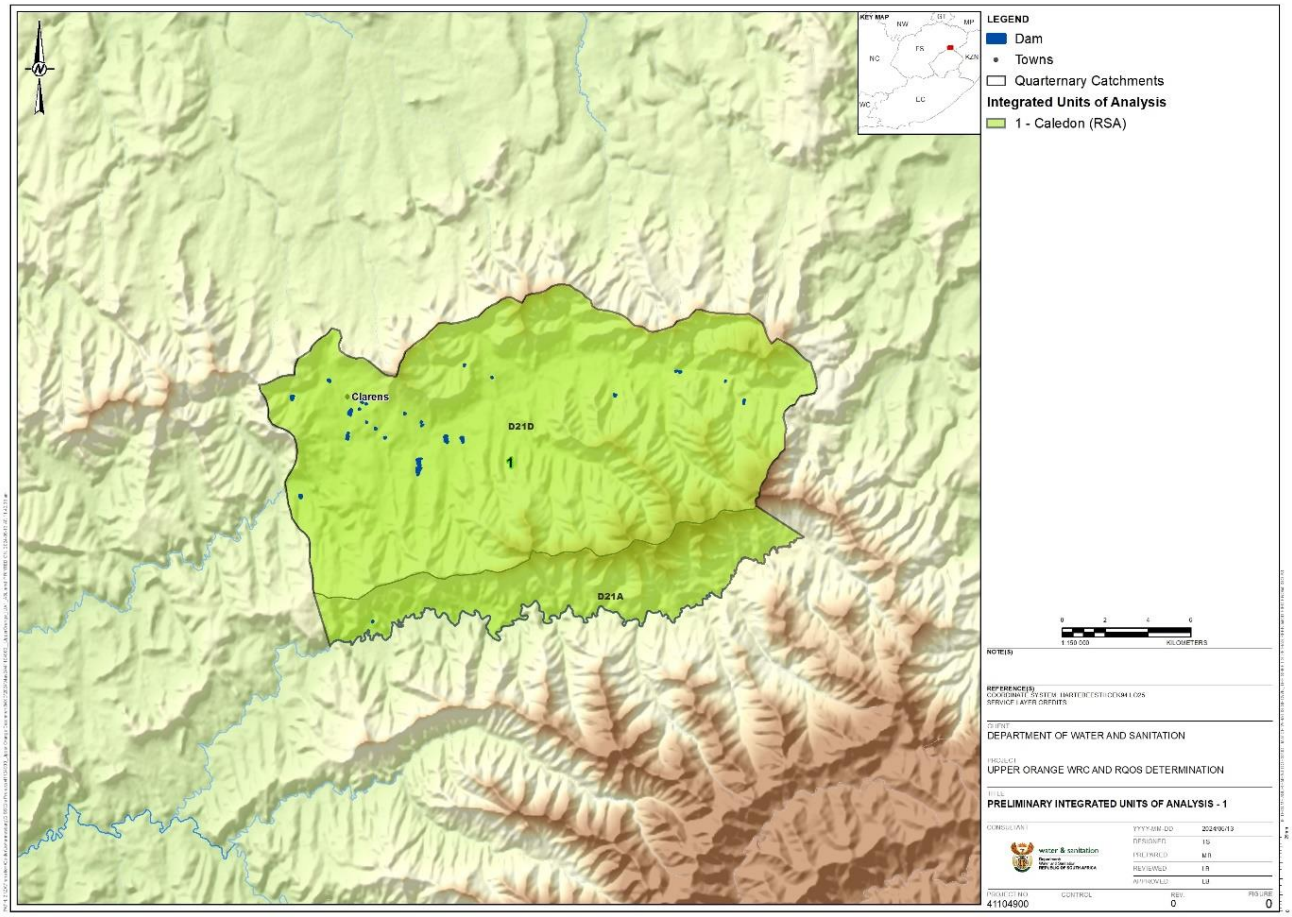

Figure 7: IUA 1: Golden Gate delineation

Groundwater Use

The aquifer systems in IUA 1 (and IUA 2) are moderate to low yielding systems and categorised as minimally used (Class 1). Water quality is Class 0/Class 1, and aquifer recharge occurs frequently (annually). Baseflows are moderate to high, but drains ±18% of annual recharge. Rainfall depletion of 25% 1-year event does not impact severely on aquifer allocable yield balance.

Based on the groundwater categorisation, it is categorised as set out in Table 8, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 8: IUA 1 Groundwater categorisation for IUA 1 (GRU 2.0)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per Integrated Units of Analysis (IUAs)
GRU 2.0	D21C – D21H, D22A – D22L, D23A – D23F.	1	1	2	1	CLASS 1 (Ideal-Good)

Ecological condition and the Ecological Reserve

A summary of eco-classification and ecological water requirement (as a percentage of natural MAR) is indicated in Table 9.

Table 9: Summary of eco-classification and EWR for biophysical nodes in IUA 1

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR01_R	D21D	Little Caledon	C	High	High	B/C	25.9	39.2	II

Note: nMAR: Natural Mean Annual Run-off (Mm^3/a)

Wetlands

The wetlands in IUA 1 are predominantly floodplain and channelled valley bottom, covering an area of 0.14% of the IUA area of 30, 718 km^2. No wetlands have been prioritised in this IUA.

Economy

Clarens is the only town within this IUA. The area in the IUA is characterised by some agriculture (mainly livestock farming and game farming) adjacent to the Little Caledon and Caledon rivers.

The main economic activity within the IUA is tourism in the scenic town of Clarens often referred to as the "Switzerland of South Africa" and in the surrounding protected areas and the Golden Gate National Park about 20km from Clarens.

Conclusions and Proposed Water Resource Class

As there is only one hydronode in this IUA, aggregation of the sub-quaternary river reaches (DWA, 2007) was also used to inform the proposed class. While all the scenarios evaluated show small reductions from the natural flows for all the months, especially in the drier months of July and August, a target ecological category (TEC) = REC of a B/C and a Class II is recommended.

Table 10: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 1

Ecological category for IUA 1										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
		100.00				100.00				II

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

In respect of the Caledon River, it should be noted that:

- While the river is not currently designated a Strategic Water Source Area (SWSA), it has been identified as important.
- The operation and maintenance of the Clarens Wastewater Treatment Works (WWTW) must be improved to ensure better effluent quality.
- Flows under present day conditions without EWR for the selected indicator species/taxon during the wetter months were noted to support critical habitats at levels reflective of natural flows and exceeded those specified for the REC. However, present day flows were insufficient for meeting the REC during drier months, instead showing a significant reduction in habitat suitability for the selected indictor specie/taxon. This is primarily owing to some of the critical habitat being completely exposed and flow requirements not meeting the needs for Perlidae (selected macroinvertebrate indicator species). For the fish, a connectivity for spawning migrations is needed and the spawning habitat must be available (no embedded). It was subsequently noted that the Little Caledon River receives water from Lesotho, and in this respect the flows will be met.

6.2 IUA 2: Caledon/ Leeu River

IUA Description

IUA 2 comprises the Caledon River below the Golden Gate Highlands National Park along the Lesotho Border and the many tributaries up to the Leeu River tributary where its confluence with the Caledon River is at the outlet of quaternary catchment D23E (Figure 8). There are several protected areas scattered through the IUA. The towns in the IUA include Fouriesburg, Ficksburg, Clocolan, Ladybrand, Tweespruit and Hobhouse. The IUA falls within parts of the local municipalities of Dihlabeng, Setsoto, Mantsopa and a small portion of Mangaung (settlement areas with subsistence agriculture). The population is estimated at 139,026 (Stats SA Census 2011 adjusted).

The key water resources include the Caledon River along the border with Lesotho, the Little Caledon and Leeu rivers. Dams include Meulspruit Dam (FSC: 2.6 Mm^3) on the Meulspruit in quaternary catchment D22B; Armenia Dam (FSC: 14.02 Mm^3) on the Leeu River in quaternary catchment D23C and several small farm dams. The IUA falls within the agriculture and tourism socio-economic zone of the catchment area. Land use is mainly for agriculture (irrigation, dryland, and mixed agriculture) and urban land use.

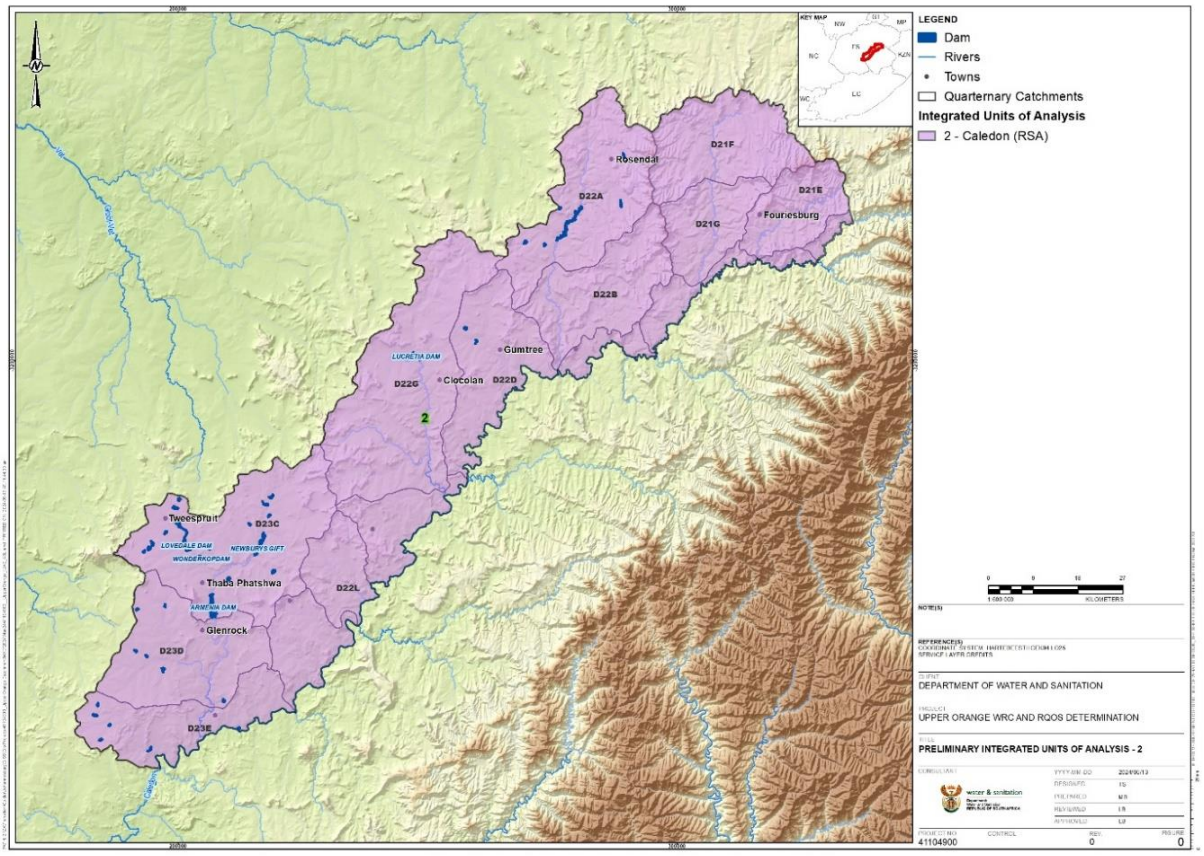

Figure 8: IUA 2: Caledon/ Leeu River delineation

Groundwater Use

The aquifer systems in IUA 2, as for IUA 1, are moderate to low yielding systems and categorised as minimally used (Class 1). Water quality is Class 0/Class 1, and aquifer recharge occurs frequently (annually). Baseflows are moderate to high, but drains ±18% of annual recharge. Rainfall depletion of 25% 1-year event does not impact severely on aquifer allocable yield balance.

Based on the groundwater categorisation, it is categorised as set out in Table 11, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 11: IUA 2 Groundwater categorisation for IUA 2 (GRU 2.0)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per Integrated Units of Analysis (IUAs)
GRU 2.0	D21C – D21H, D22A – D22L, D23A – D23F.	1	2	2	1	CLASS 1 (Ideal-Good)

Ecological condition and the Ecological Reserve

A summary of eco-classification and ecological water requirement (as a percentage of natural MAR) is indicated in Table 12: Summary of eco-classification and for the hydronode, UO_EWR01_I, used in the scenarios' evaluation.

Table 12: Summary of eco-classification and EWR for biophysical nodes in IUA 2

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR01_I	D22D	Middle Caledon	D/E	Mod	Moderate	D	674	23.15	III
UO_EWR02_R	D21G	Brand-water (Groot)	C	High	Moderate	B/C	25.9	30.95	
UO_EWR03_R	D22G	Mopeli	D	Moderate	Moderate	C/D	49.4	29.34	
UO_EWR01_FV	D22B	Meulspruit	D	Moderate	Moderate	D	63.6	12.51	

Wetlands

The wetlands in IUA 2 include depression, seeps, and channelled and unchanneled valley bottom wetlands, covering an area of 0.48% of the IUA area of 631,886 km^2, and more than half in a degraded state. The ecological categories of the wetlands as a percentage are A/ B (20%), C (14%) and D/E/F (53%). The following wetlands have been prioritised:

- **Brandwater floodplain,** a medium-sized floodplain wetland fed by an upstream catchment that is over 76 000 hectares (ha) in size, a large proportion of which is cultivated. The Brandwater floodplain is located at the toe of the Brandwater River, approximately 1.5km upstream of its confluence with the Caledon River. This wetland has an ecological category of a C.
- **Rantsho wetland complex,** a wetland complex approximately 275 ha in size located between the R26 Road and the Mohokare (Caledon) River on the Rantsho River within IUA 2. The wetland complex is unique in that it consists of three VB hydrogeomorphic (HGM) unit types which have formed because of a unique geomorphic setting and a unique set of geomorphic processes. VB wetlands, specifically FP and UCVB wetlands are typically able to provide ecosystem services to a greater degree than the other HGM units. A series of VB wetlands is unique and can provide significant streamflow regulating services. This wetland has an ecological category of a C.

Economy

The main land use in IUA 2 is mixed agriculture with farming practices including irrigation farming, dryland farming and livestock farming. There are two sand mining operations in the IUA south of the town of Hobhouse in quaternary catchment D23E. .

Conclusions and Proposed Water Resource Class

Table 13 sets out the results for the PES and REC aggregation of hydronodes in IUA 2, used to inform the proposed water resources class.

The scenarios evaluated showed that the EWR could not be met for predominantly the drier months June to September, even with the EWR implemented for medium and long-term. The wet months requirements could be met for most of the time, except during drought periods (95 to 99.9 percentiles), and the deficits are less with the EWR implemented. A target ecological category (TEC) = REC of a D and a Class III is recommended.

Table 13: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007)

Ecological category for IUA 2										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
		25.00	75.00			25.00	25.00	50.00		III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Water quality is the primary driver in this reach, coupled with limited habitat availability.
    - Fine silts passing through the system remain a concern, as they clog the gills of both fish and macroinvertebrates. Additionally, the proposed weirs may trap coarse materials like gravel, which are vital habitats for biotic communities.
        - WWTW operation and maintenance need to be improved to reduce water quality impacts to the surface water resources
- The proposed weirs reduce instream continuity and cause instream modifications, particularly affecting fish and impeding flow. Despite these impacts, the flows remain sufficient to meet the overall REC of a D.

6.3 IUA 3: Caledon River

IUA Description

IUA 3 comprises 14 quaternary catchments and falls into parts of the metropolitan municipality of Mangaung and local municipalities of Mohokare and Kopanong (less densely populated compared to Mangaung) within the Free State province. The main towns in the IUA include Wepener, Vanstadensrus, Smithfield and Rouxville.

The key water resources in the IUA include the Caledon River and several tributaries and six dams including the Welbedacht Dam, Egmont Dam, Knellpoort Dam, Rolandshoek, Vanstadensrus Dam and Smithfield Dam. The Caledon Modder transfer system transfers water from the Caledon River and Welbedacht Dam on the river via pipeline to the Bloemfontein region.

There are several protected areas within the IUA with larger areas including Caledon Nature Reserve adjacent to the Welbedacht Dam and part of the Tussen-die-Riviere Game Farm in quaternary catchments D24J and L. Irrigated agricultural activities occurring along the Caledon and its tributaries. The IUA falls within the agriculture and tourism socio economic zone, with an estimated population of 35,770 (Stats SA Census 2011 adjusted).

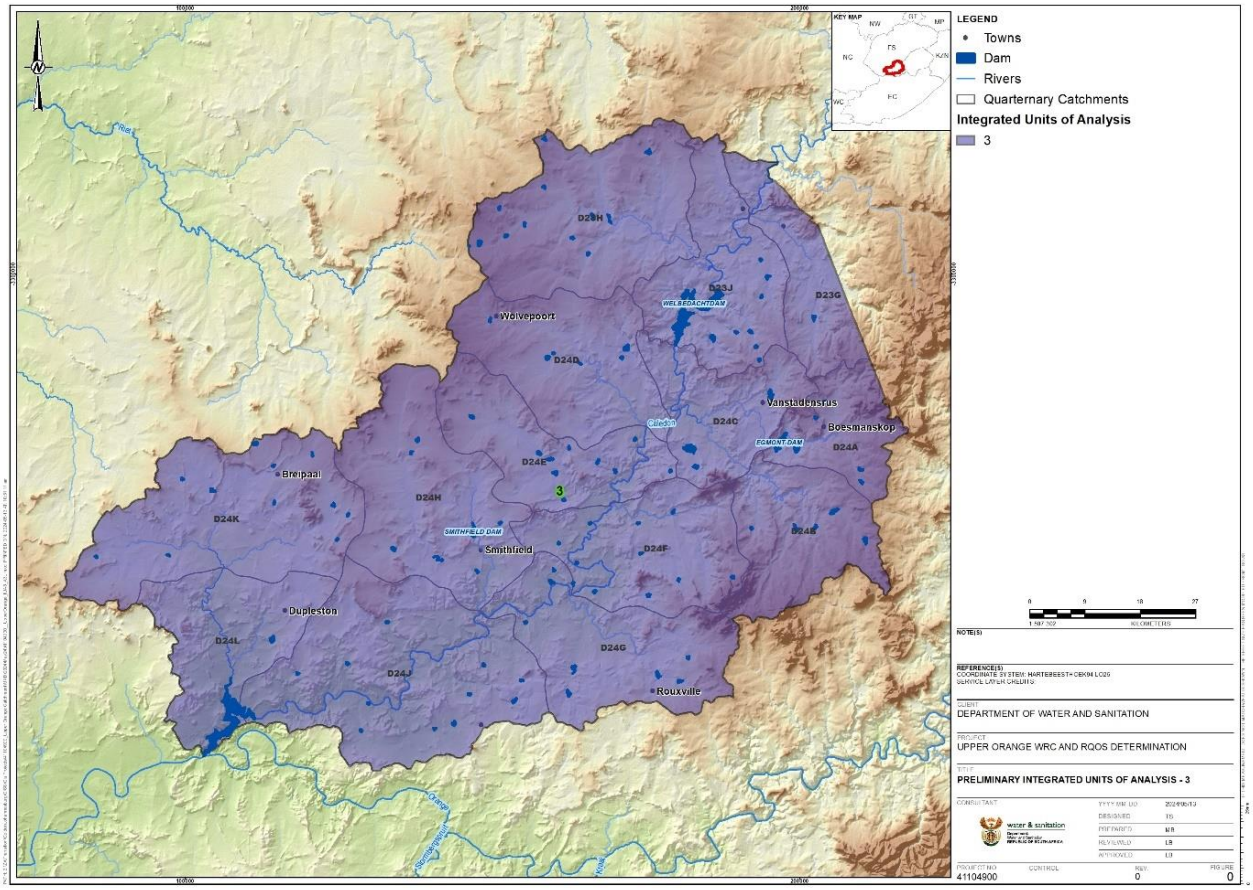

Figure 9: IUA 3: Caledon River delineation

Groundwater Use

The IUA has extensive dry land cultivation with limited stock farming, however, WARMS indicates water uses for irrigation systems. The aquifer systems are moderate to high yielding systems and categorised as moderately used (Class 2). Water quality is Class 1, and aquifer recharge occurs frequently (annually). Baseflows are moderate to high, but drains ±17% of the annual recharge. Rainfall depletion of 25% over 1-year has a moderately/ low impact on the aquifer allocable yield balance.

Based on the groundwater categorisation, it is categorised as set out in Table 14, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 14: IUA 3 Groundwater categorisation for IUA 3 (GRU 3.0)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 3.0	D23G – D23J, D24A – D24L	2	1	3	2	CLASS 2 (Marginal)

Ecological condition and the Ecological Reserve

A summary of eco-classification and ecological water requirement (as a percentage of natural MAR) is indicated for UO_EWR04_I used for the scenario's evaluation (Table 15). Due to negative socio-economic impacts if the EWR is implemented, the requirements were adjusted by reducing the maintenance low flow requirements.

Table 15: Eco-classification and EWR for biophysical nodes in IUA 3

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR10_FV	D24H	Skulpspruit	C	Mod	Mod	C	7.8	18.01	III
UO_EWR09_FV	D24H	Groenspruit	C/D	Mod	Mod	C	5.02	18.01	
UO_EWR02_FV	D24C	Witspruit	C/D	Mod	Mod	C	21.7	19.18	
UO_EWR16_FV	D24L	Slykspruit	B/C	Mod	Mod	B/C	23.01	5.1	
UO_EWR22_FV	D18K	Tele	C	Mod	Mod	C	21.54	142.3	
UO_EWR23_FV	D12A	Upper Orange	C/D	High	Mod	C	36.17	4 115.1	
UO_EWR04_I	D24G	Lower Caledon	D	Mod	Mod	C/D	1 353.6	27.53	

Wetlands

The wetlands in IUA 3 include depressions, seeps, and channelled and unchanneled valley bottom wetlands, covering an area of 0.6% of the IUA area of 822,797 km^2. The ecological categories of the wetlands as a percentage are A/B (10%), C (54%) and D/E/F (8%). The wetlands prioritised are:

- **Sandspruit wetland** is a wetland near the town of Wepener that receives the entire runoff and the discharge from the town's WWTW passes through this still reasonably intact wetland before entering the Caledon River. It's importance in terms water quality enhancement is likely to be high. This wetland will be assessed in May 2025.

Economy

Land use and economic activities within the IUA include irrigation agriculture along the Caledon River and its tributaries, extensive livestock farming (cattle and sheep for wool and meat) and game farming. Other economic land uses include agri-tourism with game farming and eco-tourism in the various protected areas and urban areas. There are a few sand mines in the upper western part of the IUA in quaternary catchments D23G and D23J.

Conclusions and Proposed Water Resource Class

The scenarios evaluated show reductions from the natural flows for all the months, especially in the drier months of July and August. It was indicated that none of the scenarios could meet the EWR all the time, even with the adjusted EWR implemented. This is a is a consequence of adjusting the low flows to reduce the socio-economic impacts.

However, with implementation of the EWR the deficits are lower. Table 16 sets out the percentage aggregation for the PES and REC for the hydronodes in IUA 3 and a proposed water resource class of a III.

Table 16: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007)

Ecological category for IUA 3										Proposed Class
% PES aggregated for EWR Sites per IUA					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
	16.67	71.43	16.67			16.67	85.71			III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs:

- Scenario flows, whether the EWR is implemented or not, generally align with the flow preferences of the indicator species/taxon. However, the biota shows a stronger positive response when EWR is implemented.
- The proposed weirs reduce instream continuity and cause instream modifications, particularly affecting fish (migration and embedded spawning habitat) and impeding flow. Despite these impacts, the flows remain sufficient to meet the overall REC of a C/D. Scenario 2b, remains better than Scenario 3b. For both scenarios 3b and 3c, it is noted that the drought flows during the wet season impact negatively on the biotic community as an ecological category of a D is recorded, while during the dry periods, they respond positively to the drought flows.
- It is crucial to highlight that water quality is the primary driver in this reach, coupled with limited habitat availability. Fine silts passing through the system remain a concern, as they clog the gills of both fish and macroinvertebrates. Additionally, the proposed weirs may trap coarse materials like gravel, which are vital habitats for biotic communities.

6.4 IUA 4: Kraai River

IUA Description

IUA 4 lies entirely within the Eastern Cape province comprising 12 quaternary catchments that fall within parts of the local municipalities of Senqu, Walter Sisulu, Emalahleni and Enoch Mgijima. The main towns in the IUA include Jamestown, Dordrecht, Barkly East, and the hamlets of Rhodes and Rossouw. The main water resources in the IUA include the Kraai River which flows through the IUA to the confluence with the Orange River and there are numerous tributaries. Parts of the Eastern Cape Drakensberg Strategic Water Source Area (SWSA) falls on the edges of the western part of the IUA. Two protected areas fall in the upper western part of the IUA and include the Lammergeier Highlands Nature Reserve and the Balloch Protected Environment. This IUA falls into the rural socio-economic zone, with an estimated population of as 28,845 (Stats SA Census 2011 adjusted).

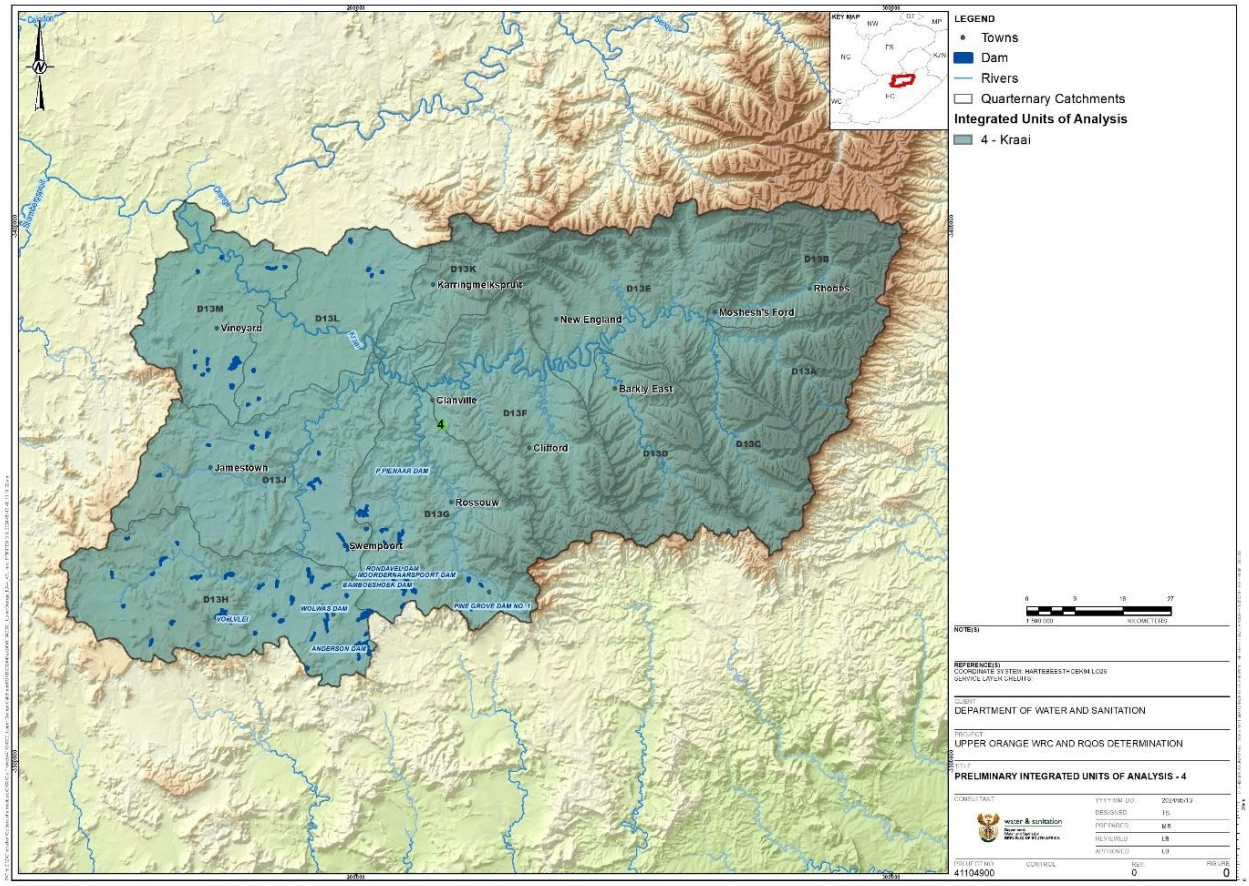

Figure 10: IUA 4: Kraai River delineation

Groundwater Use

IUA 4 has some dry land cultivation with limited stock farming, however, WARMS indicates water uses for irrigation systems. Aquifer systems are moderate to high yielding systems and categorised as moderately used (Class 2). Water quality is Class 1, and aquifer recharge occurs frequently (annually). Baseflows are moderate to high, but drains ±21% of annual recharge. Larger baseflows are recorded but these excess flows are related to leaking shallow surface water systems (wetlands driving baseflows). Rainfall depletion of 25% 1-year does impact moderately/low on aquifer allocable yield balance.

Based on the groundwater categorisation, it is categorised as set out in Table 17, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 17: IUA 3 Groundwater categorisation for IUA 4 (GRU 4.0)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 4.0	D13A – D13M	2	1	2	2	CLASS 2 (Marginal)

Ecological condition and the Ecological Reserve

A summary of eco-classification and ecological water requirement (as a percentage of natural MAR) is indicated for UO_EWR08_I used for the scenario's evaluation (Table 18).

Due to the negative socio-economic impacts with EWR implemented, especially during drought periods, the requirements were adjusted by reducing the drought flow requirements with a minimum of 0.3 m^3/s for the months of November to February.

Table 18: Eco-classification and EWR for biophysical nodes in IUA 4

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR04_R	D13E	Upper Kraai	D	Mod	Mod	C/D	25.9	39.20	III
UO_EWR08_I	D13M	Lower Kraai	C	High	High	B/C	719.0	45.8	
UO_EWR04_FV	D13K	Karringmelk-spruit	B	Very high	High	B	21.7	19.18	
UO_EWR05_FV	D13A	Bokspruit	B/C	Mod	High	B	60.4	44.99	
UO_EWR06_FV	D13J	Holspruit	C	High	Mod	C	36.9	18.05	
UO_EWR07_FV	D13C	Sterkspruit, tributary of the Kraai	C	Mod	High	B/C	47.6	37.24	
UO_EWR08_FV	D13B	Bell	B/C	Mod	High	B	72.5	45.08	

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR17_FV	D13D	Langkloof-spruit	B/C	High	High	B	44.45	43.8	

Wetlands

The wetlands in IUA 4 include depression, seeps, floodplain and channelled and unchanneled valley bottom wetlands, covering an area of 0.52% of the IUA area of 934,709 km^2. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (19%), C (11%) and D/E/F (20%).

The following wetlands have been prioritised:

- **Tiffindell Seep, a h**igh-altitude wetland complex in IUA 4 comprising a series of HSS and VB wetlands that cover a total area of 190 ha located at approximately 2 000 mamsl and is therefore characterised by a unique vegetation assemblage. The remote nature of these wetlands has resulted in the catchments remaining relatively natural. The ecological category is an A.
- **Klein-Wildebeespruit wetland complex,** a wetland complex located along the Klein Wildebeesspruit and the unnamed river to the east of the Klein-Wildebeesspruit, comprising a series of VB wetlands which amount to approximately 950 ha, fed by many seep wetlands totalling an estimated 450 ha. These two large wetland complexes are tributaries of the Kraai River and are therefore key in providing ecosystem services such as water quality enhancement and sediment trapping. This wetland complex system is found in IUA 4. The ecological category is a D.
- **Luckhof depression wetland complex,** a wetland complex comprising a series of depression wetlands that are hydrologically connected via surface and groundwater at IUA 8. These depression wetlands range in size from 7 ha to 1 200 ha. These fluvially connected wetlands flow 7in a south-easterly direction into the Lemoenspruit which is a tributary of the Orange River. T8hese wetlands form unique features in the broader landscape and provide important habitats for9 both fauna and flora. The ecological category is a B.
- **Otto du Plessis Pass wetland UCVB and CVB,** an extensive hillslope seeps and is an unusually large wetland for its high altitude. Much of the wetland vegetation remains intact. This wetland will be assessed during May 2025.
- **Wolwespruit headwaters** a wetland complex comprising a series of UCVB wetlands which are fed by multiple hillslope seep (HSS) wetlands, covering an area of approximately 420 ha within IUA 4. This forms the headwaters of the Wolwespruit. The valley-bottom (VB) wetlands have been extensively dammed, with over 15 dams along the length of the mainstem valley. Cranes were noted within this wetland complex,

predominantly within the VB systems and it is assumed that these wetlands are used as a foraging site by Blue Cranes (*Grus paradisea*) and Crowned Cranes (*Balearica regulorum*) and possibly also a breeding site for the Crowned Cranes. The ecological category is a C.

- **Barkley Pass wetland complex**, a significant wetland complex consisting of multiple VB and HSS wetlands which, in total, spread across an area of approximately 230 ha. This large wetland complex is situated on a tributary of the Langkloofspruit which is a tributary of the Kraai River – an extremely important water source for the Orange River, found in IUA 4. The ecological category is an A.

Economy

The main land uses and economic activity in IUA 4 include residential settlements or towns, agriculture and to a limited extent tourism. The main agricultural activity is livestock farming, followed by dryland agriculture and there is some irrigated agriculture occurring along parts of the Kraai River and its tributaries.

Conclusions and Proposed Water Resource Class

The scenarios evaluated indicate small reductions from the natural flows for all the months. The results indicate that the deficits are mainly during the wetter months in Sc1, when the EWR is not met all the time even when implemented (Sc1b). Scenario Sc3.2b shows that the EWR could be met all the time when the EWR is implemented with the proposed Boskraai Dam.

Table 19 sets out the percentage aggregation for the PES and REC for the hydronodes in IUA 4 and a proposed water resource class of a II.

Table 19: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 4

Ecological category for IUA 4										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
	44.44	44.44	11.11			77.78	22.22			II

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- If the Boskraai Dam is constructed in the future without implementing the EWR, flow requirements during both seasons will not be met for fish or macroinvertebrates, raising serious ecological concerns. To ensure adequate flows and maintain ecological balance under either scenario (present or future), implementing the EWR is strongly recommended.

- If this is not feasible and trade-offs are required, an Alien Invasive Plant (AIP) eradication programme should be prioritised. Extensive AIP infestations, particularly Black Wattle (*Acacia mearnsii*) along the Kraai's riparian zone currently reduce baseflows. Over time, eradication efforts could help restore some baseflows, potentially improving flow and thus biotic responses.
- The surface- groundwater interaction in this IUA must be considered when setting RQOs.

6.5 IUA 5: Upper Orange River

IUA Description

IUA 5 falls partly into the Free State and partly in the Eastern Cape province, comprises 20 quaternary catchments (Figure 11) and lies in parts of the four local municipalities of Mohokare, Senqu, Walter Sisulu and Enoch Mgijima. The main towns include Zastron, Sterkspruit, Maletswai (Aliwal North), Lady Grey, Molteno and Burgersdorp.

The main water resources in the IUA includes the main stem of the Orange River and several tributaries and part of the Eastern Cape Drakensberg Strategic Water Source Area falls within quaternary catchments D18K and parts of D18L, D12A and D12B. A few small, protected areas are found in the IUA including Mayaputi Private Nature Reserve (D12A), Highlands Safari Lodge (D15H), Buffelspruit Nature Reserve (D14A, Aliwal North), The Mountain Nature Reserve (D14E), Thaba Ghale Game Farm (D14J) and parts of the Tussen-die-Riviere Game Farm (D14K). This IUA falls mainly into the rural socio-economic zone, with an estimated population of 201,339 (Stats SA Census 2011 adjusted).

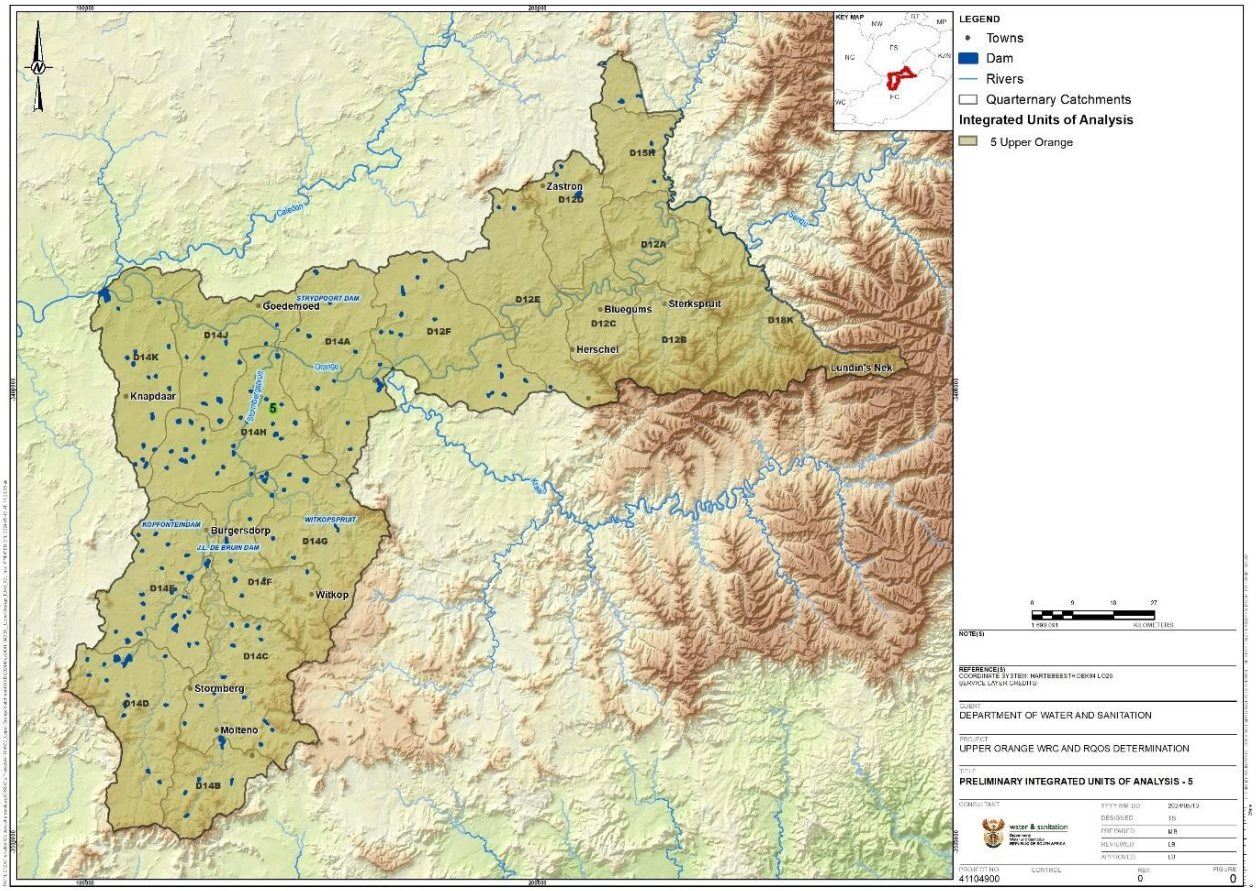

Figure 11: IUA 5: Upper Orange River delineation

Groundwater Use

IUA 5 comprises two GRUs (5.1 and 5.2). The IUA comprises occasional dry land cultivation with stock farming. WARMS indicates limited water uses for irrigation systems. Large rural developed areas (QCs D12A and D15H). GRU 5.1 aquifer systems are moderate to high yielding systems and is categorised as minimally used (Class 1). Water quality is Class 1, and aquifer recharge occurs frequently (annually). Baseflows are moderate to high, but drains ±21% of annual recharge. Rainfall depletion of 25% 1-year does impact moderately/low on aquifer allocable yield balance.

GRU 5.2 Stress Indices are just below fair (65%). Large rural developed areas in quaternary catchments D14A, D14F and D14H. Aquifer systems are moderate yielding systems and categorised as Minimal Used (Class 1). Water quality is Class 1, and aquifer recharge occurs less frequently. Baseflows are moderate to high, but drains ±25% of annual recharge. Rainfall depletion of 25% 1-year does impact moderately/low on aquifer allocable yield balance.

Based on the groundwater categorisation, it is categorised as set out in Table 20, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 20: IUA 5 Groundwater categorisation for IUA 5 (GRU 5.1 and GRU 5.2)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 5.1	D123A – D12F, D15G – G12H, D18K – D18L.	1	1	2	1	CLASS 1 (Ideal-Good)
GRU 5.2	D14A – D14K	2	2	1	2	CLASS 2 (Marginal)

Ecological condition and the Ecological Reserve

Ecological consequences were assessed for the Upper Orange (site UO_EWR03_I) and Sterkspruit (UO_EWR02_I) within this IUA and Table 21 summarises the eco-classification and ecological water requirement (as a percentage of natural MAR). Dams in Lesotho impacts on the flows at the Upper Orange EWR site and the Jozana's Hoek Dam in the upper reaches of the Sterkspruit resulting in reduced floods and freshets.

No changes were made to the EWR as determined during the high confidence study of the Reserve for the Upper Orange River or the Sterkspruit.

Table 21: Eco-classification and EWR for biophysical nodes in IUA 5

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR03_FV	D12D	Gryskop-spruit	C	Moderate	Moderate	C	7.5	18.38	III
UO_EWR02_I	D12B	Sterkspruit	D	Moderate	Moderate	C/D	30.7	38.43	

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR03_I	D12F	Upper Orange	D	Moderate	Moderate	D	4 259.5	25.06	
UO_EWR24_FV	D15G	Makhaleng	C/D	Moderate	Moderate	C/D	524.5	17.39	
UO_EWR05_R	D14E	Wonderboom-spruit	B/C	Moderate	High	B	25.9	32.38	

Wetlands

The wetlands in IUA 5 include depression, seeps, floodplain and channelled and unchanneled valley bottom wetlands, covering an area of 0.67% of the IUA area of 1,024,091 km^2. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (8%), C (1%) and D/E/F (3%).

The following wetlands have been prioritised:

- **Maletswai, CVB/UVB wetland complex** is a moderately disturbed, wetland complex with extensive intact areas and is likely to have a high importance in terms of water quality enhancement, particularly given that much of the runoff from Maletswai (Aliwal North) town passes through this wetland complex before entering the Orange River. This wetland will be assessed during May 2025.

Economy

The IUA area consists mainly of small towns and numerous settlements with associated economic activity. Large areas within the eastern part of the IUA are utilised for subsistence farming (mixed agriculture). There is some commercial irrigated agricultural activity along the Orange River and some of the river tributaries and livestock agriculture in this IUA.

Conclusions and Proposed Water Resource Class

The scenarios for the Sterkspruit evaluated show reductions from the natural flows for all the months. However, there are very small reductions between present day without (Sc1a), and with EWR (Sc1b).

The results indicate that the EWR could be met for most of the time for Sc1 and Sc2 irrespective if the EWR was implemented or not. Non-compliances were mostly during drought periods (95 to 99.9 percentiles). Scenarios Sc3a and Sc3.1a show more deficits, however, when EWR is implemented, these deficits are reduced and only during drought periods.

The EWR could not be met in either Sc1a or Sc1b. This is mostly due to Jozana's Hoek Dam in the upper reaches of the Sterkspruit with limited release capacities.

Table 22 sets out the percentage aggregation for the PES and REC for the hydronodes in IUA 5 and a proposed water resource class of a III.

Table 22: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 5

Ecological category for IUA 5										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
	20.00	40.00	40.00			20.00	60.00	20.00		III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Although the FIFHA indicates adequate flows for the indicator species/taxon, ecological conditions are likely to remain constrained if the proposed upstream dams (e.g., Verbeeldeingskraal, Pohlihali, and Makhaleng) are constructed. These dams will trap more sediment, particularly coarse material such as gravel, which is critical for biotic habitats. Fine sediments will continue to pass through the system, increasing turbidity, sediment deposition, and embedding of available rocky habitats. These changes clog the gills of biota, restrict riparian zones, encourage the spread of AIP, and degrade biotic responses. This underscores the importance of addressing non-flow drivers, such as improving water quality, to support ecological health effectively.
- Flows under present-day (Scenario 1) and future (Scenario 2) conditions, with or without EWR implementation, are insufficient for fish and macroinvertebrates during the dry season and for fish during the wet season, primarily due to limited releases from Jozana's Hoek Dam. These deficits negatively impact critical habitats despite the presence of suitable biotopes The flows compromise fish migration and spawning during the critical summer high-flow period.
- In addition to the flow requirements not being met, both fish and macroinvertebrate health are predominantly influenced by water quality (non-flow driver). Overall, priority should focus on maintaining suitable conditions during March to support spawning rather than addressing low-flow periods e.g. July, and
- The surface-groundwater interactions in the IUA needs to be considered when setting the RQOs.

6.6 IUA 6: Gariep Dam

IUA Description

The IUA comprises 17 quaternary catchments situated within the Free State, Eastern Cape and Northern Cape provinces in the local municipalities of Kopanong, Walter Sisulu and Umsobomvu respectively. The main towns in the IUA include Bethulie, Springfontein, Venterstad and Colesberg. Notable villages include Gariep Dam, Oviston and Norvalspont.

The main water resources in the IUA include the main stem of the Orange River and five tributaries. The large Gariep Dam (largest in South Africa) is in this IUA and the surrounding protected areas of the Gariep Nature Reserve and Oviston Nature Reserve. The Orange-Fish Tunnel water transfer scheme from the Gariep Dam to the Fish and Sundays rivers in the Eastern Cape in support of irrigation and urban or industrial requirements particularly in the Algoa Water Supply Area. Other smaller protected areas include the Brakfontein Reserve and Merino Private Nature Reserve in the Free State. This IUA lies within the mixed-use socio-economic zone of the Upper Orange River catchment. with an estimated population of 46,977 (Stats SA Census 2011 adjusted).

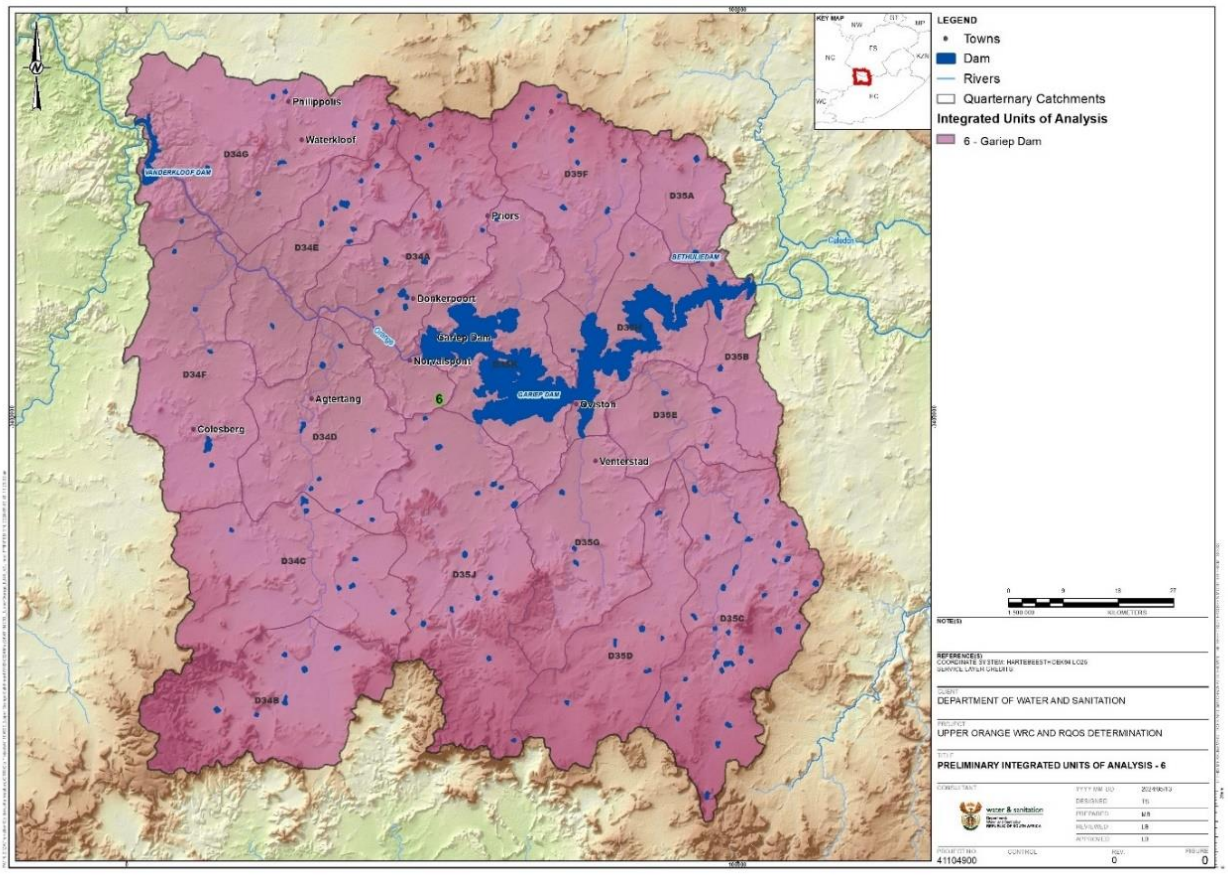

Figure 12: IUA 6: Gariep Dam delineation

Groundwater Use

IUA 6 has stock farming and WARMS indicates moderate to high water uses for irrigation systems, although this is not accurate as this could be from surface water as well. Stress Indices

are just below Fair (65%). Aquifer systems are moderate yielding systems and categorised as moderately used (C2). Water quality is C1, and aquifer recharge occurs less frequently. Aquifer Vulnerability varies between least (C1) and most (C3) vulnerable status. Baseflows are low – drains ±10% of annual recharge.

Based on the groundwater categorisation, it is categorised as set out in Table 23, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 23: Groundwater categorisation for IUA 6 (GRU 6.0)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 6.0	D34A – D34G, D35A – D35K	2	1	2	2	CLASS 2 (Marginal)

Ecological condition and the Ecological Reserve

As per the Upper Orange Reserve determination study, a conceptual Flow Management Plan (FMP) was established and an action plan provided. The action plan for flow-related management of the Upper Orange River catchment (specifically relating to the Vanderkloof and Gariep dams) was delineated into four stages:

- Immediate (current, emergency interventions should any be identified)
- Short-term (actions over the next 0 – 5 years)
- Medium-term (action between 5 – 20 years from now), and
- Long-term (actions 20 years from now and beyond).

Due to the highly variable flows at this site from hydropower and other releases from Gariep Dam, no formal EWR was determined. However, to provide some information for the FMP, the following should be considered and implemented in the short term:

i. A minimum flow of 40 m^3/s for any given month as this flow will still provide adequate habitats for the biota

ii. Additional to the daily releases, the following freshets are also important:

- November to January – 270 m^3/s over 6 days
- February – 350 m^3/s over 3 days

iii. Releases from Gariep Dam to supplement Vanderkloof Dam in late winter to early spring should coincide with the seasonal rainfall pattern, thus a later start to the release to match the late spring natural cues for fish and cleaning of habitats.

Wetlands

The wetlands in IUA 6 include depression, seeps, and channelled and unchanneled valley bottom wetlands, covering an area of 0.52% of the IUA area of 934,709 km^2. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (24%) and D/E/F (3%). There are no prioritised wetlands.

Economy

Land use and important economic sectors within the IUA include irrigation and dryland agriculture as well as extensive livestock farming. An important sector includes tourism including tourism of cultural, historical and nature perspective in the IUA.

Conclusions and Proposed Water Resource Class

As there are no hydronodes in this IUA, the ecological categories for the sub-reaches from the 2012 PES/ EIS assessment were used to inform the water resource class, as set out in Table 24.

Table 24: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 6

Ecological category for IUA 6					Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					
A or A/B	B or B/C	C or C/D	D	>D	
	5.66	49.06	43.40	1.89	III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- The FMP should be implemented

6.7 IUA 7: Seekoei River

IUA Description

The IUA delineation is based on the tributary catchments draining to Gariep Dam and the tributary catchments draining to the and the Orange River downstream of the dam (Figure 13). The IUA is situated on the lower western part of the Upper Orange River catchment comprising 10 quaternary catchments lying predominantly in the Northern Cape province and a small portion within the Eastern Cape province. These quaternary catchments fall within the local municipalities of Umsobomvu, Emthanjeni, Ubuntu and Renosterberg in the Northern Cape and Inxuba Yethemba of the Eastern Cape. The main towns in the IUA include Hanover and Noupoort.

The main water resources in the IUA are the Seekoei river and several tributaries. There are Strategic Water Source Areas for groundwater (SWSA-gw) in part of D32F (portions of the De Aar Region) and a SWSA-gw area covering parts in Noupoort region in quaternary catchments D32G and stretches into parts of D32C and D32B (Eastern Upper Karoo).

The protected areas in this IUA include High Karoo Park Protected Environment (D32D), parts of the Compassberg Protected Environment (D32B), the Hanover Aardvark Nature Reserve and Karoo Gariep Nature Reserve in quaternary catchment D32F and the Doornkloof Provincial Nature Reserve in the upper part of the IUA in D32K. The IUA falls mainly into the mixed-use socio-economic zone with land use mainly from mixed agriculture and mining. the second lowest population density within the Upper Orange River catchment and the total population is estimated as 14,344 (Stats SA Census 2011 adjusted).

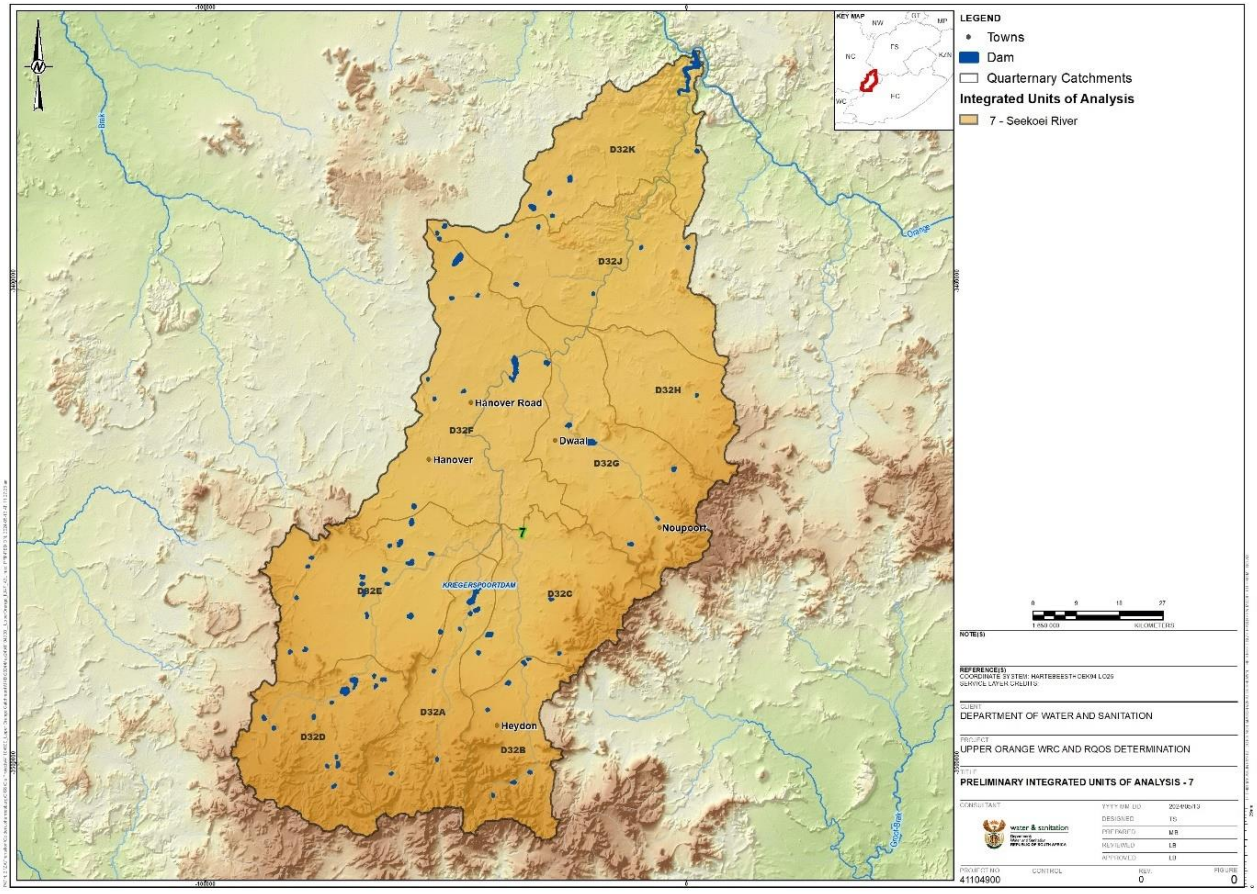

Figure 13: IUA 7: Seekoei River delineation

Groundwater Use

It is noted that there is a SWSA-gw area in D32B. GRUs 7.1 and 7.2 aquifer systems are low yielding systems and categorised as minimally used (Class 1). Water quality is C1 and the effect of primary salinity from the saline rock formations of the Karoo Supergroup is noted. Aquifer recharge occurs less frequently due to lower rainfall depths towards the Western part of the catchment. Aquifer Vulnerability is indicated as most vulnerable status (Class 3) due to lower rainfall input. Baseflows are low – drains ±6% of annual recharge in GRU 7.1 and ±7% in GRU 7.2. Rainfall depletion of 25% 1-year does impact moderately/low on aquifer allocable yield balance significantly and will deplete this allocation by 50% in GRU 7.1 and 75% in GRU 7.1 should it occurs over two consecutive seasons.

Based on the groundwater categorisation, it is categorised as set out in Table 25, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)

- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 25: IUA 5 Groundwater categorisation for IUA 7 (GRU 7.1 and GRU 7.2)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 7.1	D32E – D32K.	1	1	3	1	CLASS 1 (Ideal-Good)
GRU 7.2	D32A – D32D	1	1	3	1	CLASS 1 (Ideal-Good)

Ecological condition and the Ecological Reserve

Ecological consequences were assessed for the Seekoei River (site UO_EWR05_I) within this IUA. No large dams are situated upstream of this EWR site. The scenario evaluated show reductions from the natural flows for all the months. The results indicate that the EWR could not be met for some of the time during the wet season, even if implemented. However, the implementation resulted in smaller deficits.

Table 21 summarises the eco-classification and ecological water requirement (as a percentage of natural MAR).

Table 26: Eco-classification and EWR for the biophysical node in IUA 5

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR05_I	D32J	Seekoei	C	Moderate	Moderate	C	24.3	34.2	II

Wetlands

The wetlands in IUA 7 include depressions, seeps, and channelled and unchanneled valley bottom wetlands, covering an area of 1.07% of the IUA area of 915,159 km^2. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (2%), C (1%) and D/E/F (5%).

The following wetland has been prioritised:

- **Gordonville CVB/UVB, a w**etland complex (CVB and UVB) that is severely eroded, but with flood-out portions where sediment is currently accumulating. It is representative of many other similarly impacted wetlands in the landscape. This wetland will be assessed in May 2025.

Economy

The land use and main economic sectors within this IUA include the residential areas of the towns and agriculture with extensive livestock farming mainly of sheep (for meat and wool and sheep breeding). In D32H there is a small alluvial diamond mine.

Conclusions and Proposed Water Resource Class

As there is only one hydronodes in this IUA, the ecological categories for the sub-reaches from the 2012 PES/ EIS assessment were used to inform the water resource class (Table 27).

Table 27: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 7

Ecological category for IUA 7										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
		100					100			II

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Groundwater quality aspects must be considered when setting RQOs.

6.8 IUA 8: Vanderkloof Dam

IUA Description

IUA 8 comprises the quaternary catchments of the Vanderkloof Dam sub-catchment as well as the downstream sub-catchments of the Orange River mainstem to its confluence with the Vaal River. The IUA is situated along the upper western border of the Upper Orange River catchment and comprises 15 quaternary catchments. These are situated within parts of six local municipalities including, Siyancuma, Thembelihle, Renosterberg and a small part of Umsobomvu in the Northern Cape and Kopanong and Letsemeng of the Free State province. The main towns in the IUA include Orania, Hopetown, Petrusville, Vanderkloof, Phillipstown, and Luckhoff.

The main water resources in the IUA include the main stem of the Orange River and several tributaries. The IUA includes the Vanderkloof Dam and the Rolfontein Provincial Nature Reserve,

Tuinhoek Reserve and Grasberg Reserve adjacent to the dam. Other protected areas within the IUA include parts of the Doornkloof Provincial Nature Reserve and several other private nature reserves. This IUA falls into the agriculture and mining socio-economic zone with land use mainly irrigated agriculture and some mining, and an estimated total population of 32,577 (Stats SA Census 2011 adjusted).

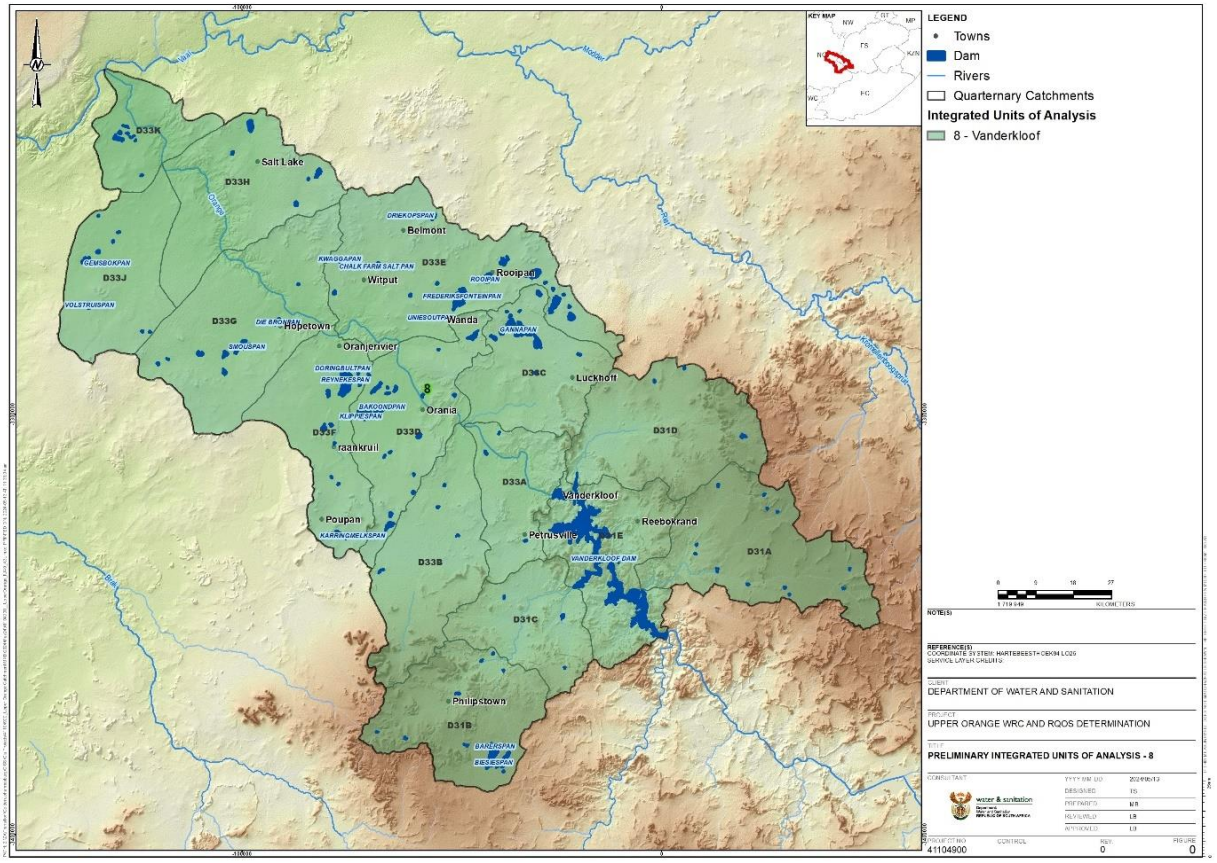

Figure 14: IUA 8: Vanderkloof Dam

Groundwater Use

IUA 8 comprises GRU 8.1, 8.2 and 8.3. Aquifer systems are moderate yielding systems and categorised as Minimally Used (Class 1). Water quality is Class 1. Aquifer recharge occurs less frequently due to lower rainfall depths.

GRU 8.1 Aquifer vulnerability is indicated as moderately vulnerable (Class 2) due to lower rainfall input. Baseflows are Low – drains ±10% of annual recharge – probably due to topographical characteristics of the GRU catchment. Rainfall depletion of 25% 1-year does impact significantly on aquifer allocable yield balance and will deplete this allocation by 75% should it occurs over two consecutive seasons. Water quality is Class 2. Aquifer recharge occurs less frequently due to lower rainfall depths.

GRU 8.2 Aquifer Vulnerability is indicated as least vulnerable (Class 1) due to low baseflow drainage. Baseflows are low – drains ±2% of annual recharge. Rainfall depletion of 25% 1-year does impact significantly on aquifer allocable yield balance and will deplete this allocation by 50% should it occurs over two consecutive seasons.

GRU 8.3 Aquifer vulnerability is indicated as least (Class 1) vulnerable status due to low baseflow drainage. Water quality is Class 2 because of poor drainage and salinity of aquifer rock formations (lower saline mudrocks of the Karoo Supergroup Formations. Aquifer recharge occurs less frequently due to lower rainfall depths. Baseflows are low – drains ±2% of annual recharge. Rainfall depletion of 25% 1-year does impact significantly on aquifer allocable yield balance and will deplete this allocation by 50% should it occurs over two consecutive seasons.

Based on the groundwater categorisation, it is categorised as set out in Table 28, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 28: Groundwater categorisation for IUA 8 (GRU 8.1, 8.2 and 8.3)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 8.1	D31A – D31E and D33A.	1	1	2	1	CLASS 1 (Ideal-Good)
GRU 8.2	D31B, D33B – D33G	1	2	1	1	CLASS 1 (Ideal-Good)
GRU 8.3	D33H – D33K	1	2	1	1	CLASS 1 (Ideal-Good)

Ecological condition and the Ecological Reserve

Ecological consequences were assessed for the Orange River at Marksdrift (site UO_EWR10_I) within this IUA. Both Gariep Dam and Vanderkloof Dam upstream of the site have a direct impact on the flows due to the operation of the dams for hydropower releases and for downstream users in the Lower Orange River. The operation of the dams impacts on all the flow components with reduced floods and increased baseflows. Due to negative socio-economic impacts if the EWR is implemented, the requirements were adjusted by reducing the maintenance low flows and the freshet and flood requirements (Report RDM/WMA13/00/CON/CLA/0125).

Table 29 summarises the eco-classification and ecological water requirement (as a percentage of natural MAR).

Table 29: Eco-classification and EWR for the biophysical node in IUA 8

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR10_I	D33K	Lower Orange	C	Mod	Mod	C	6 618.2	18.66	III

Wetlands

The wetlands in IUA 8 include depression, seeps, and channelled and unchanneled valley bottom wetlands, covering an area of 2.5% of the IUA area of 1,449,349 km^2. The ecological categories of the wetlands that have been assessed, as a percentage, are C (3%) and D/E/F (16%).

The following wetland has been prioritised:

- **Philipstown unchanneled valley-bottom (UCVB) wetland complex** comprising a wetland complex of approximately 190 ha and a depression wetland of approximately 1 100 ha. The upstream catchment areas of both wetland units are in a relatively natural condition with little to no human impact. The ecological category is a C.

Economy

This IUA's land use and economic activity is characterised by intensive irrigated agriculture and livestock and game farming. There is some mining land use from alluvial diamond mines in the upper western part of the IUA. Some salt production take space in this IUA and there are several pans. Tourism plays a role (cultural, historical and from a nature perspective) in particular the towns and along the Orange River, at the Vanderkloof Dam and in the various nature reserves in the IUA.

Conclusions and Proposed Water Resource Class

All flow components are reduced during the scenarios, especially the peaks due to the all the existing large dams (Sc1) and proposed new dams (Sc2 and Sc3) in the upper catchment. The EWR could be met all the time for all the scenarios if the EWR is implemented. However, when not implemented the maintenance flows and some freshets (20 to 70 percentiles) in the wet and early dry months) show deficits.

As there is only one hydronodes in this IUA, the ecological categories for the sub-reaches from the 2012 PES/ EIS assessment were used to inform the water resource class (Table 30).

Table 30: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 8

Ecological category for IUA 8										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
		100					100			III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Adequate flows for the indicator species/taxon, ecological conditions are likely to remain constrained if proposed upstream dams (e.g., Verbeeldingskraal, Pohlihali, and Makhaleng) are constructed. These dams will trap coarse sediment, such as gravel, which is crucial for biotic habitats, while fine sediments will continue to increase turbidity, sediment deposition, and the embedding of rocky habitats. These changes adversely impact biota by clogging gills (physiological stress impacting on reproduction), narrowing riparian zones, promoting alien invasive plants, and degrading ecological responses.
- Addressing non-flow drivers, such as improving water quality, is critical in maintaining ecological health.
- In addition to the above, to protect geomorphology and riparian vegetation.
- It is essential to implement the floods specified in the Reserve determination study. Failure to do so would have detrimental effects on these ecological components and thus may have a knock-on effect on the biotic component.
- Although the scenario flows at this EWR site near Marksdrift are meeting the REC of a Category C, there is a concern regarding the limited bigger floods of approximately 155 and 550 m^3/s (October to April) that have been removed. This will have a major impact on the geomorphological and riparian vegetation components of the system, which will have a knock-on effect on the instream biota (ecological trade-off). While the recent large floods that have occurred over the lats three years are adequate to do this, these are unpredictable. The lack of large floods will be insufficient to effectively scour habitats, mobilise sediments, and transport gravel and reset marginal vegetation, which are critical processes for maintaining ecosystem health. It is important to acknowledge that the reduced freshet may not fully support key ecological functions. Therefore, careful consideration must

be given to the potential impacts of this lower-than-ideal freshet on habitat maintenance and overall river system dynamics, and

- Groundwater quality issues need to be considered when considering the RQOs.

6.9 IUA 9: Upper Modder River

IUA Description

IUA 9 comprises the quaternary catchments of the upper catchment area of Modder River with its tributaries to the IUA outlet at the Krugersdrift Dam. This IUA comprises of 7 quaternary catchments and lies between Mangaung Metropolitan Municipality and Masilonyana Local Municipality in the Free State province. Bloemfontein is the main city in the Free State province and lies mostly within this IUA. The main towns and populated settlements include Bloemfontein, Botshabelo, Dewetsdorp, and Winnie Mandela. There are many other townships, villages and farms within the IUA.

The key water resources in the IUA include the Modder River and many tributaries. The dams in the IUA include Rustfontein Dam, Mockes Dam, Moutloatsi Dam, Setlogelo Dam, and Krugersdrift Dam. There are a few protected areas within the Mangaung metropolitan municipal area and several within Masilonyana local municipal area. The IUA falls within the commercial development socio-economic zone, with industry activity and agricultural activity alongside the rivers and mixed agriculture in other areas of the IUA, with the estimated population being 811,000 (Stats SA Census 2011 adjusted).

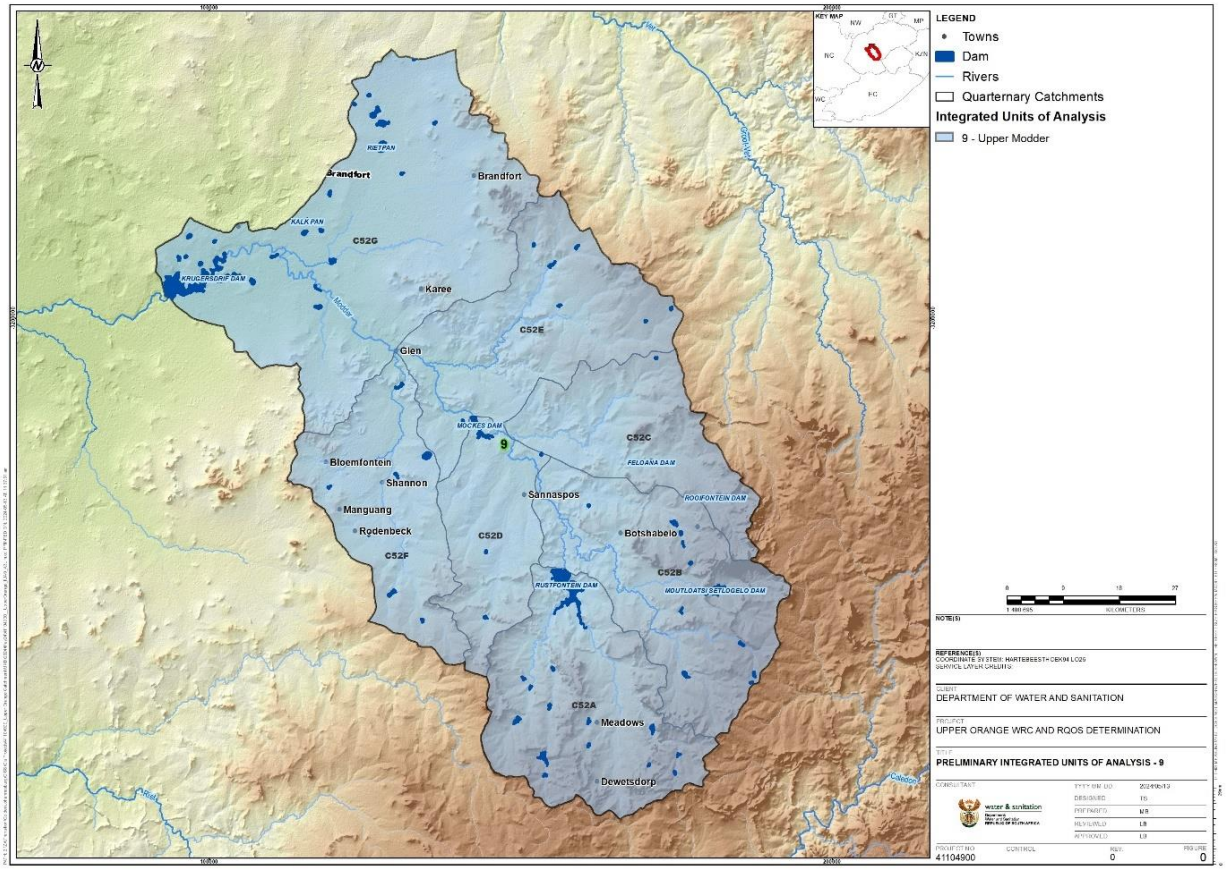

Figure 15: IUA 9: Upper Modder River IUA delineation

Groundwater Use

IUA 9 comprises GRU 9.1 and GRU 9.2. It is noted that there are SWSA-gw across quaternaries C52D, C52F and C52G (Central Pan Belt).

GRU 9.1 is a highly populated area, with high levels of stock farming. WARMS indicates moderate to high irrigation water use (4.9 Mm^3/a). Aquifer systems are moderate to high yielding systems and categorised as moderately used (Class 2). Water quality is Class 2 because of poor return water recharging into the aquifer system(s). Aquifer Vulnerability is indicated as least vulnerable (Class 1) status probably due to high discharges into the local drainages and higher rainfall depths. Baseflows are low – drains ±11% of annual recharge. Rainfall depletion of 25% 1-year does not impact significantly on the allocable yield status.

GRU 9.2 has a high level of dry land cultivation with stock farming, however, WARMS indicates very high water uses for irrigation systems (40 Mm^3/a). Aquifer systems are high yielding systems and categorised as critically used (Class 3). Water quality is Class 2 because of primary salinity of the aquifer rock formations. Several large salt producing pans are present in this GRU. Aquifer Vulnerability is indicated as least vulnerable (Class 1) status probably due to high discharges into the local drainages and higher rainfall depths. Baseflows are Low – drains ±3% of annual

recharge. Rainfall depletion of 25% 1-year does impact significantly on the allocable yield status and drops the allocable yield value negatively (-4.6 Mm^3/a).

Based on the groundwater categorisation, it is categorised as set out in Table 31, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 31: Groundwater categorisation for IUA 9 (GRU 9.1 and GRU 9.2)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 9.1	C52A – C52F	2	2	1	2	CLASS 2 (Marginal)
GRU 9.2	C52G and C52H	3	3	1	3	CLASS 3 (FAIR TO POOR)

Ecological condition and the Ecological Reserve

Only present day and medium-term scenarios were assessed at the two EWR sites UO_EWR07_i and UO_EWR06_R, as limited long-term developments are foreseen in this IUA. No changes were made to the EWRs as determined during the high confidence study of the Reserve for the Upper Orange River.

Table 32 summarises the eco-classification and EWR for the biophysical nodes in IUA 9.

Table 32: Eco-classification and EWR for the biophysical node in IUA 9

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR07_I	C52B	Upper Modder River (Sannaspos)	D	Low	Moderate	C	61.0	35.94	III
UO_EWR06_R	C52H	Middle Modder River (Soetdoring)	D	High	Moderate	C/D	113.7	33.96	
UO_EWR13_FV	C52E	Osspruit	B/C	High	Moderate	B/C	8.6	21.84	
UO_EWR14_FV	D31C	Hondeblaf River	B	Low	Moderate	B	2.0	26.74	

Wetlands

The wetlands in IUA 9 include depression, seeps, floodplains and channelled and unchanneled valley bottom wetlands, covering an area of 0.97% of the IUA area of 632,039 km^2, with a large percentage being in a degraded state. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (8%), C (11%) and D/E/F (46%).

The following wetland has been prioritised:

- **Aardoringspruit,** a large wetland complex that includes a large wetland flat and a DCVB wetland which encompasses the Aardoringspruit. The confluence of the Aardoring- and Keeromspruits occurs within the wetland resource unit (WRU), from which the Rietspruit flows. It is unusual to find a wetland flat in this part of the country. The ecological category is a C.
- **Kaalspruit wetland complex,** a wetland complex comprising several depression wetlands, and a discontinuously channelled valley-bottom (DCVB) wetland located along the Kaalspruit, a tributary of the Modder River within the IUA 9. A unique feature in this complex is a depression wetland nested within the channelled valley-bottom (CVB) wetland, which is a relatively unique and rare situation. The ecological category is a C.

Economy

The key land use in IUA 9 is residential settlements in Bloemfontein, Botshabelo, Dewetsdorp, Winnie Mandela and villages around the IUA. The area is characterised by subsistence farming (mixed crops and cattle) around the villages and settlements and commercial agriculture along the Modder River and tributaries and livestock farming with cattle.

Conclusions and Proposed Water Resource Class

For site UO_EWR07_I the high flows have decreased due to the upstream dam and increased baseflows due to WWTW discharges. At site UO_EWR06_R all the flow components have

increased compared to the natural flows as a results of the discharges from the wastewater treatment works (WWTWs).

While the % REC aggregated shows an even split of ecological categories in B or B/C and C or C/D, indicating that this IUA should be classified as a water recource class II, the extensive urban nature of the IUA indicate that only small areas in the upper portions could be a classs II, however, overall it proposed as a class III, with stricter resource quality objectives set for the upper portions.

Table 33 sets out the percentage aggregation for the PES and REC for the hydronodes in IUA 59 and a proposed water resource class of a III.

Table 33: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 9

Ecological category for IUA 1										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
	50.00		50.00			50.00	50.00			III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Addressing water quality issues is essential to improve the ecological state of the system, even where flows are deemed adequate - scenario flows, with or without EWR implementation, generally align with the flow preferences of the biota. In fact, flows are higher owing to releases from upstream WWTW. However, it is important to note that flow is not the primary driver in this system; water quality is the dominant factor influencing ecological health. The poor water quality in the system has a significant impact on biota, affecting their ability to thrive and altering ecological conditions. These impacts include reduced habitat suitability, physiological stress on species, and the potential for long-term degradation of biotic communities.
- High primary salinity is noted due to the underlying saline rock formations in the Karoo Supergroup Ecca Group Mudrocks and needs to be considered when setting RQOs.

6.10 IUA 10: Modder/ Riet River

IUA Description

IUA 10 comprises the quaternary catchments of the Modder River downstream of Krugersdrift Dam on the outskirts of Bloemfontein to the confluence of the Riet River and including the Riet River to the confluence of the Vaal River. It comprises 16 quaternary catchments and the largest

area within the IUA lies within the Free State province and in parts of the local municipalities of Lestemeng, Kopanong, Tokologo, and Mangaung. The rest of the IUA lies within the Northern Cape province and falls within parts of the local municipalities of Sol Plaatjie and Siyancuma. The towns of the IUA include Reddersburg, Edenburg Trompsburg, Jagersfontein, Fauresmith, Koffiefontein, Jacobsdal, Petrusburg and Ritchie. The IUA has several other townships, villages, and farms.

The key water resources in the IUA include the Riet River, Modder River, and many tributaries. The dams include Kalkfontein Dam and the Tierpoort Dam. There are numerous protected areas scattered within the IUA including several private game reserves and farms and many private nature reserves. The Mokala National Parks Game is in quaternary catchments C51M an C51L. This IUA falls within two socio-economic zones, the agriculture and mining zone (western part of the IUA) and the commercial development zone (eastern part of the IUA). The land use consists of agricultural activity especially in the north of the IUA and along the Riet and Modder rivers and there is some mining activity in the IUA. The population is estimated at 101,300 (Stats SA Census 2011 adjusted).

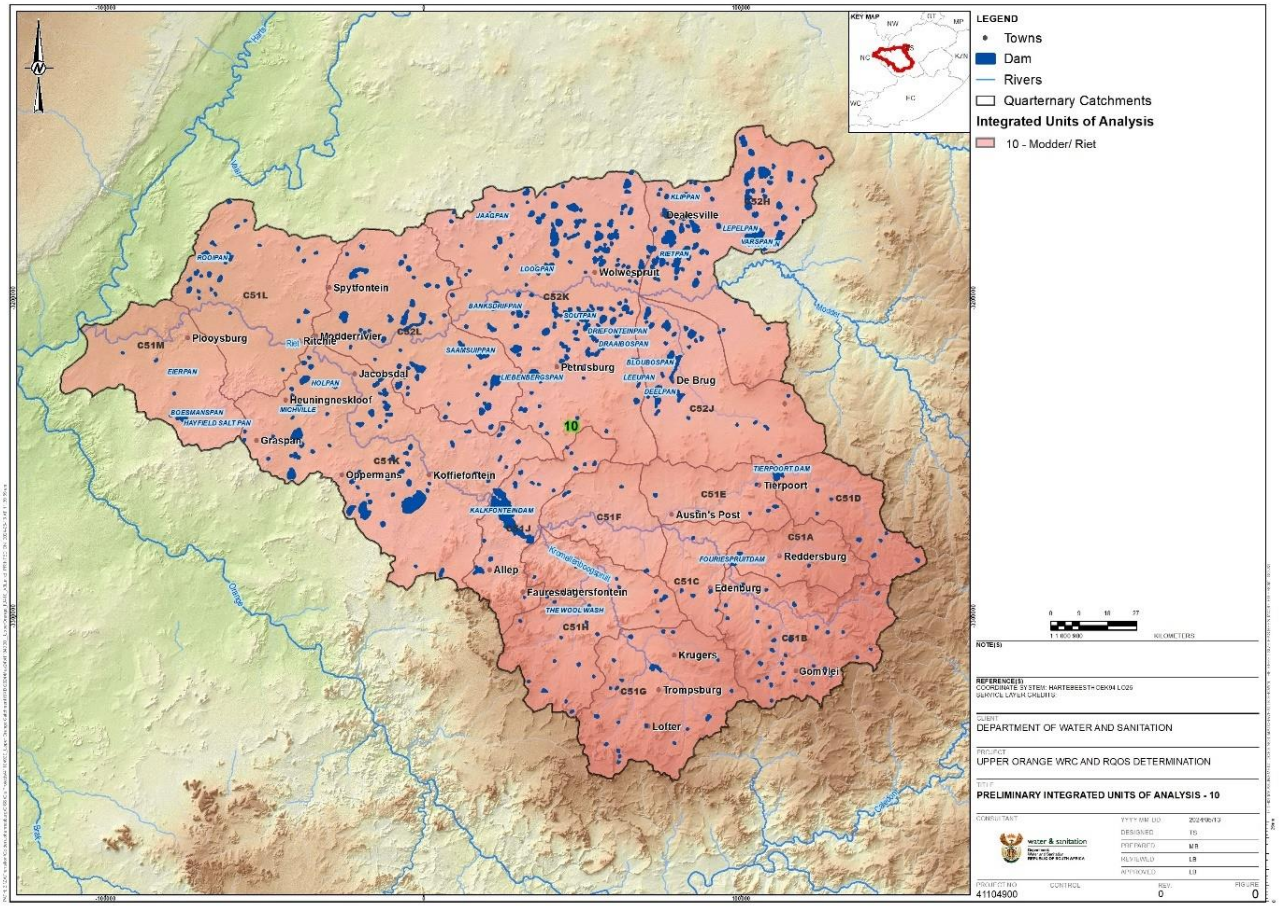

Figure 16: IUA 10: Modder/ Riet River delineation

Groundwater Use

IUA 10 comprises GRU 10.1, 10.2 and 10.3. IT is noted that there is a SWSA-gw across D52J, D52H and D52K.

GRU 10.1 has a high level of dry land cultivation with stock farming, however, WARMS indicates high water uses for irrigation systems (16 Mm^3/a). Aquifer systems are moderate to high yielding systems and categorised as moderately used (Class 2). Water quality is C1 because of shallower aquifer systems with high preferential recharge. Occasional salt producing pans are present in this GRU. Aquifer vulnerability is indicated as moderate (Class 2) vulnerable status probably due to higher rainfall recharges. Baseflows are low – drains ±12% of annual recharge. Rainfall depletion of 25% 1-year does impact on the allocable yield and will deplete this allocation by 50% should it occurs over two consecutive seasons.

GRU 10.2 has high level of dry land cultivation with stock farming and highly populated areas near Bloemfontein – WARMS indicates extremely high water uses for irrigation systems (73 Mm^3/a). Quaternary catchment C52J has a low allocatable yield value under normal rainfall depths but drops to -2.2 Mm^3/a with a 25% rainfall depletion. Aquifer systems are moderate to high yielding systems and categorised as moderately used (Class 2). Water quality is C1 because of shallower aquifer systems with high preferential recharge. Occasional salt producing pans are present in this GRU. Aquifer vulnerability is indicated as least (Class 1) vulnerable status probably due higher rainfall recharges. Baseflows are low – drains ±0.8% of annual recharge. Overall, rainfall depletion of 25% 1-year does impact on the allocable yield (see note re. QC C52J above).

GRU 10.3 has extensive stock farming. Aquifer systems are low to moderate yielding systems and categorised as minimally used (Class 1). Water quality is Class 2 because of aquifer salinity (elevated Na-Cl primary source). Occasional salt producing pans are present in this GRU. Aquifer vulnerability is indicated as least (Class 1) vulnerable status due to low water use due to poor water quality. Baseflows are low – drains ±3% of annual recharge. Overall, rainfall depletion of 25% 1-year impacts on the allocable yield.

Based on the groundwater categorisation, it is categorised as set out in Table 34, where the following is relevant:

The final score is based on the following weighted scaling:

- Aquifer Stress Index (60%)
- Aquifer Quality Index (25%)
- Aquifer Vulnerability Index (15%).

Borehole Yield Classes:

- Insignificant: 0.0-0.1 L/s
- Low: 0.1-0.5 L/s
- Moderate: 0.5-2.0 L/s
- High: 2.0-5.0 L.s; and
- Significant: >5.0 L/s (could be as high as 20 L/s in shallow calcrete rock formation under shallow water level conditions).

Table 34: Groundwater categorisation for IUA 10 (GRU 10.1, 10.2 and 10.3)

GRU Ref.	Quaternary Catchment Reference	Groundwater Quantity Class (Index)	Groundwater Quality Class (Index)	Aquifer Vulnerability Class (Index)	Final Groundwater Resource Classification[1] (Index)	Proposed Groundwater Resource Classification per IUA
GRU 10.1	C51A – C51J	2	1	1	2	CLASS 2 (Marginal)
GRU 10.2	C51K and C52J – C52L.	2	1	1	2	CLASS 2 (Marginal)
GRU 10.3	C51L and C51M	1	2	1	1	CLASS 1 (Ideal-Good)

Ecological condition and the Ecological Reserve

Ecological consequences were assessed at two EWR sites in the Upper and Lower Riet River (sites UO_EWR06_I and UO_EWR09_I) within this IUA. Both these sites are impacted by a number of upstream dams, and the lower Riet site by return flows from extensive irrigation practices.

For site UO_EWR06_I the flows are reduced during the summer months due to water use in the upper catchment. The flows at site UO_EWR09_I show further reductions in the summer months with increased flows during the dry months. This is due to the extensive irrigation in the lower Riet River. The results indicate that the EWR could be met for most of the time at both sites for all the scenarios irrespective if the EWR was implemented or not. Table 35 summarises the eco-classification and EWR for the biophysical nodes in IUA10.

Table 35: Eco-classification and EWR for the biophysical node in IUA 10

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR06_I	C51F	Upper Riet	C	Mod	Mod	C	105.2		III
UO_EWR09_I	C51L	Lower Riet	C	Very high	High	B/C*	373.8		
UO_EWR26_FV	C51L	Lower Riet	NA	NA	NA	NA	-	-	
UO_EWR11_FV	C51A	Fouriespruit	C	Mod	Mod	C	13.8	-	
UO_EWR12_FV	C52F	Renoster	D/E	Mod	Mod	D	7.9	-	
UO_EWR15_FV	C51G	Tributary of VanZylspruit	C	High	Mod	C	1.9	-	

EWR site (hydronodes)	QC	River	PES	EI	ES	REC	nMAR (Mm^3/a)	EWR (% nMAR)	Proposed Class
UO_EWR19_FV	C51K	Lower Modder	C/D	Very high	High	C	156.8	-	
UO_EWR20_FV	C51G	Upper Kromellenboog	B	Mod	Mod	B	9.3	-	
UO_EWR21_FV	C51H	Lower Kromellenboog	C	Moderate	Moderate	B/C	85.1	-	

*Not assessed

Wetlands

The wetlands in IUA 10 include depression, seeps, floodplains and channelled and unchanneled valley bottom wetlands, covering an area of 2% of the IUA area of 2,846,614 km^2, with a large percentage being in a degraded state. The ecological categories of the wetlands that have been assessed, as a percentage, are A/B (9%), C (13%) and D/E/F (26%).

The following wetland has been prioritised:

- **Soutpan Depression wetland complex,** a large complex of depression wetlands consisting of a total of 27 depression wetlands ranging in size from 6 ha to 1 800 ha. Most of these depression wetlands are endorheic and have no clear outward-flowing connection to river systems. The ecological category is a B.
- **Jagersfontein DCVB wetland,** a large contiguous series of wetlands that originate from four different river/ watercourse systems and coalesce into a VB wetland. The wetland type can be considered a DCVB wetland as the channels are not consistent throughout the HGM unit. At the time of the Reserve study, the ecological category was a C.

A few months after the Reserve determination study site visit, in September 2022, the Jagersfontein wetland was heavily impacted by a tailings dam failure which resulted in the spillage of tailings material down the Prossesspruit and associated wetland system. The tailings material deposited across a broad area for at least 10km downstream, although the impact extended further downstream towards the Kalkfontein Dam. Approximately 35-40% of the wetland area was directly affected by deposited tailings sediment which led to smothering of the vegetation, altered surface flow patterns and water quality impacts. At the time of a follow-up wetland survey on the 16th of May 2025, tailings material was still actively being removed upstream of the R706 road.

It was noted that vegetation has reemerged within the wetland and along the river, although tailings sediment is still evident and large areas of ground remain bare or sparsely vegetated, particularly immediately downstream of the tailings dam (Figure 17). Wetland habitat along a nearby, unaffected tributary was visited and the contrast in vegetation cover and diversity highlights the severe impact of the spillage to the downstream wetland condition. It is expected

that with the rehabilitation taking place this wetland could be restored to function as a category C or C/D.

Figure 17: Jagersfontein Wetland current condition and active rehabilitation (16 May 2025)

Economy

The key land use for IUA 10 is within the main residential settlements in Fauresmith, Reddersburg, Edenburg, Trompsburg, Jagersfontein, Petrusburg, Koffiefontein and villages around the IUA. An important land use and economic activity is from agriculture including irrigation agriculture along the major rivers and livestock farming of sheep. Another land use and economic activity is from alluvial diamond mining within the IUA.

Conclusions and Proposed Water Resource Class

Table 36 sets out the percentage aggregation for the PES and REC for the hydronodes in IUA 5 and a proposed water resource class of a III.

Table 36: IUA Class for the percentage representation of indicated EC groups as per WRCS guidelines (2007) for IUA 10

Ecological category for IUA 10										Proposed Class
% PES aggregated for EWR Sites per IUA (PES)					% REC aggregated for EWR Sites per IUA					
A or A/B	B or B/C	C or C/D	D	>D	A or A/B	B or B/C	C or C/D	D	>D	
	12.50	75.00	12.50			37.50	50.00	12.50		III

Additional considerations to be noted and recommendations to be taken forward in setting of the RQOs

- Scenario flows, with or without EWR implementation, generally align with the flow preferences of the biota, and
- High primary salinity is noted due to the underlying saline rock formations in the Karoo Supergroup Ecca Group Mudrocks and needs to be considered when setting RQOs.

7 CONCLUSIONS AND RECOMMENDATIONS

The proposed water resource classes have been determined considering the present, medium term (2040) and long-term (2060) scenarios evaluated, and the associated ecological and socio-economic consequences and trade-offs for each IUA. These will be taken into forward and recommendations such as improvement in water quality, alien plant removal, groundwater/ surface water interactions will all be considered when determining the RQOs.

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