**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

## RESOURCE UNITS' PRIORITISATION REPORT AND SELECTION OF SITES WP 11422

**Study Report No.**

**RDM/WMA13/00/CON/CLA/0424**

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# TERMINOLOGY AND ABBREVIATIONS

| Acronym | Description |
|---|---|
| Alloc. | Allocable |
| Bf | Baseflow |
| BHN | Basic Human Need |
| BYC | Borehole Yield Classification |
| CD: WEM | Chief Directorate: Water Ecosystems Management |
| CVB | Channelled Valley-Bottom |
| DCVB | Discontinuously Channelled Valley-Bottom |
| DWA | Department of Water Affairs |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| EC | Ecological Category |
| EI | Ecological Importance |
| EIS | Ecological Importance and Sensitivity |
| ES | Ecological Sensitivity |
| EWR | Ecological Water Requirements |
| FEPA | Freshwater Ecosystem Priority Areas |
| FSC | Full Storage Capacity |
| GDP | Gross Domestic Product |
| GIS | Geographical Information System |
| GRU | Groundwater Resource Unit |
| HGM | Hydrogeomorphic |

| Acronym | Description |
|---|---|
| HSS | Hillslope Seep |
| IUA | Integrated Unit of Analysis |
| km | Kilometre |
| $km^2$ | Square kilometres |
| kL/d | Kilolitres per day |
| L/s | Litres per second |
| mamsl | Meters above mean sea level |
| mbgl | Meters below ground level |
| MAR | Mean Annual Run-off |
| MCA | Multi criteria analysis |
| mm | Millimetres |
| $Mm^3$ | Million cubic metres |
| $Mm^3/a$ | Million cubic metres/ annum |
| $m^3/a$ | Cubic meters per annum |
| $m^3/s$ | Cubic meters per second |
| NEC | Nested Ecological Category |
| NFEPA | National Freshwater Ecosystem Priority Areas |
| NWRS3 | National Water Resources Strategy 3 |
| MAR | Mean Annual Run-off |
| PES | Present Ecological Sate |
| Ql | Quality |
| Qn | Quantity |
| Re | Recharge |
| REC | Recommended Ecological Category |

| Acronym | Description |
|---|---|
| REMP | River Eco-status Monitoring Programme |
| RQOs | Resource Quality Objectives |
| RDM | Resource Directed Measures |
| RUs | Resource Units |
| SAI | Strategic Aquifer Importance |
| SEZ | Socioeconomic Zones |
| SI | Stress Factor Index |
| SWSA | Strategic Water Source Area |
| SWSA-gw | Groundwater Strategic Water Source Area |
| SWSA-sw | Surface Water Strategic Water Source Area |
| SW-GW | Surface water- Groundwater |
| UCVB | Unchanneled Valley-Bottom |
| WMA | Water Management Area |
| WQ | Water Quality |
| WRCS | Water Resource Classification System |
| WRU | Wetland Resource Unit |
| WSS | Water Supply System |
| WTW | Water Treatment Works |
| WWTW | Wastewater Treatment Works |

# EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) initiated a study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Upper Orange River catchment in October 2023.

The purpose 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 as part of the Water Resource Classification System (WRCS).

The Orange River catchment comprises the Upper Orange and Lower Orange River catchments within the Vaal-Orange River Water Management Area (WMA04). This core area forms part of the Orange-Senqu River Basin, which straddles four International Basin States, Lesotho, South Africa, Namibia and Botswana. The Upper Orange River originates in Lesotho where it is known as the Senqu River, flows into South Africa and Namibia with Molopo River in Botswana joining the Orange River. The main stem flows west approximately 2 200 km, where it flows into the Orange River Mouth and into the Atlantic Ocean at Alexander Bay. The Orange River is of critical importance to South Africa in that it augments the Vaal River System through the Lesotho Highlands Water Project and supplies the economic heartland of South Arica as well as supplying water to the Eastern Cape via the Gariep Dam to Great Fish transfer scheme.

The Upper Orange River catchment is characterised by climate that varies from east to west, with rainfall varying from an average low of 307 mm in the west to an average high of 909 mm in the east along the eastern escarpment mountains. Topography is diverse but plains with a moderate to high relief and lowlands, hills and mountains with moderate to high relief are dominant in the central to west areas, with the high lying regions, characterized by closed hills, mountains with moderate and high relief with prominent escarpments towards the east, and particularly along the Lesotho border.

The catchment comprises four sub-catchments stretching across the Northern Cape, Free State and Eastern Cape provinces and across three dominant ecoregions, the Eastern Escarpment Mountains, Nama Karoo and Highveld, as well as the Southern Kalahari in the north of the Riet/ Modder catchments and the Drought Corridor in the northern area of the catchment. The sub-catchments are the Caledon River from its headwaters and its tributaries to the Gariep Dam; the Orange River from the Lesotho Border to the Gariep Dam, including the Kraai River catchment, and the Orange River from the Gariep Dam, through Vanderkloof Dam to Marksdrift weir, just before the confluence with the Vaal River, and the Modder-Riet River which are main tributaries of the Vaal River system but for planning purposes due to the transfers, is included in the Upper Orange River catchment.

Land use in the Upper Orange River catchments of the WMA is predominantly under natural vegetation with livestock farming as main economic activity and extensive areas under dry land cultivation, mostly to produce grains, in the north-eastern parts and several large irrigation schemes. The Modder Riet catchment is dominated by agricultural activities including several

areas of irrigation, with limited alluvial diamond mining, and a few urban centres, and in addition to the transfers from the dams, two large hydropower stations have been constructed at Gariep and Vanderkloof dams.

There are several surface and groundwater strategic water source areas in the catchment as well as protected areas such as the Golden Gate National Park.

The use of groundwater is a function of (i) groundwater quality type, (ii) aquifer type (intermediate, fracture, and fractured & weathered), (iii) aquifer potential (borehole yield classification) (iv) potential groundwater recharge (rainfall depths). Most water supply schemes have been developed for sole water supplies – one or 10 boreholes per water user/property to one or more well fields per water use entity (*viz*., municipalities, mines, or irrigation scheme).

Water users are (i) rural towns (population <30 000), (ii) shallow open cast mines (own consumption and dewatering) and (iii) agricultural irrigation schemes, excluding the large surface water irrigation schemes along the Upper Orange River and Caledon River, plus several thousand individual boreholes used on a daily interval for domestic and stock water supplies. Larger towns/cities such as Bloemfontein (±600,000 population, quaternary catchment C52F), Colesburg (±24,250 population, quaternary catchment D34F), and Botshabelo (±219,508 population, quaternary catchment C52B) do have water supplies from surface water and groundwater resources. Other towns are dependent on groundwater resources, i.e., Philipstown (4,100 population, quaternary catchment D31B), Dealesville (±6,580 population, quaternary catchment C52H), Burgersdorp (±19,320 population, quaternary catchment D14E), and Barkly East (±12,100 population, quaternary catchment D13D).

Generally, the groundwater aquifer systems do not fit perfectly into the quaternary catchment demarcations, however, in the case of the Upper Orange River catchment, the geological formations are quite horizontal and the exploited aquifer systems are regarded as merely shallow systems (i.e., <65 mbgl). From a groundwater flux “point of view”, it is expected that groundwater flow will mimic the topography and report to the local surface water domain – as can be seen in the large groundwater flow contribution(s) to the baseflows in the surface water systems.

The wetlands in the catchment include seeps, depressions/ pans, floodplains, channelled valley bottom systems; and unchanneled valley bottom systems.

The Water Resource Classification System describes a 7-step procedure that, when applied to a specific catchment, will result in the determination of a water resource class. The study is currently in Steps 1 and 2 of the process. Step 1 of the process, that has mostly been completed, is to delineate the Integrated Units of Analysis (IUAs), the spatial units that will be defined as a network of significant water resources. Each IUA represents a homogenous area that requires its own specification of the water resource class. A detailed status quo assessment that included a socio-economic analysis of the catchment has been undertaken to understand the current conditions. The delineation of a catchment into IUAs is done primarily according to several socio-economic criteria, drainage region (catchment) boundaries and land use characteristics.

Integrated Units of Analysis are therefore a combination of SEZs and watershed boundaries. Ecological information also plays a role in their delineation, as well as the assessment of the present state of water resources and impacts, and key modelling points in the system. Ten IUAs have been delineated for 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 |

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

The delineation of a catchment into resource units is done primarily on a biophysical basis, and where the hydrology, geomorphic characteristics (i.e., geomorphic zone), water quality attributes and river size remain relatively similar, a resource unit can be defined. In addition, management requirements also play a role in the delineation of a resource unit (DWAF, 1999, Volume 3).

Based on the consideration on IUAs delineated and of the status quo components, as well as using expert knowledge including discussions with specialists, catchment water resource managers and the DWS study team, 40 surface resource units have been delineated in the Upper Orange River catchment. The delineation and prioritisation of resource units is required to facilitate effective management within the catchment and necessitates the breakdown of a river into discrete manageable units.

Resource Quality Objectives are then developed per resource unit within the context of the IUA perspective and the water resource class set. In this study for the Upper Orange River catchment, RQOs for rivers, groundwater and wetland resources will be determined.

While the RQO determination procedure proposes that RQOs be set for each resource unit, this may not always be possible due the potentially large number of RUs that could be delineated for a catchment. In this respect, a rationalisation process has therefore been developed as part of the RQO Determination Procedure (DWA, 2011) to prioritise and select the most useful resource units for RQO determination. A decision support tool, *Resource Unit Prioritisation Tool*, has been developed to guide and support the rationalisation process for RU selection and prioritisation. The tool incorporates a multi-criteria decision analyses approach that aids in the assessment of determining the importance of monitoring each resource unit as part of management operations, thus assisting with resource unit prioritisation.

This report details the process of delineating and prioritising the resource units for the water resources in the Upper Orange River catchment. It provides the information used to delineate the resource units and details the results of the preliminary prioritised resource units. These results will be taken through to stakeholders' consultation for finalisation of the prioritised resource units.

Considering the various components and considerations assessed for resource unit's delineation and prioritisation, and based on the understanding and expert knowledge of the Upper Orange River catchment, the results of the resource unit's delineation are illustrated in Figure E1, and those resource units prioritised for rivers and dams, wetlands, and groundwater are summarised in Table E1:

- Forty (40) river and dam resource units have been delineated, and 31 have been prioritised.
- Groundwater priority RU areas have been identified with areas of high stress index and aquifers of strategic importance identified in in IUA 4, IUA 5, IUA 9 and IUA 10, and
- Sixteen (16) wetlands/ wetland complexes have been prioritised in the catchment area, four of which still need to be mapped and assessed.

The evaluation of the resource unit's prioritisation has been done with catchment managers and specialists.

Resource quality objectives for the prioritised and selected rivers and groundwater resource units and wetlands/wetland complexes will then be determined for the sub-components and indicators that are still to be selected in Steps 4 and 5 of the RQO determination process.

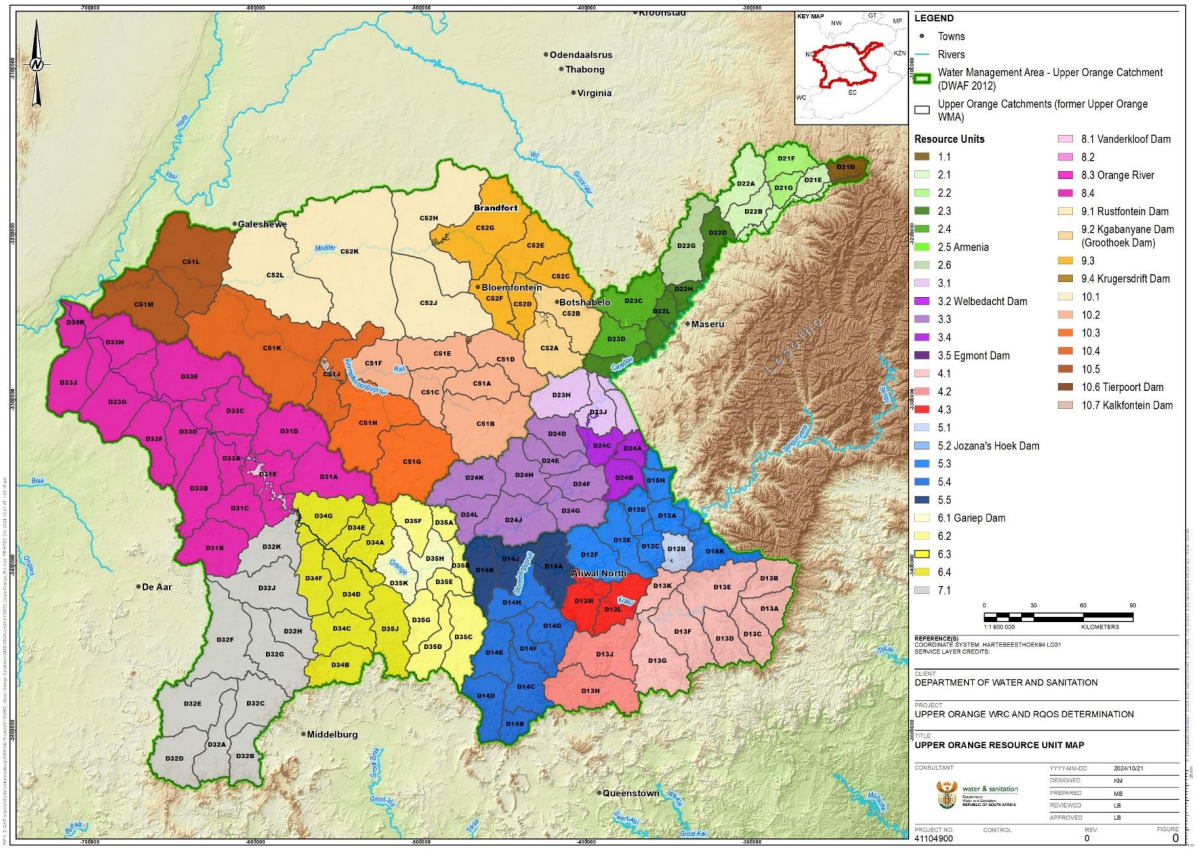


**Figure E1: Resource Units delineated**

**Table E1: Summary of prioritised Resource Units and proposed sites**

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands | | Latitude | Longitude |
| **IUA 1: Golden Gate** | | | | | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | X | | | UO_EWR 01_R | -28.557796 | 28.405709 |
| **IUA 2: Caledon/ Leeu River** | | | | | | | |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | X | | Brandwater floodplain | UO_EWR02_R | -28.68034 | 28.139926 |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | X | | | Weir D2H037 (WQ site: D23 101817) site on the Caledon River | -29.610357 | 27.064005 |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | X | | Rantsho wetland complex | UO_EWR 03_R | -29.101205 | 27.570751 |
| **IUA 3: Caledon River** | | | | | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | X | | Sandspruit wetlands | A site is proposed just upstream of Welbedacht Dam and downstream of the Rietspruit confluence | -29.807334 | 26.937420 |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands | | Latitude | Longitude |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | X | | | D2R004 (WQ site: D24 101820) near the Dam wall | -29.9089 | 26.86056 |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | X | | | UO_EWR 04_I is too far upstream so propose a new lower site near the outlet of the RU. | -30.517928 | 26.074946 |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | X | | | Will require a new lower site on the Caledon River at the outlet of the RU, downstream of the Witspruit confluence | -30.023631 | 26.855741 |
| **IUA 4: Kraai River** | | | | | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit, Wolwespruit and Karringmelkspruit | X | GRU 4.1 (QCs D13A-F and D13K) | Tiffendell seep; Klein Wildebeespruit wetland complex; Luckoff depression wetlands; Otto du Plessis Pass wetlands; Wolwespruit headwaters wetland complex | Would require a new site on the Kraai River at RU outlet downstream of Karringmelkspruit confluence | -30.903509 | 27.129140 |
| **4.2** | Holspruit and tributarie Braklaagtespruit, Leeuspruit, | X | | | UO_EWR 07_FV | -30.917621 | 27.800753 |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands | | Latitude | Longitude |
| | Skulpspruit and Telemachusspruit | | | | | | |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit | X | | | UO_EWR 08_I | -30.69007 | 26.74157 |
| **IUA 5: Upper Orange River** | | | | | | | |
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | X | | | UO_EWR 02_I | -30.5178445 | 27.3690799 |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | X | | | D1R001 (WQ site: D12 101803) | -30.63667 | 27.36917 |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | X | GRU 5.1 (QCs D12A and D15H) | Maletswai wetland complex | UO_EWR03_I | -30.6528889 | 26.8230496 |
| **5.4** | Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | X | GRU 5.2 (QC D14A) | | UO_EWR 05_R. is too high in the catchment, so propose a new site | *-30.634325 | *26.487208 |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands | | Latitude | Longitude |
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | X | GRU 5.2 (QC D14F) | | Weir D1H003 is too high in the RU so propose a new lower site | *-30.516262 | *26.093637 |
| **IUA 6: Gariep Dam** | | | | | | | |
| **6.1** | Gariep Dam | X | | | D3R002 near dam wall (WQ site: D34 101834) | -30.6231 | 25.50722 |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | X | | | D3H013 very high in catchment - propose site at the R717 bridge | *25.200023 | *-30.503265 |
| **IUA 7: Seekoei River** | | | | | | | |
| **7.1** | Seekoei River | X | | Gordonville wetland complex | UO_EWR05_I | -30.534359 | 24.962895 |
| **IUA 8: Vanderkloof Dam** | | | | | | | |
| **8.1** | Vanderkloof Dam | X | | | D3H024 on right bank canal (WQ site: D33 101832) | -29.9869 | 24.72224 |
| **8.2** | Orange River below Vanderkloof Dam | X | | | Will require a new site near the RU outlet | -29.910890 | 24.636253 |
| **8.3** | Orange River mainstem | X | | | UO_EWR 10_I | -29.1620 | 23.695944 |
| **8.4** | Tributaries draining to the Orange River on RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit | | | Philipstown wetland complex; Barkley Pass wetland complex | | | |
| **IUA 9: Upper Modder River** | | | | | | | |
| **9.1** | Rustfontein Dam on the Modder River | X | | | C5R003 (WQ site: 90840) | -29.2713 | 26.6161 |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, | X | GRU 9.2 (QC C52G) | Aardoringspruit wetlands | UO_EWR06_R | -28.807191 | 26.109695 |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands | | Latitude | Longitude |
| | Koringspruit, Matjiesspruit, Osspruit, Renosterspruit, Doringspruit, Rietspruit and Stinkhoutspruit | | | | | | |
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | X | | | C5R004 (WQ site: C52 90841) | -28.8833 | 25.95611 |
| **IUA 10: Modder/ Riet Rivers** | | | | | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | X | GRU 9.2 (QC C52H) and GRU 10.2 (C52J and C52K) | Kaalspruit wetland complex; Soutpan Depression wetland complex | UO_EWR_20_FV but may need a slightly lower site, propose C5H035 (WQ site: C52 90831) | -29.0286 | 24.63839 |
| **10.2** | Fouriespruit and tributaries including Fouriespruit Dam, Rietspruit and tributaries, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | X | | | UO_EWR 06_I | -29.535065 | 25.52457 |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit | X | | Jagersfontein DCVB wetland | UO_EWR22_FV | -29.653814 | 25.434994 |
| **10.4** | Riet River | X | | | Propose a site on the Riet River downstream of Kalkfontein Dam at C5RIET_JACOB REMP site | -29.041914 | 24.599933 |
| **10.5** | Main stem Riet River to Vaal River confluence | X | | | C5H014 (WQ site: C51 90817) | -29.0333 | 23.98333 |
| **10.7** | Kalkfontein Dam | X | | | C5R002 (WQ site: C51 90839) | -29.4959 | 25.2223 |

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# 1 INTRODUCTION

## 1.1. Background

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 (RQOs) in the Upper Orange River catchment which falls within the Orange/ Vaal Water Management Area (WMA 04).

Water resource classification, the Reserve and 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). The steps to achieve these are stipulated in the Water Resource Classification System (WRCS), Regulation 810 gazetted in September 2010. The WRCS is intended to ensure comprehensive protection of all water resources.

## 1.2. Purpose of the Study

The main objective of the study is to coordinate the implementation of the determination of water resources 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.

## 1.3. Purpose of this Report

The delineation and prioritisation of resource units (RU) is required to facilitate effective management within the catchment areas and necessitates the breakdown of a river into discrete manageable units, principally from an ecological perspective and the resource units are generally ecologically homogenous in nature. The delineation of Integrated Units of Analysis (IUA) and resource units and the subsequent prioritisation of RUs are undertaken as the initial steps of the water resource classification and Resource Quality Objectives (RQO) processes as detailed in

Chapter 8 of Report *Status Quo and delineation of Integrated Units of Analysis and Resource Units Report,* Report Number RDM/WMA13/00/CON/CLA/0224.

Resource Quality Objectives are then developed per resource unit within the context of the IUA catchment perspective and the water resource class set. In this study for the Upper Orange River catchment, RQOs for rivers, dams, groundwater, and wetland resources will be determined:

- Rivers on a resource unit scale (river RUs),
- Priority dams within a resource unit,
- Priority wetland resources on a resource unit scale,
- Groundwater resources on a groundwater resource unit scale which is comparable with river catchments, and
- Priority groundwater resources on a system specific scale (priority groundwater IUAs).

This report details the process of delineating and prioritising the resource units for the water resources in the Upper Orange River catchment. It provides the information used to delineate the resource units and details the results of the preliminary prioritised resource units.

These results will be taken through to stakeholders' consultation for finalisation of the prioritised resource units.

## 2 STUDY AREA

The Orange River catchment ( Figure 1) comprises the Upper Orange and Lower Orange River catchments within the Vaal-Orange River Water Management Area (WMA04).

This core area forms part of the Orange-Senqu River Basin, which straddles four International Basin States, Lesotho, South Africa, Namibia and Botswana. The Upper Orange River originates in Lesotho where it is known as the Senqu River, flows into South Africa and Namibia with Molopo River in Botswana joining the Orange River. The main stem flows west approximately 2 200 kms, where it flows into the Orange River Mouth and into the Atlantic Ocean at Alexander Bay. The Orange River is of critical importance to South Africa in that it augments the Vaal River System through the Lesotho Highlands Water Project and supplies the economic heartland of South Arica as well as supplying water to the Eastern Cape via the Gariep Dam to Great Fish transfer scheme.

The Upper Orange River catchment is characterised by climate that varies from east to west, with rainfall varying from an average low of 307 mm in the west to an average high of 909 mm in the east along the eastern escarpment mountains. Topography is diverse but plains with a moderate to high relief and lowlands, hills and mountains with moderate to high relief are dominant in the central to west areas, with the high lying regions, characterized by closed hills, mountains with moderate and high relief with prominent escarpments towards the east, and particularly along the Lesotho border.

The Upper Orange River catchment comprises four sub-catchments stretching across the Northern Cape, Free State and Eastern Cape provinces and across three dominant ecoregions, the Eastern Escarpment Mountains, Nama Karoo and Highveld, as well as the Southern Kalahari in the north of the Riet/ Modder catchments and the Drought Corridor in the northern area of the catchment. The four sub-catchments include:

- 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.

Groundwater occurrence 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 parts 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.

Land use in the Upper Orange River catchments of the WMA is predominantly under natural vegetation with livestock farming as main economic activity and extensive areas under dry land cultivation, mostly to produce grains, in the north-eastern parts. The Modder Riet catchment is dominated by agricultural activities, with limited alluvial diamond mining, and a few urban centres.

Large areas under irrigation for the growing of grain and fodder crops have been developed along the main rivers, mostly downstream of irrigation dams. Bloemfontein, Botshabelo, Thaba 'Nchu and Maletswai (Aliwal North) represent the main urban and industrial developments in the catchment. Smaller towns include Clarens, Ficksburg, Hobhouse, Fouriesburg, Hlohlolwane (Clocolan), Winnie Mandela (Brandfort), Ladybrand, Vanstadensrus, Wepener, Smithfield, Hanover and Noupoort. An estimated 15 million people are dependent on secure water supplies from this basin.

Two large hydropower stations have been constructed at Gariep and Vanderkloof dams.

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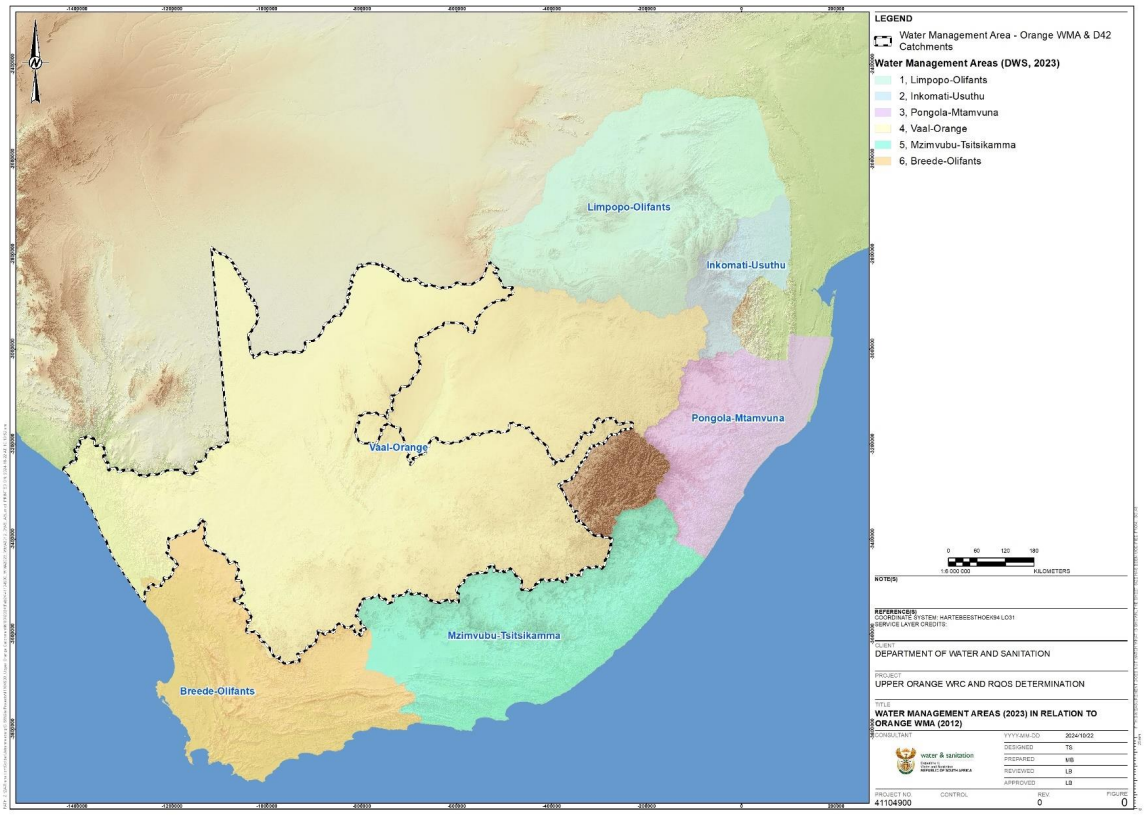



**Figure 1: Orange River Catchment within Vaal-Orange WMA (WMA04) in South Africa**

## 2.1. Catchment Boundaries

To enable improved representation of the water resources situation in the WMA, and to facilitate the applicability and better use of information for strategic management and planning purposes, the area was divided into sub-areas based on practical considerations such as size and location of sub-catchments, homogeneity of natural characteristics, location of pertinent water infrastructure, such as dams, and economic development. Four sub-areas were identified and the sub-catchments, associated rivers, catchment areas and quaternary catchments are listed in Table 1 and illustrated in Figure 2.

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

| Secondary Catchment | Tertiary Catchment | Quaternary catchments | Main River/(s) | Catchment area[(1)] (km$^2$) | |
|---|---|---|---|---|---|
| | | | | 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, D22G, portions of D22H and D22J | Meulspruit, Brandwater/ Groot, Rantsho; Mopeli | 4 369 | 4 369 |

| Secondary Catchment | Tertiary Catchment | Quaternary catchments | Main River/(s) | Catchment area[(1)] ($km^2$) | |
|---|---|---|---|---|---|
| | | | | Gross | Net |
| | D23 | Portion of D23A, E, F and G; D23C, D23D, D23H, D23J | Montsoane, Maseng, Tsoaning<br>Leeurivier, 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 | Bergrivier, Orange River, | 4 910 | 4 396 |
| | D32 | D32A – H, D32J and K | Seekoeirivier | 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

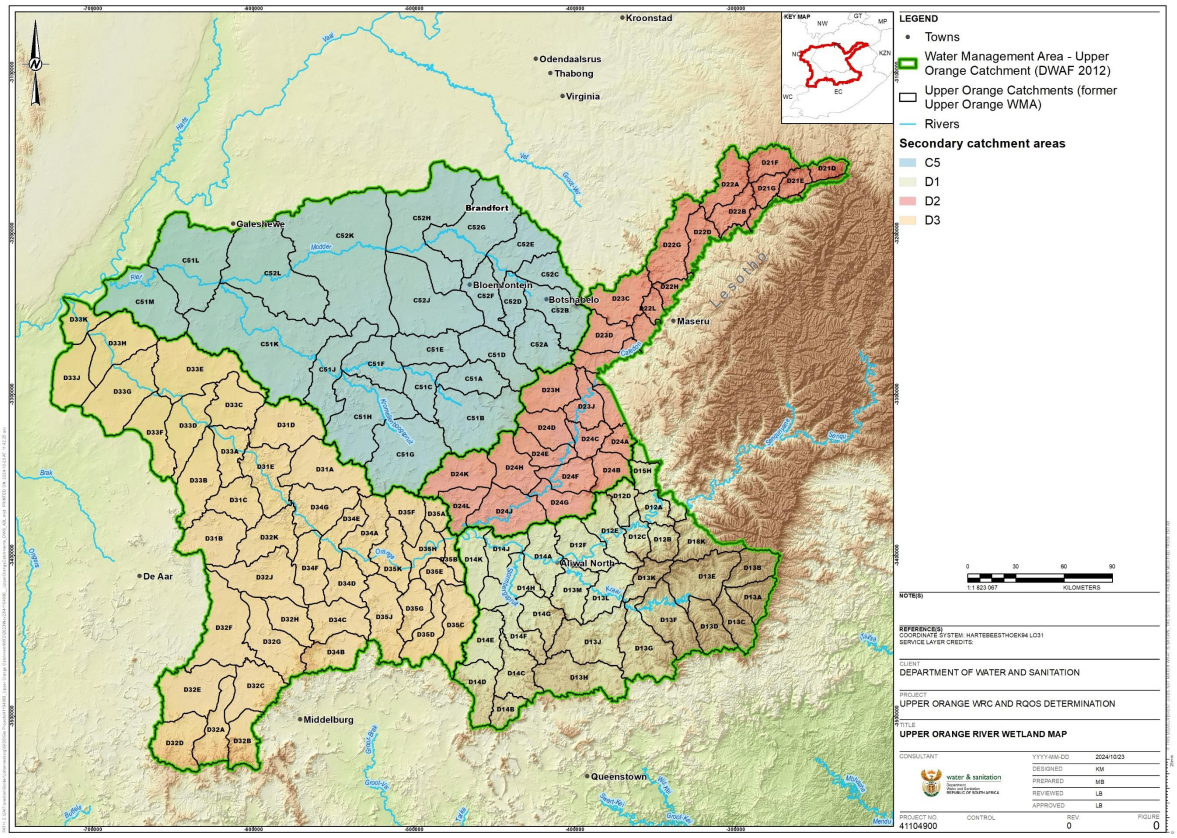



**Figure 2: Upper Orange River catchment – Study Area extent and Locality (South African Portion)**

# 3 DELINEATION OF INTEGRATED UNITS OF ANALYSIS

Integrated units of Analysis (IUAs) are the spatial units that are defined as significant water resources. The objective of defining IUAs is to establish broad scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on the ecological conditions at a sub-catchment level (DWA, 2007).

Delineation of units of analysis is required as it would not be appropriate to set the same water resource class for all water resources in a catchment. The delineation of a catchment into IUAs for the purpose of determining the water resource classes for significant rivers is done primarily according to several socio-economic criteria and drainage region (catchment) boundaries. IUAs are thus predominantly a combination of socio-economic zones (SEZs) and watershed boundaries (DWA, 2007), however, ecological information and biophysical characteristics also play a role in the delineation.

Considering the SEZs determined, and the assessment of the information and considerations outlined in the *Status Quo and delineation of Integrated Units of Analysis and Resource Units* Report, Report Number RDM/WMA13/00/CON/CLA/0224, ten IUAs were delineated for the Upper Orange River catchment.

Aspects such as the availability of representative Ecological Water Requirement (EWR) sites within each IUA, catchment boundaries and modelling that has been undertaken for the catchments were also considered. Overlaying these aspects and data has resulted in the delineation of the IUAs which are similar in respect of the various components assessed, and that would be able to be managed as an entity, in addition comprising a logical unit for which scenarios can be designed and evaluated. The ten IUAs delineated are listed in Table 2 and illustrated in Figure 3.

**Table 2: Preliminary Integrated Units of Analysis (IUAs) in the Upper Orange River catchment**

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Golden Gate | Little Caledon River and Caledon River in the portion of D21A along the Lesotho border | • Predominantly natural<br>• Tourism - Golden Gate National Park in the upper half of the IUA with several lodges, hotels and tarred roads<br>• Town of Clarens with the Clarens wastewater treatment works (WWTW) and Water Supply System (WSS) (901kL/d) with abstractions from the small Caledon and tunnel<br>• Agriculture in lower catchment of the quaternary catchment; small game farms; may be limited abstraction from the Caledon for subsistence agriculture; | Agriculture and Tourism | UO_EWR 01_R on the Little Caledon River at the outlet of the IUA | None on main stem river but many small farm dams | D21D and a portion of D21A along South Africa/ Lesotho border | Golden Gate National Park | The current PES is a C; however, it is likely to be higher | Channeled valley bottom wetlands | GRU2 (Groundwater conditions similar in IUA 1 and IUA2).<br>Upper part of the Karoo Supergroup formations with merely silty sandstones/ siltstones and limited intrusive Karoo Dolerite features. |
| 2 | Caledon/ Leeu River | Caledon River along the Lesotho Border. With tributaries: Little Caledon, Brandwater, Moolmanspruit, Meulspruit, Rantsho River, Morakabi/ Mopeli River, Beytelspruit, McCabes Spruit, Modderpoort-spruit, Tenniskopspruit, Tweelingspruit, Appledore Spruit, Mokopu River, Bokpoortspruit and Leeu River | • Extensive agriculture including dryland cultivation and irrigation (crops and livestock farming)<br>• Tourism<br>• Towns and associated WWTWs and WTWs<br>  ○ Ficksburg<br>  ○ Fouriesburg<br>  ○ Clocolan<br>  ○ Ladybrand, and<br>  ○ Hobhouse | Agriculture and Tourism | UO_EWR 02_R<br>UO_EWR 03_R<br>UO_EWR 01_l<br>UO_EWR 01_FV | • D22B: Meulspruit Dam (FSC: 2.6 Mm3) on the Meulspruit;<br>• D23C: Armenia Dam (FSC: 14.02 Mm3) on the Leeu River – small storage dam for irrigation<br>• Small farm dams | 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 | Various small areas throughout the IUA (D21F, D22B, D22D, D22G, D22L, D22M, D23D, D23E) | C - D (an unnamed tributary of the Meulspruit = B) | • D21E, F and G: channelled valley bottom wetlands, seeps and floodplain<br>• D22A and B: depression and channelled valley bottom wetlands<br>• ***Brandwater Floodplain – D21G***<br>• Channelled valley bottom wetlands noted in all quaternary catchments but most dominant in D23C<br>• Depression wetlands - D23C and D22A<br>• Small floodplain in D23D<br>• Valley head seeps in D23C and D23A<br>• Unchanneled valley bottom wetlands and flat in D23A<br>• ***Rantsho wetland complex – D22G,*** unique in that it | GRU2 (includes IUAs 1 and 2).<br>Upper part of the Karoo Supergroup formations with merely silty sandstones/siltstones and limited intrusive Karoo Dolerite features |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | consists of three valley-bottom hydrogeomorphic (HGM) unit types which have formed because of a unique geomorphic setting and a unique set of geomorphic processes. A series of valley bottom wetlands is unique and can provide significant streamflow regulating services. | |
| 3 | Caledon River | Caledon River with tributaries: Klipspruit, Rietspruit River, Nuwejaarspruit, Bloemspruit, Klipspruit, Elandspruit, Witspruit, Blaasbalkspruit, Boesmanskopspruit, Vaalspruit, Wilgeboom-spruit, Vinkelspruit, Grahamstad-spruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | • Main towns and associated WWTWs and WTWs<br>o Vanstadensrus<br>o Wepener on Sandveld River, and<br>o Smithfield on Skulpspruit (tributary)<br>• Caledon Nature Reserve around the Welbedacht Dam and Tussen-die-Riviere Nature Reserve in the lower reaches of the Caledon River<br>• Irrigated agriculture dominates along the main river and tributaries.<br>• There are also transfers from Caledon River, e.g. to Modder from the Welbedacht Dam, through Rietspruit.<br>• Welbedacht Water Treatment Works | Agriculture and Tourism | UO_EWR 02_FV<br>UO_EWR 03_FV<br>UO_EWR 10_FV<br>UO_EWR 04_I | • Egmont Dam (FSC: 8.8 $Mm^3$) in D24A<br>• Welbedacht Dam (FSC: 5.5 $Mm^3$) in D24C on the Caledon River - Small storage dam for irrigation and transfer to Bloemfontein; the dam is highly silted<br>• Knellpoort Dam (off-channel) in Rietspruit sub-catchment (FSC: 138.4 $Mm^3$) in D23H<br>• Rolandshoek Dam on the Blaasbak River (FSC: 5,4 $Mm^3$) in D24C<br>• Vanstadensrus Dam (FSC: 1.8 $Mm^3$) in D24C<br>• Smithfield Dam on the Groenspruit (FSC: 4.64 $Mm^3$) | D23F, D23G, D23H, D23J, D24A, D24B, D24C, D24D, D24E, D24F, D24G, D24H, D24J, D24K and D24L | Areas in D23J, D24J, D24L and D14K | Predominantly C - D | • Channelled valley bottom wetlands and flat in D23H<br>• Seeps in D23H and D23J<br>• Floodplain wetland and flat around the Welbedacht Dam<br>• Channelled valley bottom wetlands throughout<br>• Seeps throughout<br>• Floodplain wetland along the Caledon River<br>• Depression wetlands in D24F along the Caledon River<br>• Flats in D23H and D23J<br>• Floodplain wetland along the Caledon River at the confluence with the Orange River into Gariep Dam<br>• Sandspruit wetland (not prioritised as part of the Reserve 2023, however, is important in terms water quality enhancement | GRU3, Upper part of the Karoo Supergroup formations with merely silty sandstones/siltstones and large intrusive Karoo Dolerite features (circular sills) |
| 4 | Kraai River | Kraai River and tributaries: Bokspruit, Langkloofspruit, Rytjieiesvlaktesprui | • Scattered rural settlements<br>• Cultivation (irrigated and dry land crops) and | Rural | UO_EWR08_I<br>UO_EWR04_R<br>UO_EWR05_FV<br>UO_EWR07_FV<br>UO_EWR08_FV | Small farm dams in western portion of the IUA in the tributaries in quaternary | D13A – D13M | Areas in D13K and D13E | A (SWSA), B - C | • Unchanneled continuous valley bottom and hillslope seeps - ***Tiffendell Seep wetland*** | GRU 4 (IUA 4). Middle part of the Karoo Supergroup formations with merely sandstones/siltstones and |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | t, Vaalhoek, Wesbankspruit, Wilgespruit, Kromspruit, Holspruit, Braklaaglespruit, Skulspruit, Telemachusspruit, Kamingmelkspruit, Oslaagte, Elandspruit, Sterkspruit, Koffiehoekspruit, Bamboeshoek-spruit, Vrouenshoekspruit, Vlooikraalspruit, Three Drifts, Diepspruit, Joggemspruit, Klein-Wildebeesspruit, Saalboomspruit, Noodshulpspruit, Saalboomspruit, Wasbankspruit, Wolwespruit, Rooihoogte se Loop, Kromspruit, Skulpspruit, Leeuspruit, Karringmelkspruit, Bossielaagtespruit, Rondefonteinspruit, Windvoelspruit, Elandspruit, Klipspruit | predominantly subsistence farming | | UO_EWR09_FV<br>UO_EWR18_FV<br>UO_EWR19_FV | catchments: D13G, H, J, M and L | | | | ***complex (category A) in D13B,*** a high-altitude wetland complex - 2 000 mamsl, characterised by a unique vegetation assemblage; ***and Wolwespruit headwaters wetland complex (UCVB and HSS)(category C),*** a foraging site for both crane species and possibly also a breeding site for the Crowned Cranes<br>• Channelled valley bottom wetlands in D13E, including ***Klein-Wildebeespruit wetland complex (CVB and HSS)(category D)***, key for providing ecosystem services such as water quality enhancement and sediment trapping<br>• Seeps in D13C, D, E G, K and J<br>• Unchanneled valley bottom wetlands in D13C, D, E G, K, H and J, D35C and D<br>• Channelled valley bottom wetlands in D13C, D, E G, K, H and J, D35C and D<br>• Otto du Plessis Pass unchanneled continuous valley bottom wetland and channelled valley bottom wetland, with extensive hillslope seeps (not prioritised in Reserve 2023) - an unusually large wetland for its high altitude; much of the wetland vegetation remains intact and its | large intrusive Karoo Dolerite features (circular sills) and sub-vertical dykes features present.<br><br>Several quaternary catchments show negative water balances (high baseflow figures). |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | catchment appears in good condition. | |
| 5 | Upper Orange River | Orange River (upstream from the Caledon confluence and Stormbergspruit) and tributaries: Tele, border with (Lesotho), Sterkspruit, Makhaleng (lower reach), Stormberg, Wonderboomspruit | • Extensive subsistence agriculture (cultivation with limited irrigation, and extensive livestock grazing) in the upper portions<br>• Irrigation along the river in the middle to lower portions<br>• Sand mining (on main stem)<br>• Towns and associated WWTWs and WTWs<br>o Zastron<br>o Maletswai (Aliwal North)<br>o Burgersdorp<br>o Witkop<br>o Stormberg, and<br>o Molteno | Rural | UO_EWR02_I<br>UO_EWR03_I<br>UO_EWR05_R<br>UO_EWR23_FV<br>UO_EWR24_FV<br>UO_EWR03_FV | • Main stem Orange (Lesotho – Khatze, Polihali (proposed), Makhaleng Dam (proposed)<br>• Jozannashoek Dam (upper reaches Sterkspruit – D12B)<br>• JI De Bruin Dam (D14C) (Klein-Buffelspruit)<br>• Many small farm dams on the tributaries and specifically in the D14 tertiary catchment | D12A – D12F, D14A – D14K, Portions of D15G, D15H, D18K and D18L | Small area in D12A, D14J and D14E | Predominantly C-D | • Small areas of depression wetlands<br>• Channelled valley bottom wetland around the town of Aliwal North<br>• Small areas of seeps<br>• No prioritised wetlands for the Reserve 2023, however, Maletswai channelled valley bottom wetland complex is important for water quality. | GRU 5.1 and GRU 5.2. Middle to Upper part of the Karoo Supergroup formations with merely sandstones/siltstones and large intrusive Karoo Dolerite features (circular sills) and sub-vertical dykes features present. |
| 6 | Gariep Dam | Orange River main stem with tributaries: Oorlogspruit, Brakspruit, Broekspruit, Otterspoortspruit, Suurbergspruit | • Gariep Dam (Orange-Fish transfer and hydropower)<br>• Gariep Nature Reserve<br>• Doornkloof Provincial Nature Reserve<br>• Livestock grazing<br>• Irrigation below the dam<br>• Village of Oviston with WWTW and WTW | Mixed use | None | • Gariep Dam (FSC: 4,903.5Mm$^3$)<br>• Many small farms dams | D34A, D34B, D34C, D34D, D34E, D34F, and D34G, D35A, D35B, D35C, D35D, D35E, D35F, D35J, D35G, D35H, D35K | Gariep Nature Reserve | Predominantly C-D (tributaries); Orange River reach in B35K and D34A - E | • Few depression wetlands in D34B, C, D and F<br>• Seeps in D34B and D34F | GRU 6.0. Middle part of the Karoo Supergroup formations with merely sandstones/siltstones and large intrusive Karoo Dolerite features (circular sills) and sub-vertical dykes features present. Aquifer system classified as a fractured type. |
| 7 | Seekoei River | Seekoei River with tributaries Elands, Elandsfonteinspruit, Klein-Seekoei, Noupoortspruit, Elandskloof | • Main activity is livestock farming mainly with sheep for wool and meat.<br>• Rural and livestock agriculture<br>• Main towns of Hanover and Noupoort and associated WWTWs and WTWs | Mixed Use | UO_EWR05_I (D32J) | No major dams, however many small farm dams and weirs | D32A, D32B, D32C, D32D, D32E, D32F, D32G, D32H, D32J, D32K | Small areas in D32F and D32K; National Parks in D32D and D32B | C | • Few depression wetlands throughout<br>• Few seeps in D32E<br>• At the EWR site in D32K– blue cranes in wetland area<br>• Gordonville channelled and unchanneled valley bottom wetland complex that has been severely eroded, but with flood-out portions | GRU 7.1 & GRU 7.2 Middle part of the Karoo Supergroup formations with merely sandstones/siltstones and limited intrusive Karoo Dolerite features (laminar/flat sills) and sub-vertical dykes features present. Aquifer system classified as fractured and fractured & weathered types. |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | where sediment is currently accumulating and is representative of many other similarly impacted wetlands in the landscape. It was the focus of a detailed geomorphological baseline description by Grenfell et al. (2012) useful in distinguishing what might be natural incision vs. anthropogenically driven incision. | Contributions to baseflow in surface water systems limited to the main drainage systems. Local areas where alluvial accumulations close the main river systems act is surface water-groundwater systems (conjunctive flows during wet-dry seasons.<br><br>SWSA-gw area in D32B |
| **8** | **Vanderkloof Dam** | Orange River mainstem with various unnamed tributaries | • Vanderkloof Dam (transfer to Riet River catchment and hydropower)<br>• Extensive Irrigation downstream and at the outlet of the IUA<br>• Hopetown and associated WWTW and WTW | Agriculture and mining | UO_EWR10-I<br>UO_EWR15-FV | Vanderkloof Dam (FSC: 3,092.4 $Mm^3$) - major storage dam – irrigation, domestic, hydropower and recreation | D33A – D33K (along main stem Orange River); D31A – D31E | Small areas in D33A, D33C and D33D | Predominantly C, some D's and some unassessed areas | • Unchanneled valley bottom wetlands<br>• Philipstown Unchanneled valley bottom wetland complex (C) provides important habitat diversity.<br>• Channelled valley bottom wetlands<br>• Hillslope seeps<br>• ***Barkley Pass wetland complex (UCVB, CVB and HSS) (A)*** located at approximately 2 000 mamsl, characterised by a unique vegetation assemblage, representative of rare intactness for wetlands in South Africa.<br>• Depression wetlands throughout with ***Luckhof depression wetland complex (B)*** which forms a unique feature in the broader landscape and provides important habitats for both fauna and flora | GRU 8.1, GRU 8.2 and GRU 8.3 (based on decreasing recharge and ground water quality. Middle and Lower parts of the Karoo Supergroup formations with merely sandstones/siltstones (Beaufort Group) and mudrock (Ecca Group). Limited intrusive Karoo Dolerite features (laminar/flat sills) and sub-vertical dykes features present. Aquifer system classified as fractured and fractured & weathered types. Contributions to baseflow in surface water systems limited to the main drainage systems. |
| **9** | **Upper Modder** | Upper Modder River and tributaries: | • Mangaung Metropolitan | Commercial Development | UO_EWR14_FV<br>UO_EWR13_FV<br>UO_EWR07_I | • Kgabanyane Dam (FSC: 15.4 $Mm^3$) in C52B | C52A, C52B, C52C, C52D, | Small areas in C52B, | C - D (and F in Renoster and Bloemspruit) | • Depression wetlands in C52G | GRU 9.1 and GRU 9.2. Middle (Beaufort sandstones/siltstones) to |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Renosterspruit, Bloemspruit, Bree River, Bo-Kromspruit, Kromspruit, Gannaspruit, Wildebeespruit, Kgabanyane River, Osspruit, Klein-Osspruit, Doringspruit and Stinkhoutspruit | Municipality - urban Area (Towns)<br>• Mangaung Metropolitan Municipality WWTWs<br>o Bloemspruit<br>o Bainsvlei<br>o Welvaart<br>o Northern Works<br>o Bloemindustria<br>o Suid-oostelike<br>o Vanstadensrus, and<br>o Botshabelo<br>• Mangaung Metropolitan Municipality is supplied with water from a bulk supplier, Bloem Water, and<br>• Vanstadensrus, and Soutpan (Krugersdrift) WTWs<br>• Agricultural areas (dryland, and some irrigation, in the lower portions of the Modder catchment around Krugersdrift Dam<br>• Extensive subsistence agriculture in the upper reaches of the IUA | | UO_EWR06_R | on the Modder River<br>• Rustfontein Dam (FSC: 75.05 $Mm^3$) in C52A on a tributary of the Modder River - small storage dam for domestic and irrigation use<br>• Mockes Dam (FSC: 4.16 $Mm^3$) in C52D on the Modder River - small storage dam for domestic and irrigation<br>• Krugersdrift Dam (FSC: 73.44 $Mm^3$) in C52G at the IUA outlet | C52E, C52F and C52G | C52E and C52G | | • Discontinuous channelled valley bottom and floodplain wetlands in upper reaches in C52C and C52G<br>• ***Aardoringspruit wetland complex (DCVB and F)(ecological category C)*** - a large wetland complex that includes a large wetland flat and a discontinuous valley bottom wetland which encompasses the Aardoringspruit River - unusual to find a wetland flat in this part of the country. | Lower (Ecca mudrocks) parts of the Karoo Supergroup formations and moderate intrusive Karoo Dolerite features (laminar sills) and sub-vertical dykes features present.<br>Aquifer system classified as a fractured & weathered type.<br>Groundwater quality, especially in the Ecca Group mudstones has an elevated primary salinity signature due to the marine sedimentary environment during deposition in the middle Karro Period.<br>Several large salt(pan) mines are present in GRU 9.2 and the northern part of GRU 9.1 |
| **10** | **Modder-Riet Rivers** | | Irrigation agriculture along the Riet River and diamond mine at Koffiefontein | Agriculture and mining | UO_EWR09_I<br>UO_EWR06_I<br>UO_EWR 11_FV | • Rietwater Dam (FSC: 1.95 Mm3), a small storage dam at the outlet of D51A<br>• Kalkfontein Dam (FSC: 325.2 Mm3) on the Riet River in C51J – small storage dam for irrigation<br>• Tierpoort Dam (FSC: 34 Mm3) on the Riet River in C51J - small storage dam for irrigation | C51M, C51L, C51K, C51J, C51F, C51H, C51G, C51C, C51B, C51A, C51E and C52L, C52K, C52J, C52H | Small areas throughout the IUA | Predominantly C - D | • Extensive depression wetlands throughout the IUA<br>• ***Soutpan depression wetland complex (ecological category B) -*** salt pans support vegetation that is distinct from the surrounding vegetation.<br>• Discontinuous channelled valley bottom and channelled valley bottom wetlands<br>• ***Kaalspruit wetland complex (CVB, DCVB and D)(ecological category C) -*** unique feature in this complex is a depression wetland | GRU 10.1 and GRU 10.2. Middle (Beaufort sandstones/siltstones) and Lower (Ecca mudrocks) parts of the Karoo Supergroup formations and moderate intrusive Karoo Dolerite features (laminar sills) and sub-vertical dykes features present.<br>Aquifer system classified as a fractured & weathered type in GRU 10.1, and a fractured aquifer system in GRUs 10.2.<br>Groundwater quality, especially in the Ecca Group mudstones has an |

| IUA | Delineation | Rivers | Description | Socio-Economic Zone | EWR sites | Dams | Quaternaries | Protected Areas | PES | Wetlands *(Prioritised for Reserve, 2023)* | Groundwater |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | nested within the channelled valley-bottom<br>• ***Jagersfontein discontinuous channelled valley bottom wetland*** in C51H on the Kromellenboogspruit (this was categorised as an ecological category C for the Reserve studies but may have been impacted by the Jagersfontein spill, and may need to be reassessed)<br>• Few seeps in C52K and C51K | elevated primary salinity signature due to the marine sedimentary environment during deposition in the middle Karro Period.<br>Several large salt(pan) mines are present in GRU 102 and includes the large groundwater irrigation scheme at Petrusburg (central part of quaternary catchment C52K.<br>GRU 10.3 consists of pre-Karoo Supergroup rock formations and the aquifer characteristics are different ITO BYC (and qualities) |

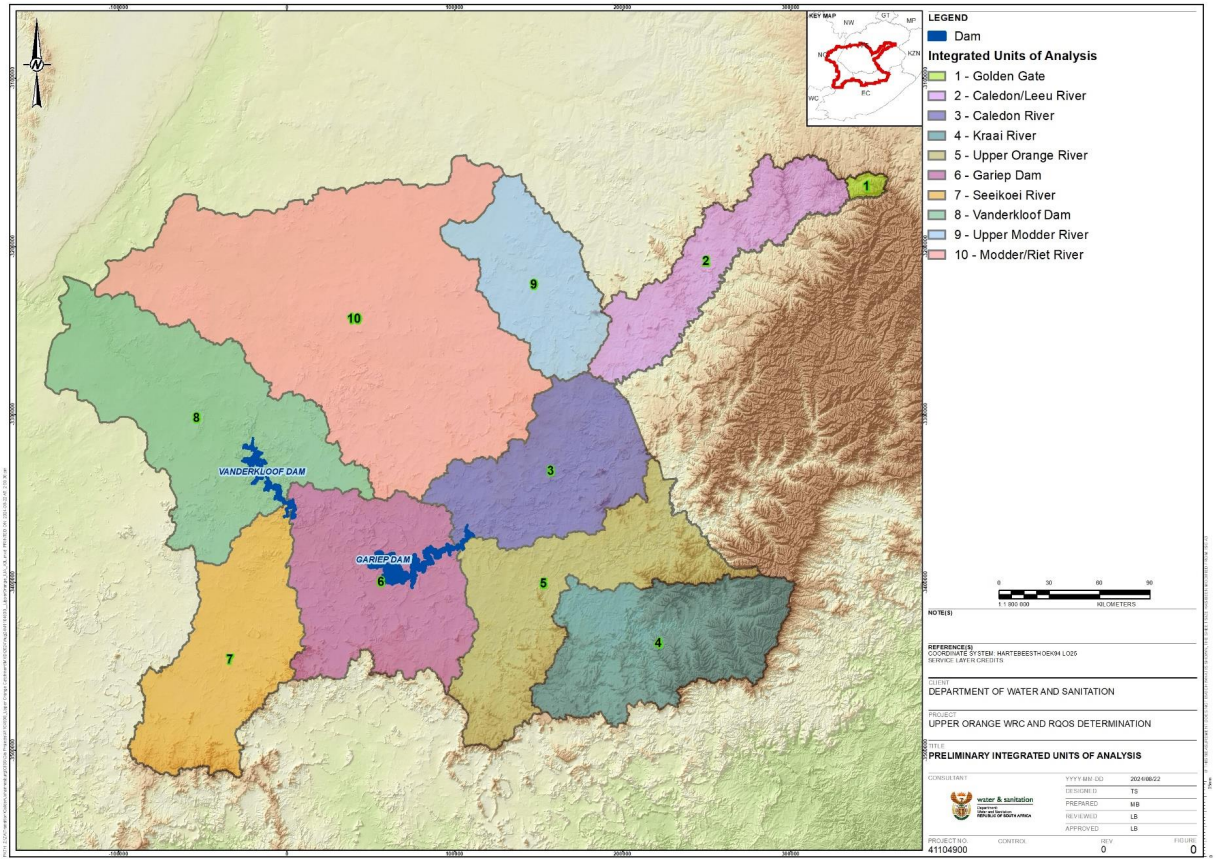



**Figure 3: Preliminary IUAs delineated for the Upper Orange River catchment**

# 4 RESOURCE UNITS' DELINEATION: SURFACE WATER

## 4.1. Approach to delineation

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

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

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

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

## 4.2. Resource Units - consideration for delineation

Spatial data from the water resource classification component where the IUAs and the water resource system analysis were reviewed has served as the departure point for the delineation of the resource units. The ecological water requirements' sites and biological sites have been reviewed and their relevance and rationale for inclusion has been assessed.

Each IUA has now been divided into smaller units considering quaternary catchment boundaries and sub-quaternary assessment has also taken place where required. However, the delineation based on quaternary catchment boundaries was preferred as it relates to the unit of management of the water resources in the catchment from a regulation, authorisation, and management point of view. The quaternary catchment level delineation will facilitate the implementation and application of the RQOs determined. Where present, the RQOs will be linked to the EWR sites

on the Caledon River, Orange River mainstem and some tributaries, and associated biological sites throughout the catchment that will serve as the monitoring sites for future compliance assessment. These reaches will be specified at sub-quaternary level to support the monitoring programmes to be established.

Resource unit delineation has been done based on assessment of the following considerations and components:

- IUA boundaries, quaternary and sub-quaternary boundaries: these formed the basis of delineation (alignment to the water resource classification) and is of relevance from a management and implementation perspective.
- EWR sites (in terms of the classification process outputs): relevant from an ecological point of view and important in meeting the classification of ecological categories to be specified at the nodes.
- PES/ EIS and ecological condition of sub-quinary reaches: used to determine the reaches that require higher protection as well as areas that are degraded and need to be improved within an IUA.
- Protected and conservation areas: areas that are of importance from a biodiversity and conservation point of view (different to the higher impacted areas), that would need RQOs to support the conservation status.
- Operation of the system: how the water resources in the system are regulated and managed from a system point of view. This relates more importantly to regulation of the weirs and the irrigation releases, and their influence on aspects such as surface water flow, transfers, and strategic water resource areas.
- Water quality impacts: the water quality status/ condition of the resources influences the delineation of the resource units in terms of where specific RQOs are required. Highly impacted, poor water quality areas would need RQOs to ensure improvement, and similarly areas of good water quality would require protection to ensure maintenance of the resources, in line with the water resource management classes and ecological condition.
- Land use and anthropogenic activities: the activities within the IUAs have been considered in respect of the nature, intensity, scale, type and extent of impact. These aspects influenced the delineation of resource units in terms of the management required and the RQOs that would be required to ensure the water resources are improved and/ or sustainably used.
- User dependence: the reliance of users on the water resources for domestic water supply.
- Groundwater units: the priority groundwater resources and their importance to the system and users.
- Wetlands: the priority wetland areas and systems and their importance from their value, support to the ecosystem and services they provide, and to the users; and

- Expert knowledge of the catchment area and system.

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

### 4.2.1. Land Cover

Land use in the Upper Orange River catchments is largely under natural vegetation with livestock farming as the main economic activity and extensive areas under dry land cultivation, mostly to produce grains, in the north-eastern parts.

The Caledon River along the Lesotho border in IUA 2 is highly impacted by sediment which emanates from Lesotho because of overgrazing causing extensive erosion. This has caused silting in the Welbedacht Dam in IUA 3.

The Modder Riet catchments in the upper portion of IUA 9 and throughout IUA 10, are also dominated by agricultural activities, with limited mining, and the largest urban centre in the Mangaung Local Municipality area in IUA 9.

Large areas under irrigation for the growing of grain and fodder crops have been developed along the main rivers, mostly downstream of irrigation dams, specifically in IUAs 2, 8, 9 and 10.

Bloemfontein, Botshabelo and Thaba ‘Nchu as well as Maletswai (Aliwal North) represent the main urban and industrial developments in the catchment. Smaller towns include Clarens, Ficksburg, Hobhouse, Fouriesburg, Hlohlolwane (Clocolan), Winnie Mandela (Brandfort), Ladybrand, Vanstadensrus, Wepener, Smithfield, Hanover and Noupoort. These towns therefore also have sanitation in the form of wastewater treatment works, septic tanks and French drains and forms of pit latrines, which all impact on surface and groundwater resources.

There are several alluvial diamond Mines in IUA 10, with the main area of concern being the Jagersfontein Diamond Mine in IUA 10 where the breaching of a tailing’s facility has impacted the unnamed tributary that drains into the Jagersfontein Wetland Complex and the Prosesspruit.

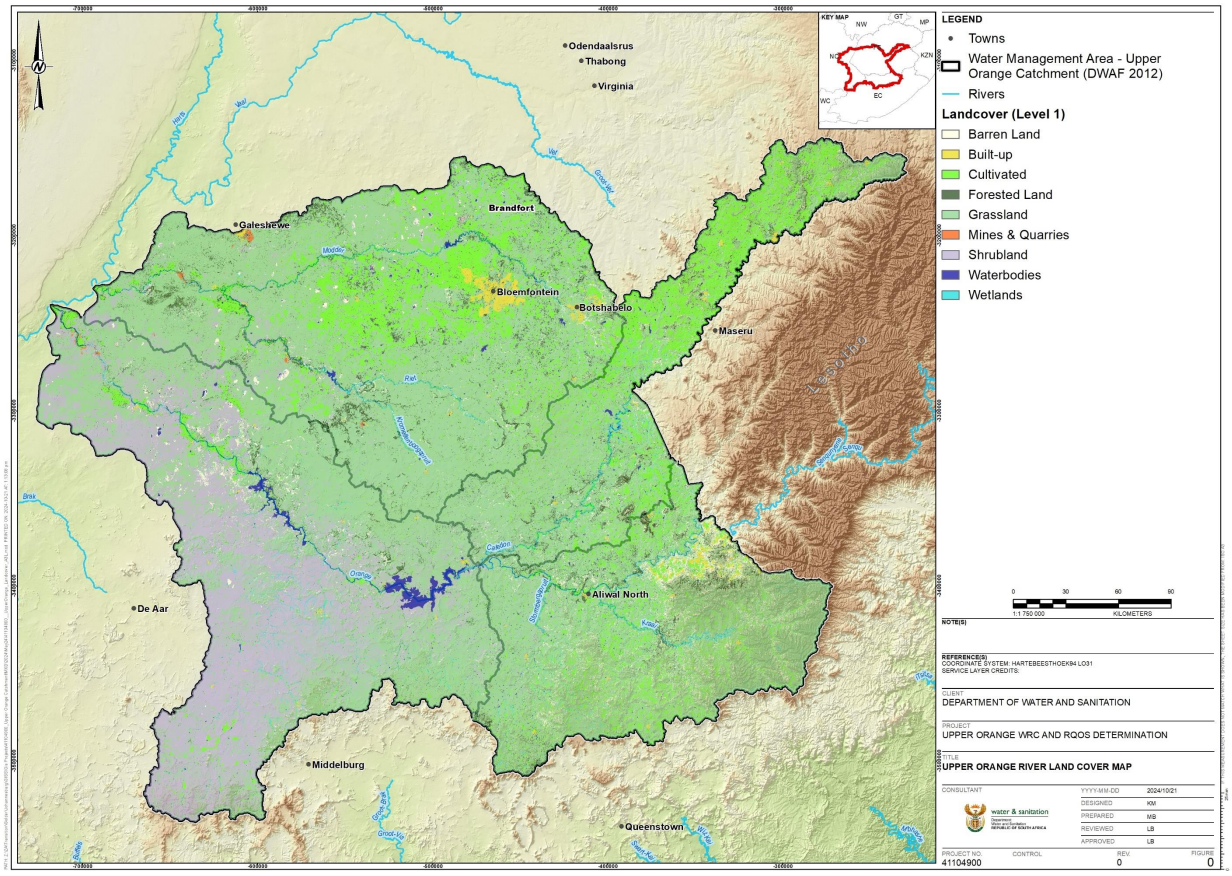



**Figure 4: Land cover in the Upper Orange River catchment**

### 4.2.2. Ecological Information

As resource unit definition is largely based on the ecological condition and characteristics of the water resource, it is important to understand the ecological state of the surface water resources in the Upper Orange River catchment. Table 3 summarises the ecological categories for each of the secondary catchments (DWS, 2013).

The predominant ecological category for the catchment is a C indicating moderate modification, followed by categories B, largely natural state and then D, a largely modified state. There are very few ecological category A's, with two unnamed reaches in the upper reaches of the Kraai River catchment in IUA 4, and one river reach in IUA 5.

There are seven river reaches in an E/F ecological category, indicating serious modification: two reaches in IUA 5 in Sterkspruit and Tele River, two reaches in the Rietspruit in IUA 3, one reach in the Orange River IUA 6, and three in Bloemspruit and Renosterspruit in IUA 9.

**Table 3: Ecological categories**

| Ecological Category | A | B | C | D | E/F |
|---|---|---|---|---|---|
| Secondary Catchment D1 | 3 | 68 | 29 | 31 | 1 |
| Secondary Catchment D2 | 0 | 30 | 102 | 29 | 2 |
| Secondary Catchment D3 | 0 | 15 | 97 | 43 | 1 |
| Secondary Catchment C5 | 0 | 49 | 114 | 32 | 3 |
| Total number of reaches: 649 | 3 | 162 | 342 | 135 | 7 |
| Percentage (%) | 0.46 | 24.96 | 52.70 | 20.80 | 1.08 |

The present ecological status (PES) of the rivers assessed in the 10 IUAs delineated, are summarised in Table 4 and shown in Figure 5.

**Table 4: Ecological Status**

| IUA | Quaternary Catchment | PES | Ecological Importance | Ecological Sensitivity |
|---|---|---|---|---|
| 1: Golden Gate | D21D and a portion of D21A along South Africa/ Lesotho border | The current PES is a C, however it is likely to be higher | High | High |
| 2: Caledon/ Leeu River | D21E - G; 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 | C - D (an unnamed tributary of the Meulspruit = B) | Moderate - High (D21G – Brandwater) | Moderate |
| 3: Caledon River | D23F – D23J, D24A – D24L | Predominantly C - D | Moderate | Moderate |
| 4: Kraai River | D13A - D13M | A (SWSA), B - C | Moderate - High (D13E) | Moderate - High (D13A, D13B, D13C, |

| IUA | Quaternary Catchment | PES | Ecological Importance | Ecological Sensitivity |
|---|---|---|---|---|
| | | | | D13E and D13G) |
| 5: Upper Orange River | D12A – D12F, D14A – D14K, Portions of D15G, D15H, D18K and D18L | Predominantly C-D | Moderate - High (D12A) | Moderate |
| 6: Gariep Dam | D34A – D34G, D35A – D35K | Predominantly C-D (tributaries); Orange River reach in B35K and D34A - E | | |
| 7: Seekoei River | D32A - D32K | C | Moderate | Moderate |
| 8: Vanderkloof Dam | D33A – D33K (along main stem Orange River); D31A – D31E | Predominantly C, some D's and some unassessed areas | Low (D31C) - Moderate | Moderate |
| 9: Upper Modder River | C52A, C52B, C52C, C52D, C52E, C52F and C52G | C - D (and F in Renoster and Bloemspruit) | Low - High (C52E and C42H) | Moderate |
| 10: Modder-Riet Rivers | C51A - C51M | Predominantly C - D | Moderate - High (C51G and C51F) - Very High (C52K and C51L) | Moderate - High (C52K and C51L) |

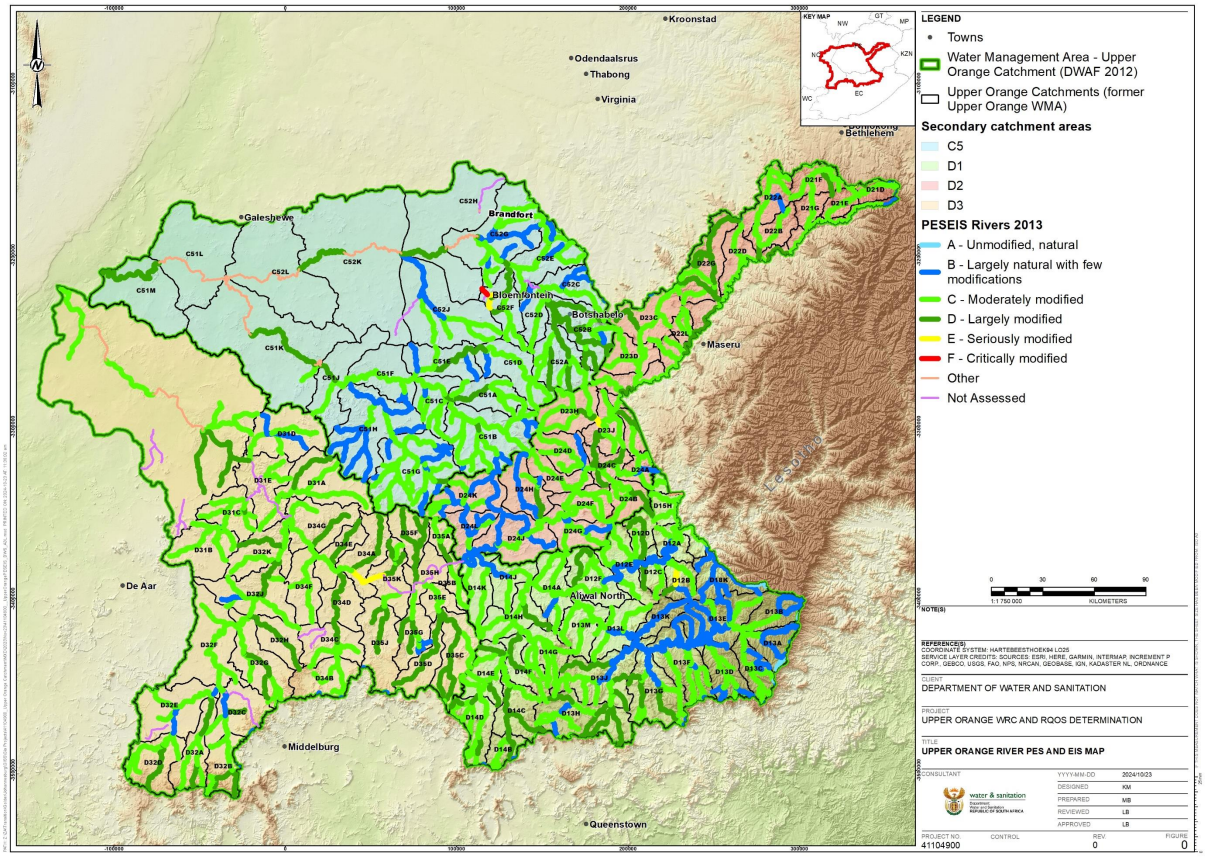



**Figure 5: Present Ecological Status (DWS, 2013)**

### 4.2.3. Ecological Water Requirements Sites

In the Upper Orange River catchment, there are several ecological water requirements (EWR) sites for which data has been collected in various studies since 2005, and the latest study relates to the High Confidence Reserve study completed in March 2024. The EWR sites are listed in Table 5 and their locations illustrated in Figure 6.

**Table 5: Ecological Water Requirements (EWR) Sites**

| EWR site code | River | Quaternary catchment | Co-ordinates | |
|---|---|---|---|---|
| **INTERMEDIATE EWR SITES** | | | | |
| UO_EWR01_I | Middle Caledon | D22D | -28.909102 | 27.784924 |
| UO_EWR02_I | Sterkspruit | D12B | -30.51784446 | 27.3690799 |
| UO_EWR03_I | Upper Orange | D12F | -30.65288889 | 26.8230496 |
| UO_EWR04_I | Lower Caledon | D24J | -30.28011493 | 26.6530603 |
| UO_EWR05_I | Seekoei | D32J | -30.53390069 | 24.9625368 |
| UO_EWR06_I | Upper Riet | C51F | -29.53478727 | 25.5244957 |
| UO_EWR07_I | Upper Modder (Sannaspos) | C52G | -29.160017 | 26.572492 |
| UO_EWR08_I | Lower Kraai | D13M | -30.69007 | 26.74157 |
| UO_EWR09_I | Lower Riet | C51L | -29.026963 | 24.512919 |
| UO_EWR10_I | Lower Orange | D33K | -29.1448547 | 23.6914039 |
| **RAPID 3 EWR SITES** | | | | |
| UO_EWR01_R | Little Caledon | D21D | -28.557796 | 28.405709 |
| UO_EWR02_R | Brandwater (Groot) | D21G | -28.68034 | 28.139926 |
| UO_EWR03_R | Mopeli | D22G | -29.101205 | 27.570751 |
| UO_EWR04_R | Upper Kraai | D13E | -30.85179 | 27.77689 |
| UO_EWR05_R | Wonderboomspruit | D14E | -31.005262 | 26.341938 |
| UO_EWR06_R | Middle Modder (Soetdoring) | C52H | -28.807191 | 26.109695 |
| **FIELD VERIFICATION SITES (only diatoms, *in situ* water quality and IHI)** | | | | |
| UO_EWR01_FV | Meulspruit | D22B | -28.8857 | 27.83494 |
| UO_EWR02_FV | Witspruit | D24C | -30.0083 | 26.92832 |
| UO_EWR03_FV | Gryskopspruit | D12D | -30.3396 | 27.17688 |
| UO_EWR04_FV | Karringmelkspruit | D13K | -30.8118 | 27.2665 |
| UO_EWR05_FV | Bokspruit | D13A | -30.8847 | 27.88456 |
| UO_EWR06_FV | Holspruit | D13J | -30.9953 | 27.05664 |

| EWR site code | River | Quaternary catchment | Co-ordinates | |
|---|---|---|---|---|
| UO_EWR07_FV | Sterkspruit, tributary of the Kraai | D13C | -30.9176 | 27.80075 |
| UO_EWR08_FV | Bell | D13B | -30.8526 | 27.78656 |
| UO_EWR09_FV | Groenspruit | D24H | -30.2412 | 26.5613 |
| UO_EWR10_FV | Skulpspruit | D24H | -30.2344 | 26.51134 |
| UO_EWR11_FV | Fouriespruit | C51A | -29.6712 | 26.07439 |
| UO_EWR12_FV | Renoster | C52F | -29.1163 | 26.3287 |
| UO_EWR13_FV | Os-spruit | C52E | -28.9392 | 26.51141 |
| UO_EWR14_FV | Hondeblaf | D31C | -30.2051 | 24.71803 |
| UO_EWR15_FV | Tributary of VanZylspruit | C51G | -30.0312 | 25.78646 |
| UO_EWR16_FV | Slykspruit | D24L | -30.393 | 26.12093 |
| UO_EWR17_FV | Langkloofspruit | D13D | -30.9541 | 27.60613 |
| UO_EWR18_FV | Wasbankspruit | D13G | -31.1555 | 27.28444 |
| UO_EWR19_FV | Lower Modder | C52K | -28.8917 | 25.65645 |
| UO_EWR20_FV | Upper Kromellenboog | C51G | -30.0663 | 25.68106 |
| UO_EWR21_FV | Lower Kromellenboog | C51H | -29.6536 | 25.43507 |
| UO_EWR22_FV | Tele | D18K | -30.4486 | 27.58234 |
| UO_EWR23_FV | Upper Orange | D12A | -30.3988 | 27.34299 |
| UO_EWR24_FV | Makhaleng | D15G | -30.1641 | 27.39825 |

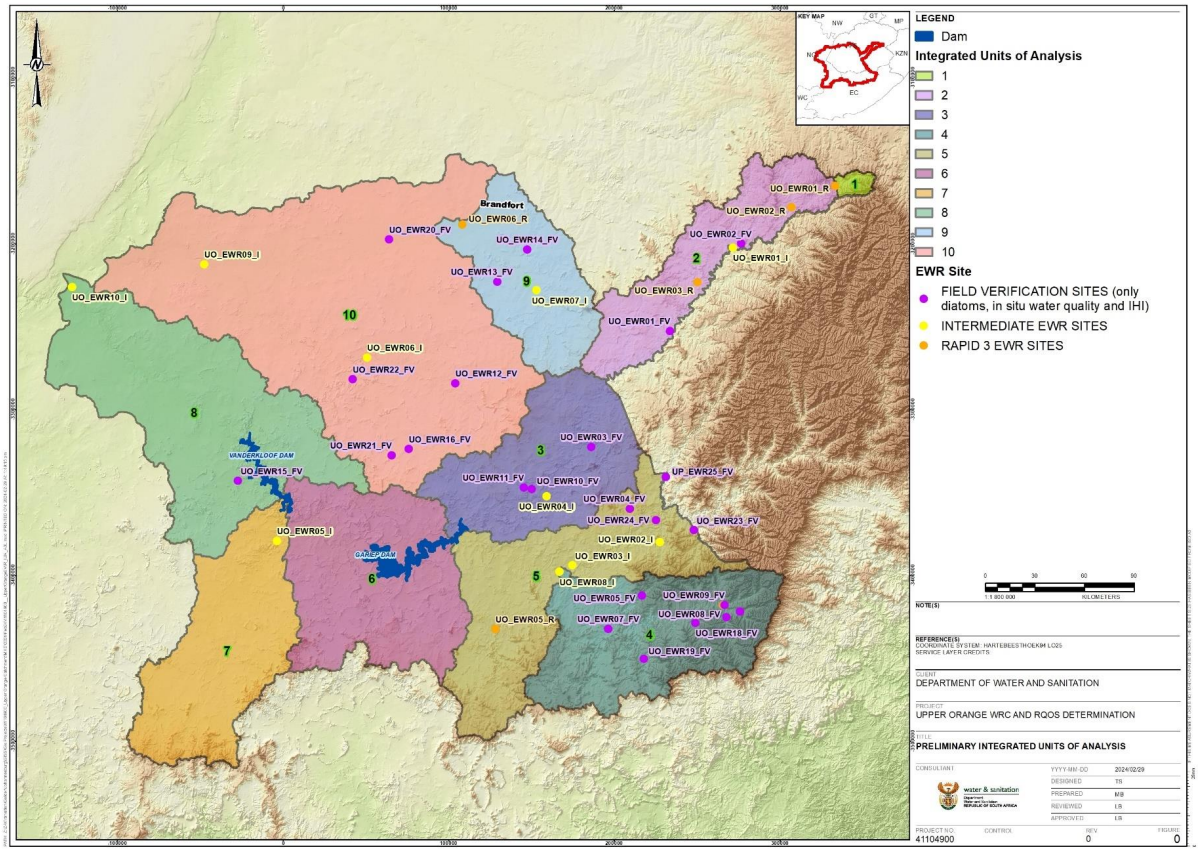



**Figure 6: Upper Orange River catchment Ecological Water Requirements sites per IUA**

### 4.2.4. Freshwater Ecosystem Priority Areas

Freshwater Ecosystem Priority Areas (FEPAs) identified through the National Freshwater Ecosystem Priority Areas Project of the Water Research Commission (WRC, 2011) in the Upper Orange River catchment were considered and assessed for resource unit delineation. FEPAs have been identified as those areas that are important for sustaining the integrity and continued functioning of their related ecosystems. The FEPAs of importance as identified in the catchment are shown in Figure 7 (WRC, 2011). FEPAs are present in the following IUAs:

- IUA 1: The Golden Gate National Park
- IUA 2: FEPAs in quaternary catchments D21F, D22G, D23D and E. Quaternary catchments D23C and D23D in IUA 2 are fish support areas, and there is a rehabilitation FEPA in D23A.
- IUA 3: along the Caledon River to Gariep Dam has FEPAs in D24A, D23H, D24D, D24E, D24F, D24G D24H and D24L. Important upstream areas are noted in D24F, D23H and D24K with a rehabilitation FEPA in D23J and D24C.
- IUA 4: The Kraai River catchment has a high concentration of FEPAs throughout, with important upstream areas in quaternary catchments D13B, C, D, F, G , H and J. There is a fish support area in D13D and a rehabilitation FEPA in D13A.
- IUA 5: this IUA also has FEPAs throughout the catchment, except for quaternary catchment D18K and D15H and a few small areas along the Lesotho border. There are important upstream areas in quaternary catchments D12B and C, D12E and F, and D14A, H, J and K. there is a very small rehabilitation FEPA in D14H.
- IUA 6: FEPAs in D34A, D34C, D34F and a very small area in D35G
- IUA 7: this IUA supports a large are of upstream FEPAs throughout, with FEPAs in D32A, D, E, G, F and J with a fish support area in D32C.
- IUA 8: FEPAs in D33A, E and F, and important upstream areas in D33B and C, and lower down in the IUA in D33J. There are fish support areas in D33A, D, E, G, H, J and K.
- IUA 9: FEPAs in D52A, B, C, D, E F and G and important upstream areas in D52E and a small area in C52G.
- IUA 10: FEPAs and important upstream areas in C51G, H and C and a small rehabilitation FEPA in C51G.

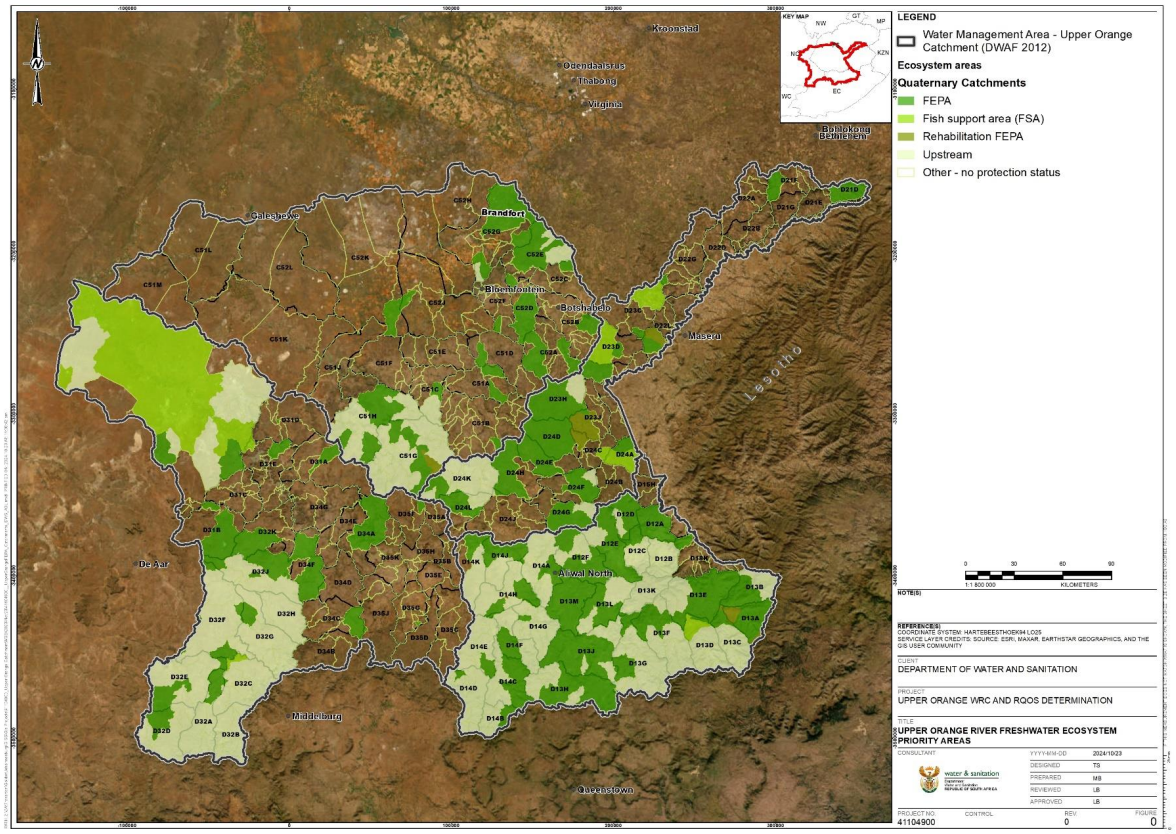



**Figure 7: Freshwater Ecosystem Priority Areas (WRC, 2011)**

### 4.2.5. Strategic Water Source Areas

Parts of the Upper Orange River catchment have been identified and delineated as strategic water source areas (SWSA) in South Africa (WRC, 2018). Water source areas, also referred to as Water towers, are natural areas that provide disproportionate (i.e., relatively large) volumes of surface water run-off compared to adjacent lowland areas, and/ or groundwater water per unit area, or which meet critical social, economic and environmental water requirements and provide water security. Strategic Water Source Areas (SWSAs) are a subset of water source areas that are considered of strategic significance for water security (WRC, 2018).

Surface water SWSAs are found in areas with high rainfall and produce most of the runoff. These are located predominantly along the eastern side of South Africa, particularly along the Drakensberg escarpment from the Eastern Cape though to Limpopo and are the source of most of the major river systems, such as the Orange River.

Water source areas are critical because they produce large volumes of water that sustain people locally and regionally and, in the case of groundwater, are often the only sustainable and reliable water source.

In terms of WRC (2018), SWSAs have been identified and delineated if the area of land either:

(a) supplies a disproportionate amount of mean annual surface water runoff in relation to their size and are considered nationally important; or

(b) has a high groundwater recharge and are locations where the groundwater forms a nationally important resource; or

(c) meets both criteria (a) and (b).

***Groundwater Strategic Water Source Areas (SWSA-gw)***

Thirty-seven (37) SWSA-gw have been identified at national level with a further 20 at sub-national level. The areas delineated in the Upper Orange River catchment are summarised in Table 6.

**Table 6: Groundwater Strategic Water Sources Areas in the Upper Orange River catchment**

| National/ Sub-national | Groundwater SWSA | Area | Quaternary catchments | IUA |
|---|---|---|---|---|
| National | Central Pan belt | 3,368 km$^2$ | C52K, C52J, C52H, C52G, C52F, C52D | Predominantly within IUA 10, and a smaller portion within IUA 9 |
| National | De Aar Region | 2,475 km$^2$ | D32F | IUA 7(portions) |
| Sub-national | Eastern Upper Karoo | 6,131 km$^2$ | D32B, D32C and D32G | IUA 7 (small portions) |
| Sub-national | | 3,371 km$^2$ | D13A (475 km$^2$) D13B (533 km$^2$) D13E | IUA 4 |

| National/ Sub-national | Groundwater SWSA | Area | Quaternary catchments | IUA |
|---|---|---|---|---|
| | Eastern Upper Karoo (small portions) | | (1031 km$^2$) D13K (397 km$^2$) | |
| | | | D18K (935 km$^2$) | IUA 5 |

### *Surface Water Strategic Water Source Areas (SWSA-sw)*

The total area of the national SWSA-sw in the southern African region is 124,075 km$^2$ (10% of the region) and provides a mean annual run-off (MAR) of 24,954 million m$^3$ (50% of the total), which has been increased with the addition of the sub-nationally important Pondoland Coast and Zululand Coast SWSA-sw to an area of about 148,478 km$^2$ (12% of the area) and provide a MAR of 29,354 million m$^3$ (59% of the total) (WRC, 2018). The South African SWSA-sw area covers approximately 96,129 km$^2$ (8% of the total area) and provide a MAR of 19,379 million m3 (39% of the national volume). The greatest volume of MAR is generated by the Southern Drakensberg (9% of national and transboundary MAR), followed by the Eastern Cape Drakensberg and the Boland (WRC, 2018).

The areas of the SWSA-sw within Lesotho and Swaziland are 18,570 km$^2$and 9,376 km$^2$, respectively. The total MAR for Lesotho is about 4,445 million m$^3$ and the portions of the SWSAs that fall within Lesotho (Eastern Cape, Southern, Northern and Maloti Drakensberg, totalling 61% of Lesotho's area) generate about 3,522 million m$^3$ or 79% of that county's MAR, highlighting the importance of these areas that contribute to the Vaal-Orange Water Management Area (WRC, 2018).

Table 7 summarises the surface water SWSAs in the Upper Orange River catchment.

**Table 7: Surface Water Strategic Water Sources Areas in the Upper Orange River Catchment**

| Surface water SWSA | Quaternary catchments | Integrated Unit of Analysis |
|---|---|---|
| Maloti Drakensburg SWSA | D21A | IUA 1 |
| Eastern Cape Drakensburg SWSA | D13E, D13K, D13 A, B and C and D13F | IUA 4 |
| | D12B, D18K, D18L | IUA 5 |

Figure 8 illustrates the groundwater and surface water relevant to the Upper Orange River catchments.

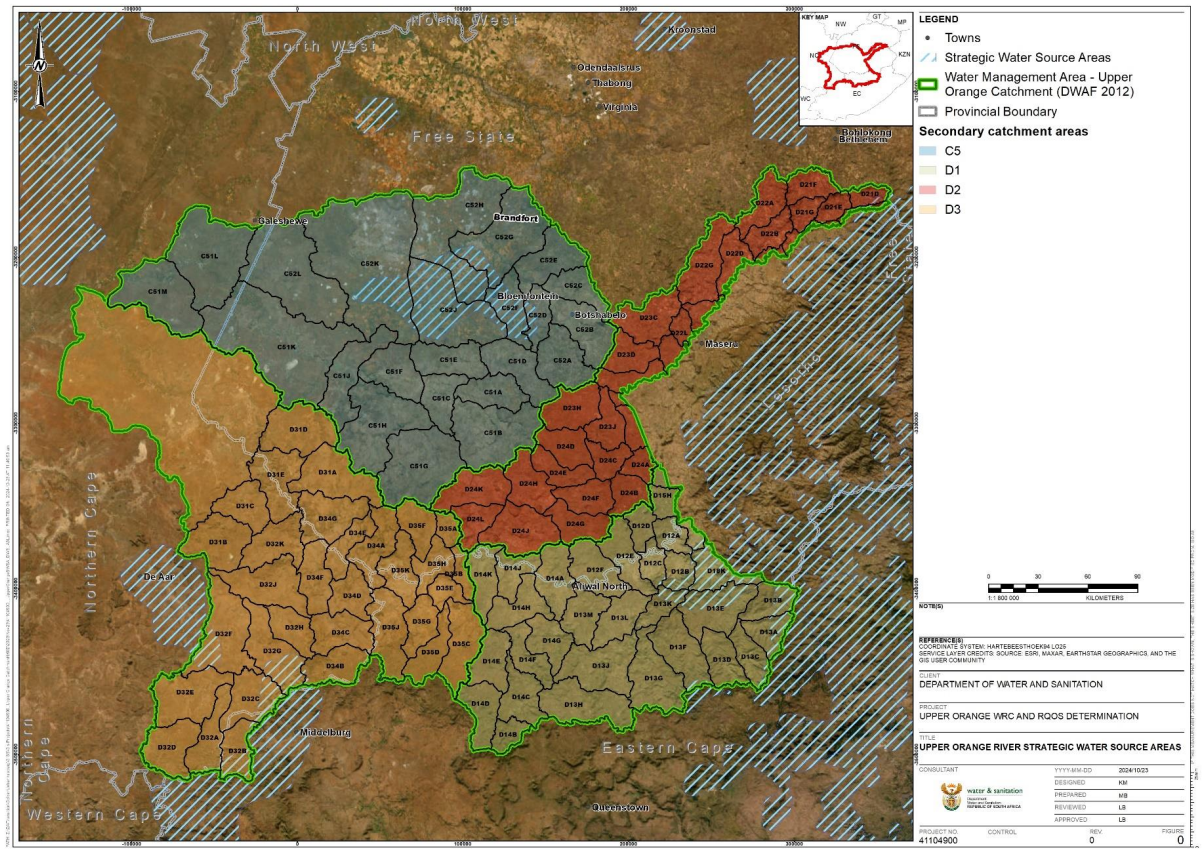



**Figure 8: Strategic Water Source Areas within the Upper Orange River Catchment**

### 4.2.6. Protected and Conservation Areas

Figure 9 illustrates those areas that have been designated protected areas of which the Gariep Nature Reserve is the largest in IUA 6. A porton of the Golden gate National Park falls in the upper reaches of the Caledon River catchment in IUA 1. There are many other smaller protected areas scattered throughout the sub-catchnments as follows:

IUA 1: Golden Gate National Park

IUA 2: Various small areas throughout the IUA (D21F, D22B, D22D, D22G, D22L, D22M, D23D, D23E)

IUA 3: Areas in D23J, D24J, D24L and D14K

IUA 4: Areas in D13K and D13E

IUA 5: Small area in D12A, D14J and D14E

IUA 6: Gariep Nature Reserve

IUA 7: Small areas in D32F and D32K; National Parks in D32D and D32B

IUA 8: Small areas in D33A, D33C and D33D

IUA 9: Small areas in C52B, C52E and C52G, and

IUA 10: Small areas throughout the IUA

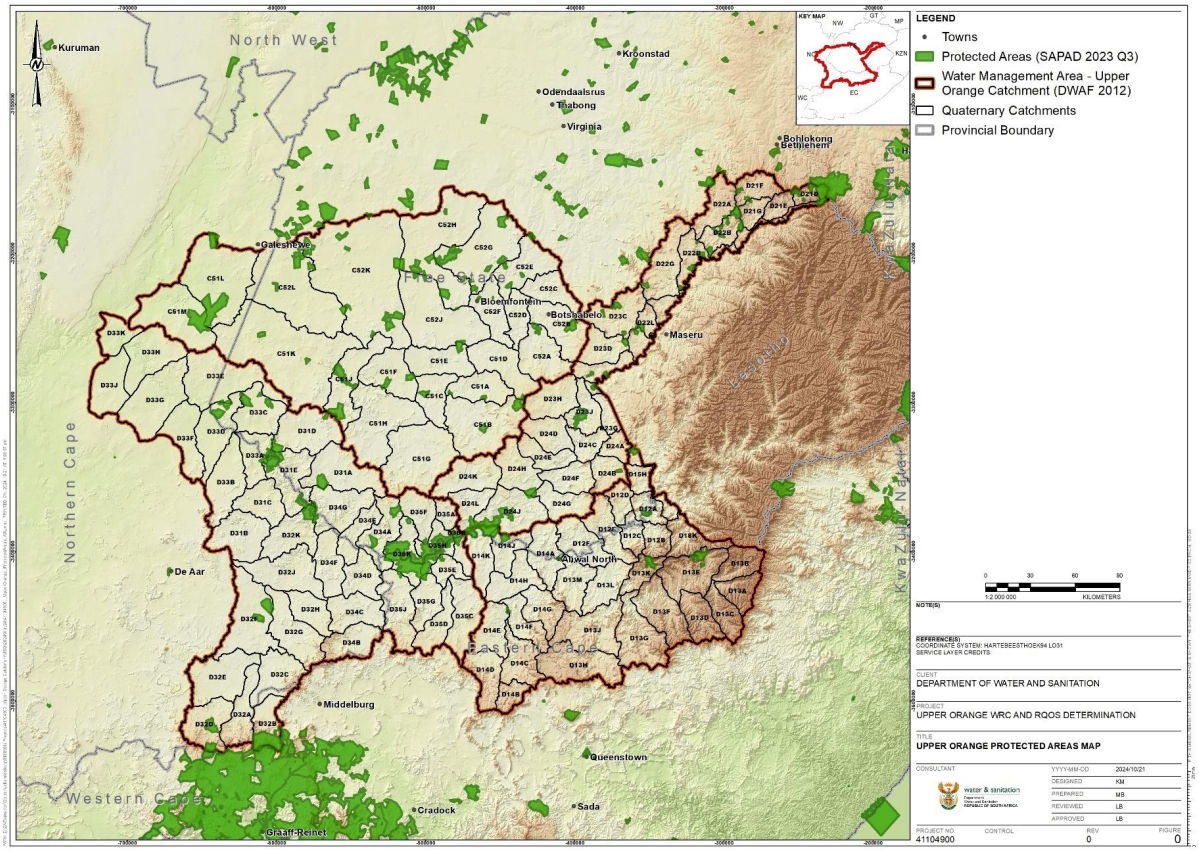



**Figure 9: Protected Areas in the Upper Orange River catchment**

### 4.2.7. Water Infrastructure, Use and Development

The Lower Orange Catchment forms part of the Orange-Senqu System. There are a number of major dams in the Orange-Senqu System, such as the Katse and Mohale dams in Lesotho, as well as the Gariep Dam and the Vanderkloof Dam in South Africa. The system also includes many minor dams mainly supporting irrigation water use.

The Welbedacht Dam is situated on the Caledon River while the Knellpoort Dam is situated on the Rietspruit, a tributary of the Caledon River. The Knellpoort Dam is operated as an off-channel storage dam by pumping water from the Caledon River into the dam. The Knellpoort Dam was built to augment the storage capacity of Welbedacht Dam and to transfer water to the upper reaches of the Modder River. The storage capacity of Welbedacht Dam has reduced significantly due to siltation. Water from the Welbedacht Dam is pumped to the Welbedacht water purification works from where potable water is pumped to supplement the water supply from the Modder River (Vaal River tributary) to Bloemfontein. Water is also supplied from this system to Botshabelo, Thaba Nchu, as well as the smaller towns of Wepener, Dewetsdorp, Reddersburg, Edenburg and Excelsior, which are also dependent to varying degrees on local water resources (DWS, 2015).

The Gariep Dam (5 432 $Mm^3$) and Vanderkloof Dam (3 188 $Mm^3$) on the Orange River within South Africa are the largest storage dams in the Orange-Senqu River system. Both dams are used to regulate the river flow for irrigation purposes as well as to generate hydroelectricity during the peak demand periods (DWS, 2015). Releases from Vanderkloof Dam into the Orange River are dictated by the downstream flow requirements.

There are several large dams, summarised in Table 8, in IUAs 2, 3, 7, 8, 9 and 10, with many small farm dams scattered throughout the catchment.

**Table 8: Large dams in the Upper Orange River Catchment per IUA**

| Dam name | Purpose | Live full supply capacity (million $m^3$) | IUA |
|---|---|---|---|
| Gariep | Major storage dam – irrigation, domestic, hydropower, transfer to Eastern Cape and recreation | 5 342 | IUA 7 |
| Vanderkloof | Major storage dam – irrigation, domestic, hydropower and recreation | 3 188 | IUA 8 |
| Armenia | Small storage dam for irrigation and domestic (Town of Hobhouse) | 13.2 | IUA 2 |
| Egmont | Small storage dam for irrigation | 8.8 | IUA3 |
| Welbedacht | Storage dam for irrigation and domestic transfer to Bloemfontein (highly silted) | 5.42 | |
| Knellpoort Dam | Off channel storage dam in the Rietspruit catchment for domestic use to support water requirements of Mangaung | 138.4 | |

| Dam name | Purpose | Live full supply capacity (million $m^3$) | IUA |
|---|---|---|---|
| | Metropolitan Municipality because of the silting of Welbedacht Dam | | |
| Rustfontein | Small storage dam for domestic and irrigation | 72.6 | IUA 9 |
| Mockes | Small storage dam for domestic | 4.63 | |
| Krugersdrift | Small storage dam for irrigation | 71.19 | |
| Tierpoort | Small storage dam for irrigation | 34.5 | IUA 10 |
| Kalkfontein | Small storage dam for irrigation and domestic (supply to Jagersfontein and Faresmith) | 319.6 | |

Gariep and Vanderkloof dams are both used to supply all the irrigation, urban, mining and environmental requirements in the Lower Orange.

Verbeeldelingskraal Dam is a proposed on the Orange River just upstream of the Town of Maletswai, in IUA 5.

**Main Irrigation Schemes**

There is considerable irrigation within the Upper orange River catchment, specifically in IUA 10 and IUA 8.

The Orange-Riet Water User Association (WUA) is the biggest irrigation scheme in the Upper Orange at the confluence of the Riet River and the Vaal and Orange River confluence, in IUA 8 and IUA 10.

There is also an irrigation scheme at the Kalkfontein Dam in IUA 10, in the Lower Modder River in IUA 10, downstream of Vanderkloof Dam in IUA 8 and the smallest around the Tierpoort Dam in IUA 10.

**Water Supply Schemes/ Transfers**

While it is noted that the Upper Orange River forms part of the Orange -Senqu River system which is detailed in the Status Quo and Delineation of Integrated Units of Analysis and Resource Units Report, RDM/WMA13/00/CON/CLA/0224, there are major transfers from this catchment to various water supply schemes. The major water supply schemes and transfers are summarised in Table 9.

**Table 9: Major water supply schemes/ transfers**

| Scheme | Purpose | Capacity | IUAs involved |
|---|---|---|---|
| Caledon Modder Transfer 1: Novo Transfer Scheme | Supports the water supply to Bloemfontein, Botshabelo, Thaba | Maximum capacity of 2.2 $m^3/s$ | IUA 2 to IUA 9 |

| Scheme | Purpose | Capacity | IUAs involved |
|---|---|---|---|
| Caledon Modder Transfer 2: Welbedacht Dam to Bloemfontein | 'Nchu, Dewetsdorp, Reddersburg and Edenburg.<br>Novo Transfer Scheme transfers water from Knellpoort Dam to Rustfontein Dam in the upper reaches of the Modder River basin. This is done via the Novo Pump Station at Knellpoort Dam (29.7 km of pipeline and 12 km of river channel). The Novo Transfer Scheme is then linked to the Mazelspoort Scheme downstream on the Modder River. | 1.29 $m^3/s$. | |
| Orange-Fish Tunnel transfers | To divert water to the Eastern Cape for irrigation, urban (including Grahamstown and Nelson Mandela Metro) and industrial use. | 620 million $m^3/a$;<br>53 $m^3/s$ | IUA 7 |
| Orange-Riet Transfer | Water from the Vanderkloof Dam via the Vanderkloof Main Canal transferring water to the Riet River catchment.<br>The scheme is used mainly for irrigation, but also supplies urban requirements of Koffiefontein, Ritchie and Jacobsdal | 260 million $m^3/a$ | IUA 8 to IUA 10 |
| Orange Vaal Transfer Scheme | To mitigate shortages and high salinity issues at Douglas Weir on the Lower Vaal River | Ranges from 120 to 142 million $m^3/a$, depending on the water level and water quality in the Vaal River | IUA 7 |

### Hydropower Schemes

Two large hydropower stations have been constructed at Gariep and Vanderkloof dams in IUAs 7 and 8 respectively, summarised in Table 10.

**Table 10: Hydropower Schemes**

| Scheme | Purpose | Capacity | IUAs involved |
|---|---|---|---|
| Gariep Dam Hydropower Scheme | Operational when supplying downstream users | Gariep Dam serves to generate hydropower (Eskom), capable of providing up to 360 MW of electricity at a flow rate of 800 $m^3/s$. | IUA 7 |

| | | | |
|---|---|---|---|
| Vanderkloof Dam Hydropower Scheme | Operational when supplying downstream users | Vanderkloof Dam can produce up to 240 MW of electricity at a discharge flow rate of 400 $m^3/s$. | IUA 8 |

### Climate Change

The DWS National Integrated Water Information System (NIWIS)[1] dashboard related to Climate Change indicators includes changes in temperature, wet spells, dry spells, irrigation demand, potential evaporation, mean annual precipitation and streamflow. The available climate change data used is at quinary scale (i.e. sub-division of the quaternary). The following climate change aspects are noted:

- Assessing the impacts of climate change is a specialized field, and may be very localised and therefore, the impacts of climate change may differ from large irrigation schemes to smaller localized schemes
- Impact of climate change on irrigation practices may differ from the east to the west in the catchment
- Impact of climate change on irrigation practices may differ from ground water to surface water use, and
- The assumption is that, in the catchment, climate change may affect annual rainfall and temperatures but may also lead to longer drought periods as well as more periods flooding.
- Overall, the rainfall is expected to decrease between 0% to 9% in almost all areas except for marginal increases (1% - 3%) expected in the Kraai River catchment. the streamflow is expected to reduce by between 10% and 69% throughout the catchment, with the Riet River catchments showing the most drastic decrease (DWS, 2024).

In respect of groundwater, the climate change phenomenon may have a significant impact on the annual [required] replenishment of groundwater resources due to assumed changed rainfall patterns. Groundwater recharge estimates are an important factor in the algorithms used for groundwater resources classification, i.e., the stress index, and subsequently the estimation of “allocable” groundwater per quaternary catchment. Groundwater recharge is driven by rainfall intensities (mm over time) and rainfall depths (total depths per rainstorm).

These aspects may all have an impact on the resource units scoring.

[1] - DWS - NIWIS - Climate and Weather -

# 5 RESOURCE UNIT DELINEATION RESULTS

As described previously a resource unit is a reach of river within an IUA that is sufficiently ecologically distinct to warrant its own specification of resource quality objectives. Based on the consideration of the IUAs delineated, integration of the status quo aspects of the catchment detailed in Status Quo and Delineation of Integrated Units of Analysis and Resource Units Report, RDM/WMA13/00/CON/CLA/0224, consideration of the aspects discussed above, as well as using expert knowledge including discussions with specialists, catchment water resource managers and the DWS study team, 40 surface water resource units have been delineated in the Lower Orange Catchment study area. The resource units are shown in listed and described in Table 11 and illustrated in Figure 10. The resource units were delineated during the status quo assessment tasks and were presented and discussed with the stakeholders in the Upper Orange River catchment.

The resource units will form the basis of the RQO determination process once the water resource classes are set.

**Table 11: Preliminary Surface Water Resource Units Delineated within IUAs**

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **IUA 1: Golden Gate** | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | D21D and a portion of D21A along SA/ Lesotho border | Mainstem Caledon/ Little Caledon; homogenous land-use activities and impacts along river reach in the Golden Gate National Park to the outlet of the IUA. Includes UO_EWR 01_R on the Little Caledon at IUA/ RU outlet. FEPA and SWSA, protected area. PES: C, and EI: High and ES: High |
| **IUA 2: Caledon/ Leeu River** | | | |
| **2.1** | Little Caledon River and Caledon River along the Lesotho Border including tributaries Moolmanspruit and Meulspruit, and the Meulspruit Dam. | D21E, portion of D21C; D22A and D22B; portions of D21H and D22C along the SA/ Lesotho border | Mainstem Caledon/ Little Caledon and Meulspruit Dam; homogenous land-use activities and impacts along river reach (agriculture and tourism). Weirs D2H035 and D2H034 on the dam. WMS sites 101808, 101815, 187224, 191335 and UO_EWR 02_FV, few protected areas; no FEPAs; small farm dams. PES: C-D (an unnamed tributary of the Meulspruit, B); EI: Moderate and ES: Moderate. |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | D21F and D21G | Tributaries of the Caledon River, homogenous land-use activities and impacts along river reach (agriculture and tourism). FEPA, no weirs but many small farm dams. PES: predominantly C-D; EI: Moderate with D21G = High; ES: Moderate. |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | Portions of D22D; D22H; D22L, Portion of D23A, and portion of D23E | Mainstem Caledon and tributaries; homogenous land-use activities and impacts along river reach (extensive agriculture including irrigation; small towns). FEPA and Rehabilitation FEPA. Weir D2H022 on the Caledon River and D2H037 on the Caledon River at Hobhouse; WMS sites 101810, 101817, 191353 and 191354, the latter two with limited data. PES: predominantly C-D; EI: Moderate and ES: Moderate. |
| **2.4** | Leeu River and tributaries Klein-Leeu River and Mokopu River, including Lovedale and Newberry dams. | D23C, D23D | Tributaries of the Caledon River, homogenous land-use activities and impacts along the tributaries. FEPA and Fish Support area. No WMS sites, RESM. D2LEEU-EWR06. PES: predominantly C-D; EI: Moderate and ES: Moderate. |
| **2.5** | Armenia Dam on the Leeu River | D23C | Dam with D2R002 flow monitoring and WMS sites: 101819 for water quality. |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | D22G | Tributaries including Mopeli Dam, homogenous land-use activities and impacts along river reach (extensive agriculture including irrigation). EWR site: UO_EWR 03_R. PES: predominantly C-D; EI: Moderate and ES: Moderate. |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **IUA 3: Caledon** | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | D23H, D23J, D23G and D23F | Mainstem Caledon River and tributaries, homogenous land-use activities and impacts along river reach (extensive agriculture and irrigation and Welbedacht WTW), No WMS sites. FEPA - D23H, Rehabilitation FEPA – D23J, Upstream FEPA – D23H. PES: predominantly C-D; EI: Moderate; ES: Moderate |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | D23J | Dam with flow monitoring at D2R004 and downstream weir D2H033. WMS water quality sites 101820 and 86337. Heavy siltation, protected area. |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | D24D, D24E, D24F, D24G, D24H and D24J; D24K and D24L | Mainstem Caledon River and tributaries, homogenous land-use activities and impacts along river reach (extensive agriculture and irrigation and tourism; small towns). FEPA – D24A, D24E, D24H, D24F and D24G, Upstream FEPA – D24F and D24G, FEPA – D24L and D24K, Upstream FEPA – D24K and D24L. EWR sites: UO_EWR 10_FV, UO_EWR 11_FV, UO_EWR 04_I. Weir D2H036 on the Caledon River and WMS sites: 101816, and 191366, 191380 and 193325 downstream WWTW. PES: C-D; EI: Moderate; ES: Moderate. |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | D24A, D24B, D24C | Mainstem Caledon River and tributaries, homogenous land-use activities and impacts along river reach (Extensive agriculture and irrigation (Witspruit), subsistence agriculture, tourism, and small towns).<br>Fish support area – D24A and D24C and FEPA – D24A. No weirs or WMS monitoring sites. EWR site: UO_EWR 03_FV. PES: C-D; EI: Moderate; ES: Moderate |
| **3.5** | Egmont Dam | D24A | Dam with flow monitoring site D2R001 and WMS water quality site 101818. |
| **IUA 4: Kraai River** | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit and Wolwespruit | D13A, D13B, D13C, D13D, D13E, D13F, D13G and D13K | Mainstem river and tributaries, homogenous land-use activities and impacts along river reach (natural terrain, tourism; Irrigation along the rivers, extensive subsistence agriculture in the Wolwespruit sub-catchment), SWSA upper areas of D13E, D13K, D13B, D13A, D13C, and D13F. FEPA – D13A, D13B, D13E and D13F, Fish support area – D13D, Upstream FEPA – D13B, D13C, D13D, D13E, D13K, Rehabilitation FEPA – D13A. No weirs or water quality monitoring sites. EWR sites: UO_EWR 05_FV, UO_EWR 08_FV, UO_EWR 09_FV, UO_EWR 04_R, UO_EWR 18_FV, UO_EWR 19_FV. PES: predominantly B-C; A in D18K, EI: Moderate, High in D13E and ES: Moderate, High in D13A, D13B, D13C, D13E and D13G. |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **4.2** | Holspruit and tributaries: Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachusspruit | D13J and D13H | Tributaries: homogenous land-use activities and impacts along river reach (extensive subsistence agriculture, some irrigation throughout this RU – considerable erosion, Town of Jamestown). NO weirs and water quality monitoring sites. FEPAs and upstream FEPAs in D13J and D13H. EWR site: UO_EWR 07_FV. PES: predominantly B-C; EI: Moderate and ES: Moderate. |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit and Elandspruit | D13M and D13L | Mainstem Kraai River with tributaries, homogenous land-use activities and impacts along river reach (extensive subsistence agriculture and some irrigation along the river). FEPAs and upstream FEPAs D13M and D13L. Weir D1H011 and WMS water quality site 101795. EWR site: UO_EWR 08_I. PES: predominantly B-C; EI: Moderate and ES: Moderate. |
| **IUA 5: Upper Orange River** | | | |
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | D12B | Tributaries, homogenous land-use activities and impacts along river reach (extensive subsistence agriculture and villages), Upstream FEPA – D12B, SWSA in upper portions of the D12B. No weirs and water quality sites. EWR site: UO_EWR 02_I. PES: predominantly C-D, EI: Moderate and ES: Moderate. |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | Upper D12B | Dam, flow monitoring at the dam D1R001 and water quality site 101803. |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | D18K, Portions of D15G, D15H and D18L in SA, D12A, D12C, D12D, D12E and D12F | Mainstem and tributaries, homogenous land-use activities and impacts along river reach (Extensive subsistence agriculture and villages, larger formal cultivated areas, towns: Zastron/ Matlakeng, Herschel and Lady Grey). FEPA – D12A, DD12C, D12D, D12E and D12F, Upstream FEPA – D12A, DD12C, D12D, D12E and D12F. Weir at D1H006 and D1H009, and WMS water quality sites: 101791, 101793, 191410 and 191423 (downstream of WWTW).<br>FEPA – D12A, DD12C, D12D, D12E and D12F, and upstream FEPA – D12A, DD12C, D12D, D12E and D12F. PES: predominantly C-D, EI: Moderate; High (D12A); ES: Moderate |
| **5.4** | Stormbergspruit and tributaries: Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | D14B, D14C, D14D, D14E, D14F, D14G and D14H | Tributaries of the Orange River, homogenous land-use activities and impacts along river reach (Subsistence agriculture and villages as well as larger cultivated areas, and towns of Molteno and Burgersdorp). FEPA – D14B, D14C, D14D, D14F, D14G and D14H, Upstream FEPA – D14B, D14C, D14D, D14F, D14G and D14H. Weir D1H001 and WMS water quality site: 101788. EWR site: UO_EWR 05_R. PES: predominantly C-D, EI: Moderate and ES: Moderate. |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | D14A, D14J and D14K | Mainstem and tributaries, homogenous land-use activities and impacts along river reach (Extensive irrigation around the town of Maletswai, subsistence agriculture)<br>Weir D1H003 and WMS water quality site: 101789, and sites 191387, 191414 and 191415, downstream WWTW. No EWR site. FEPA – D14A, D14J and D14K, Upstream FEPA – D14A, D14J and D14K. PES: predominantly C-D, EI: Moderate and ES: Moderate. |
| **IUA 6: Gariep** | | | |
| **6.1** | Gariep Dam | D35H and D35K | Dam, (tourism, hydropower and transfers), flow monitoring site D3R002 and water quality site 101834. |
| **6.2** | Orange River and tributaries Rooirantjies, Oudagspruit, Winnaarbakespruit, Brandspruit, Broekspruit, Bossiespruit, Swarthoekspruit and Brakspruit | D35A, D35B, D35C, D35D, D35E, D35F and D35G | Very short section of mainstem Orange River, predominantly tributaries, homogenous land-use activities and impacts along river reach (predominantly natural and irrigation). No weirs, WMS site 193063 downstream WWTW. FEPA in D35F. PES: predominantly C-D (tributaries). EIS – not assessed. |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | D34A, D34E, D34F and D34G | Mainstem Orange River, homogenous land-use activities and impacts along river reach. FEPA in D34A and D34F. Weir at D3H013 and WMS water quality site: 101828. PES: predominantly C-D (tributaries), Orange River reach in B35K and D34A – E due to flow impacts. EIS – not assessed. |
| **6.4** | Orange River tributaries Suurbergspruit, Donkerpoortspruit, Oorlogspruit, Klipfonteinspruit, Rietkuilspruit and Vanderwaltfonteinspruit | D35J, D34A, D34B, D34C, D34D, D34E, D34F and D34G | Tributaries, homogenous land-use activities and impacts along river reach (Irrigation downstream of the dam along the river, tourism, predominantly natural, subsistence agriculture and the town of Colesberg). PES: predominantly C-D (tributaries). EIS – not assessed. |
| **IUA 7: Seekoei River** | | | |
| **7.1** | Seekoei River | D32A, D32B, D32C, D32D, D32E, D32F, D32G, D32H, D32J and D32K | Mainstem Seekoei River, homogenous land-use activities and impacts along river reach (agriculture, some irrigation and the towns of Noupoort and Hanover). Weirs: D3H012 and D3H015, and WMS water quality sites: 101827, 101829 as well as 191312 downstream Hanover WWTW (limited data). FEPA – D32D, D32E, D32C, D32F and D32G. Upstream FEPA – D32A, D32B. Groundwater SWSA in D32F (southwest area); D32B (southern portion) and D32C and D32G (eastern portion). PES: C, EI: Moderate, and ES: Moderate. |
| **IUA 8: Vanderfkloof Dam** | | | |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **8.1** | Vanderkloof Dam | D31E | Dam, village of Vanderkloof, hydropower, transfers. FEPA and protected area. Flow monitoring site D3R003 and water quality site: 101837, and weir on canal: D3H024 and WMS water quality site: 101832. |
| **8.2** | Orange River below Vanderkloof Dam | D33A | Orange River mainstem, homogenous land-use activities and impacts along river reach (sacrificial zone below the dam, extensive irrigation). Weir D3H012 and water quality site 101827. FEPA and Fish support area. PES: D and EI: Moderate and ES: Moderate |
| **8.3** | Orange River mainstem to Vaal confluence. | D33A, D33B, D33C, D33D, D33E, D33F, D33H, D33J and D33K (along mainstem) | Orange River mainstem, homogenous land-use activities and impacts along river reach (main stem Orange below sacrificial zone to Vaal River confluence and extensive irrigation along the river). Fish support area along the Orange River to the confluence with the Vaal River. No weirs or water quality sites. EWR site at Marksdrift weir: UO_EWR 10_I. PES: D and EI: Moderate and ES: Moderate |
| **8.4** | Tributaries draining to the Orange River in RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit | D31A, D31B, D31C, D31D, D33A, D33B, D33C, D33D, D33E, D33F, D33H, D33J and D33K | Tributaries, homogenous land-use activities and impacts along river reach (Natural with irrigation along the river as for RU 8.3). FEPA – D33A, D33B and D33F, upstream FEPA – D33B, D33C and D33J and D33K and fish support area throughout. No WMS flow or water quality sites. PES: C/D and unassessed because of the ephemeral nature of the tributaries, and EI: Low - moderate and ES: Low - moderate |
| **IUA 9: Upper Modder** | | | |
| **9.1** | Rustfontein Dam on the Modder River | C52A | Dam, flow monitoring site C5R003 with WMS water quality site: 90840, weir C5H037 with water quality site 90832 on the left canal, and limited data at 189024. Protected area - Rustfontein Nature Reserve, FEPA around the dam. |
| **9.2** | Modder River and Klein Modder and Kgabanyane Dam (Groothoek Dam) on the Kgabanyane River, with tributaries: Gannaspruit, Krompsruit, Bo-Kromspruit, Wildebeespruit and Grootpan | C52A and C52B | Mainstem Modder River, Kgabanyane Dam and tributaries, homogenous land-use activities and impacts along river reach (Agriculture in upper areas, Rustfontein Nature Reserve in Upper Modder around the dam and extensive urban area - Town of Botshabelo. FEPA – C52A and C52D upper areas. PES: Predominantly C-D, and B in one reach in C52B, EI: Low - High (C52E and C52C) and ES: Moderate. |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Bloemspruit, Renostersprui, Doringspruit, Rietspruit and Stinkhoutspruit | C52C, C52D, C52E, C52F and C52G | Mainstem Modder River and tributaries, homogenous land-use activities and impacts along river reach (extensive agriculture, City of Bloemfontein). Weirs: C5H007, C5H053 and C5H054. WMS water quality sites: 90813, 90836, 90837 and limited data for sites: 188085, !89013, 189015, 189019, 189021, 191145 and 191156 (the latter two downstream of WWTW). FEPA – C52D, C52C C52E and C52G and SWSA (Groundwater) in C52F and C52D. PES: predominantly C-D and F in , few in a B category. EI: Low - High (C52E and C52D) and ES: Moderate. |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | C52G | Dam, flow monitoring site: C5R004 and weir: C5H039 , WMS water quality sites: 90833 and 90841. FEPA around the dam – protected area. |
| **IUA 10: Modder/ Riet Rivers** | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | C52H, C52J, C52K and C52L | Modder River mainstem, homogenous land-use activities and impacts along river reach (extensive agriculture with irrigation along the river, tourism, diamond mining in D52L just outside the City of Kimberley which falls within the Lower Vaal catchment). Weir: C5H018 and C5H035, WMS water quality monitoring sites: 189076 and 191171. EWR site: UO_EWR_20_FV. FEPA – small portions of C52K and C52J and SWSA (Groundwater) in C52H, C52K and C52J. PES: predominantly C-D, EI: Moderate, with high in C52K; EI: Moderate, with high in C52K. |
| **10.2** | Riet River and tributaries: Fouriespruit and tributaries including Fouriespruit Dam, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | C51A, C51B, C51C, C51D, C51E and C51F | Mainstem Riet River and tributaries, homogenous land-use activities and impacts along river reach (extensive agriculture with irrigation along the river and Town of Reddersburg). Weirs: C5H012 and WMS water quality sites: 90816, 189023 and 191200, limited data for the latter two. EWR site: UO_EWR 06_I. FEPA – small portions of C51A, C51D and C51C, upstream FEPA – C51C. PES: predominantly C, few Ds and Bs. EI: Moderate, High in C51F; ES: Moderate. |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit to confluence with the Riet River | C51G and C51H | Tributary of the Riet River, homogenous land-use activities and impacts along river reach (extensive agriculture with some irrigation at the confluence with the Vanzylspruit and Kromellenboog-spruit at the large dam built on the Vanzylspruit, Towns of Trompsburg and Jagersontein). No weirs. WMS water quality sites: 189022, 189026 and 191429 with limited data. EWR Sites: UO_EWR 16_FV and UO_EWR 21_FV. FEPA – C51G and C51H (predominantly along the rivers), upstream FEPA - C51G and C51H and rehabilitation FEPA – small portion in the upper areas of C51G along the river. PES: B-C; EI: Moderate – High in C51G; ES: Moderate. |
| **10.4** | Riet River | C51J and C51K | Mainstem Riet River, homogenous land-use activities and impacts along river reach (Extensive agriculture with irrigation along the Riet River downstream of Kalkfontein Dam and at the outlet of QC C51K at the confluence with the Modder River, tourism along the Riet River at the Kalkfontein Dam Nature Reserve, diamond mining in downstream, reaches of the Riet catchment at Koffiefontein, and towns of Koffiefontein and Jacobsdal). Small protected areas. Weir: C5H030; WMS water quality site: 90830, and sites 188235, 189016, 189047, 190123, and 191172 with limited data. PES: predominantly C-D, EI: Moderate and ES: Moderate. |

| RU Number | Resource Unit Description | Quaternary catchments | Rationale |
|---|---|---|---|
| **10.5** | Mainstem Riet River to Vaal River confluence | C51L and C51M | Mainstem Riet River, homogenous land-use activities and impacts along river reach (Extensive agriculture with irrigation along the Riet River, tourism - Mokala National Park). Weir: C5H014, C5H016 and C5H048; WMS water quality sites: limited data for 189020, 189096 and 191175. EWR Site: UO_EWR09_I. Protected area. PES: predominantly D, EI: Moderate with Very High in C51L, and ES: Moderate with High in C51L. |
| **10.6** | Tierpoort Dam | C51D | Dam, flow monitoring site: C5R001 and weir C5H042 and C5H0543 on canals, and WMS water quality sites: 90838 and |
| **10.7** | Kalkfontein Dam | C51J | Dam, flow monitoring site: C5R002 and weir C5H036 and C5H040, and WMS water quality site: 90839, and 191170 (limited data). |

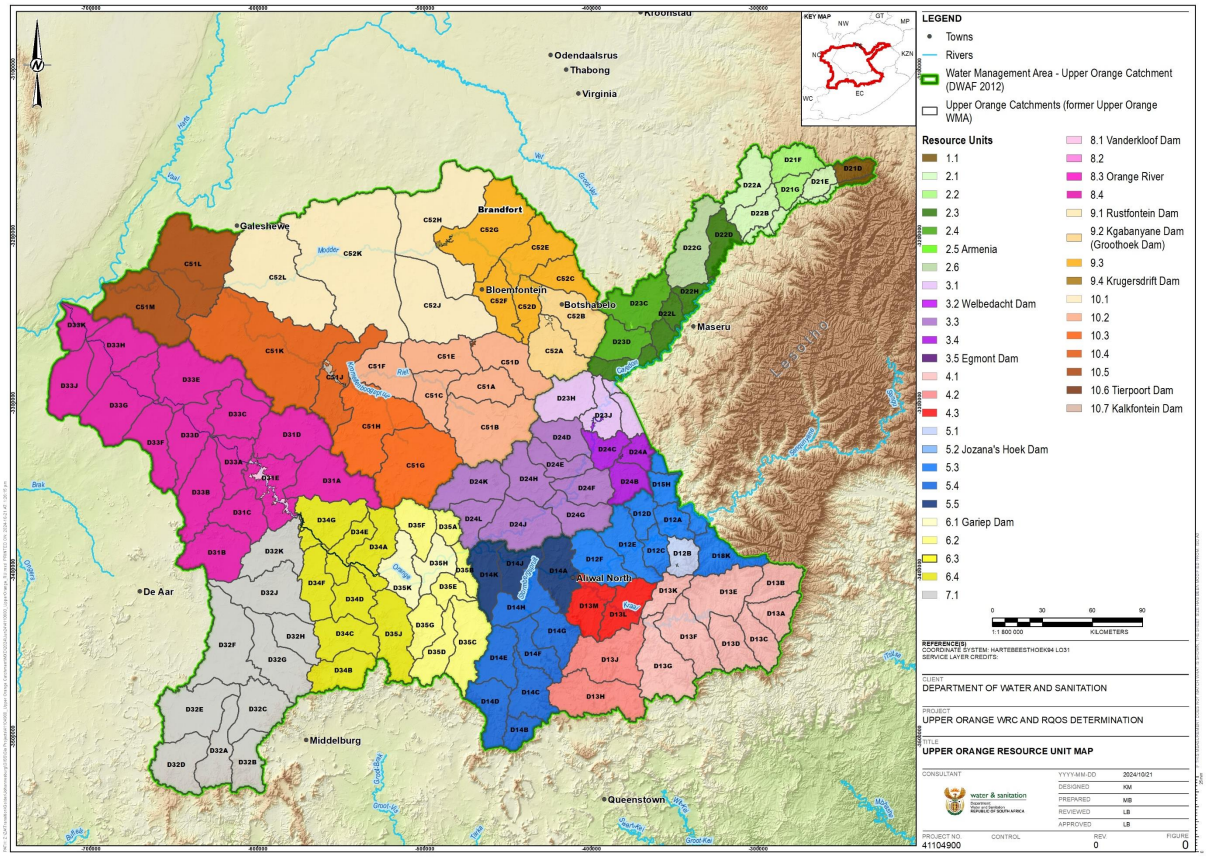



**Figure 10: Preliminary Resource Units delineated in the Upper Orange River Catchment**

# 6 RESOURCE UNIT PRIORITISATION

While the RQO determination procedure proposes that RQOs be set for each resource unit, this may not always possible due the potentially large number of RUs that could be delineated for a catchment. A rationalisation process has therefore been developed as part of the RQO Determination Procedure (DWA, 2011) to prioritise and select the most useful RUs for RQO determination.

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

The criteria assessed per RU include:

- Position of RUs within an IUA,
- Importance of the RU to users,
- Threat posed to water resource quality for users,
- Threat posed to water resource quality for the environment,
- Ecological considerations,
- Practical Constraints, and
- Management Considerations.

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

While the tool may be applied using desktop information, local knowledge and good understanding of the catchment is required to obtain optimal results.

## 6.1 Resource Unit Prioritisation Based on Assessment Criteria

As described above the Resource Unit Prioritisation Tool incorporates seven criteria that are scored, ranked, weighted, rated, and assessed. The criteria assessed to prioritise the RUs are described in Table 12.

**Table 12: Resource Unit Prioritisation Criteria**

| Criterion | Description and Reasoning | Sub-criteria rated per criterion per RU (0: low, 0.5: moderate or 1: high) |
|---|---|---|
| **Position of RU within IUA** | This is the first criterion that is considered within the RU Prioritisation Tool. Resource Units on large main stem rivers at the downstream end of the IUAs are located at the edge of socio-economic zones where user requirements are likely to differ. Such Resource Units also aggregate the upstream impacts from the entire IUA and thus enable the assessment of management performance at meeting objectives (including the gazetted IUA Class) for the upstream catchment. These RU thus receive high prioritisation in the Tool. It is important to note that estuaries will always be prioritised in this way (DWA, 2011). | Resource Units located on large main stem river at the downstream end of the IUA (IUA outlet node) |
| **Assessment of the importance of each Resource Unit to users** | This is the second criterion assessed and considers both current and future use. The tool assesses several sub-criteria relevant to different user considerations. | Resource units which provide important cultural services to society<br>Resource units which are important in supporting livelihoods of significant vulnerable communities<br>Resource units which are important in meeting strategic requirements and international obligations<br>Resource units that provide supporting and regulating services<br>Resource units most important in supporting activities contributing to the economy (GDP & job creation) in the catchment (e.g. commercial agriculture, industrial abstractions, and bulk abstractions by water authorities) |
| **Level of threat posed to the water resource quality for users** | This assessment considers the risk of the water resources to the users. Resource units which are threatened or are likely to be threatened by current or future activities should be monitored (most likely to be impacted by high-risk activities) | Level of threat posed to users |

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

The Resource Unit Prioritisation Tool was applied at a desktop level for the surface water resources in Lower Orange catchment considering the information presented in the Status Quo and delineation of IUAs report (DWS, 2024a). The desktop prioritisation scores have been finalised based on the review of the report by catchment managers, local stakeholders, and specialists and the selection of prioritised RUs revised as necessary.

The results of the rating of each sub-criteria are included in Appendix A and the total and overall prioritisation ratings are presented in Table 13 and illustrated in Figure 11 and Figure 12. The total prioritization score reflects the summed importance of the RU based on scores for all criteria evaluated, with the maximum score being 1, when all sub-criteria obtain maximum scores; while the priority rating highlights the resource units scoring highest, and other resource units are scored relative to this and shaded to reflect their relative priorities.

The resource units rated as high and in cases where the moderate rating was at 0.7 (>0.65), are proposed to be prioritised for RQO development. This includes 31 of the 40 resource units. The following resource units scored below 0.7 and are therefore not considered priority for RQO development in terms of the criteria and sub-criteria assessed are part of the prioritisation process:

- RU 2.1: Little Caledon River and Caledon River along the Lesotho Border including tributaries Moolmanspruit and Meulspruit, and the Meulspruit Dam
- RU 2.4: Leeu River and tributaries Klein-Leeu River and Mokopu River, and including Lovedale and Newberry dams
- RU 2.5: Armenia Dam on the Leeu River
- RU 3.5: Egmont Dam
- RU 6.2: Orange River and tributaries Rooirantjies, Oudagspruit, Winnaarbakespruit, Brandspruit, Broekspruit, Bossiespruit, Swarthoekspruit and Brakspruit
- RU 6.4: Tributaries Suurbergspruit, Donkerpoortspruit, Oorlogspruit, Klipfonteinspruit, Rietkuilspruit and Vanderwaltfonteinspruit, of the Orange River
- RU 8.4: Tributaries draining to the Orange River in RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit
- RU 9.2: Kgabanyane Dam (Groothoek Dam) on the Kgabanyane River, and
- RU 10.6: Tierpoort Dam.

It is noted that while RU 6.2 is on the main stem Orange River, the main stem portion is very short, and the tributaries draining to the dam are not prioritised as they are predominantly non-perennial.

**Table 13: RU Delineation Priority based on rating score**

| RU Number | Resource Unit Description | Quaternary catchments | Overall prioritisation rating and ranking |
|---|---|---|---|
| **IUA 1: Golden Gate** | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | D21D and a portion of D21A along SA/ Lesotho border | 1 |
| **IUA 2: Caledon/ Leeu River** | | | |
| **2.1** | Little Caledon River and Caledon River along the Lesotho Border including tributaries Moolmanspruit and Meulspruit, and the Meulspruit Dam | D21E, portion of D21C; D22A and D22B; portions of D21H and D22C along the SA/ Lesotho border | 0.3 |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | D21F and D21G | 0.7 |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, | Portions of D22D; D22H; D22L, Portion of D23A, and portion of D23E | 1.0 |

| RU Number | Resource Unit Description | Quaternary catchments | Overall prioritisation rating and ranking |
|---|---|---|---|
| | Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | | |
| **2.4** | Leeu River and tributaries Klein-Leeu River and Mokopu River, and including Lovedale and Newberry dams | D23C, D23D | 0.6 |
| **2.5** | Armenia Dam on the Leeu River | D23C | 0.5 |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | D22G | 0.7 |
| **IUA 3: Caledon** | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | D23H, D23J, D23G and D23F | 1.0 |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | D23J | 0.9 |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | D24D, D24E, D24F, D24G, D24H and D24J; D24K and D24L | 0.8 |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | D24A, D24B, D24C | 0.8 |
| **3.5** | Egmont Dam | D24A | 0.4 |
| **IUA 4: Kraai River** | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit and Wolwespruit | D13A, D13B, D13C, D13D, D13E, D13F, D13G and D13K | 0.8 |
| **4.2** | Holspruit and tributarie Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachusspruit | D13J and D13H | 0.7 |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit | D13M and D13L | 1.0 |
| **IUA 5: Upper Orange River** | | | |

| RU Number | Resource Unit Description | Quaternary catchments | Overall prioritisation rating and ranking |
|---|---|---|---|
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | D12B | 0.8 |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | Upper D12B | 0.7 |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | D18K, Portions of D15G, D15H and D18L in SA, D12A, D12C, D12D, D12E, D12F | 0.9 |
| **5.4** | Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | D14B, D14C, D14D, D14E, D14F, D14G and D14H | 0.7 |
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | D14A, D14J and D14K | 1.0 |
| **IUA 6: Gariep** | | | |
| **6.1** | Gariep Dam | D35H and D35K | 0.9 |
| **6.2** | Orange River and tributaries Rooirantjies, Oudagspruit, Winnaarbakespruit, Brandspruit, Broekspruit, Bossiespruit, Swarthoekspruit and Brakspruit | D35A, D35B, D35C, D35D, D35E, D35F and D35G | 0.63 |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | D34A, D34E, D34F and D34G | 1.0 |
| **6.4** | Tributaries Suurbergspruit, Donkerpoortspruit, Oorlogspruit, Klipfonteinspruit, Rietkuilspruit and Vanderwaltfonteinspruit, of the Orange River | D35J, D34A, D34B, D34C, D34D, D34E, D34F and D34G | 0.62 |
| **IUA 7: Seekoei River** | | | |
| **7.1** | Seekoei River | D32A, D32B, D32C, D32D, D32E, D32F, D32G, D32H, D32J and D32K | 1.0 |
| **IUA 8: Vanderfkloof Dam** | | | |
| **8.1** | Vanderkloof Dam | D31E | 0.76 |
| **8.2** | Orange River below Vanderkloof Dam | D33A | 0.97 |
| **8.3** | Orange River mainstem | D33A, D33B, D33C, D33D, D33E, D33F, | 1 |

| RU Number | Resource Unit Description | Quaternary catchments | Overall prioritisation rating and ranking |
|---|---|---|---|
| | | D33H, D33J and D33K (along mainstem) | |
| **8.4** | Tributaries draining to the Orange River in RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit | D31A, D31B, D31C, D31D, D33A, D33B, D33C, D33D, D33E, D33F, D33H, D33J and D33K | 0.44 |
| **IUA 9: Upper Modder** | | | |
| **9.1** | Rustfontein Dam on the Modder River | C52A | 0.9 |
| **9.2** | Kgabanyane Dam (Groothoek Dam) on the Kgabanyane River | C52A and C52B | 0.6 |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Renosterspruit, Doringspruit, Rietspruit and Stinkhoutspruit | C52C, C52D, C52E, C52F and C52G | 1.0 |
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | C52G | 1.0 |
| **IUA 10: Modder/ Riet Rivers** | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | C52H, C52J, C52K and C52L | 0.9 |
| **10.2** | Riet River and tributaries: Fouriespruit and tributaries including Fouriespruit Dam, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | C51A, C51B, C51C, C51D, C51E and C51F | 0.8 |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit to confluence with the Riet River | C51G and C51H | 0.7 |
| **10.4** | Riet River | C51J and C51K | 0.9 |
| **10.5** | Mainstem Riet River to Vaal River confluence | C51L and C51M | 1.0 |
| **10.6** | Tierpoort Dam | C51D | 0.6 |
| **10.7** | Kalkfontein Dam | C51J | 0.7 |

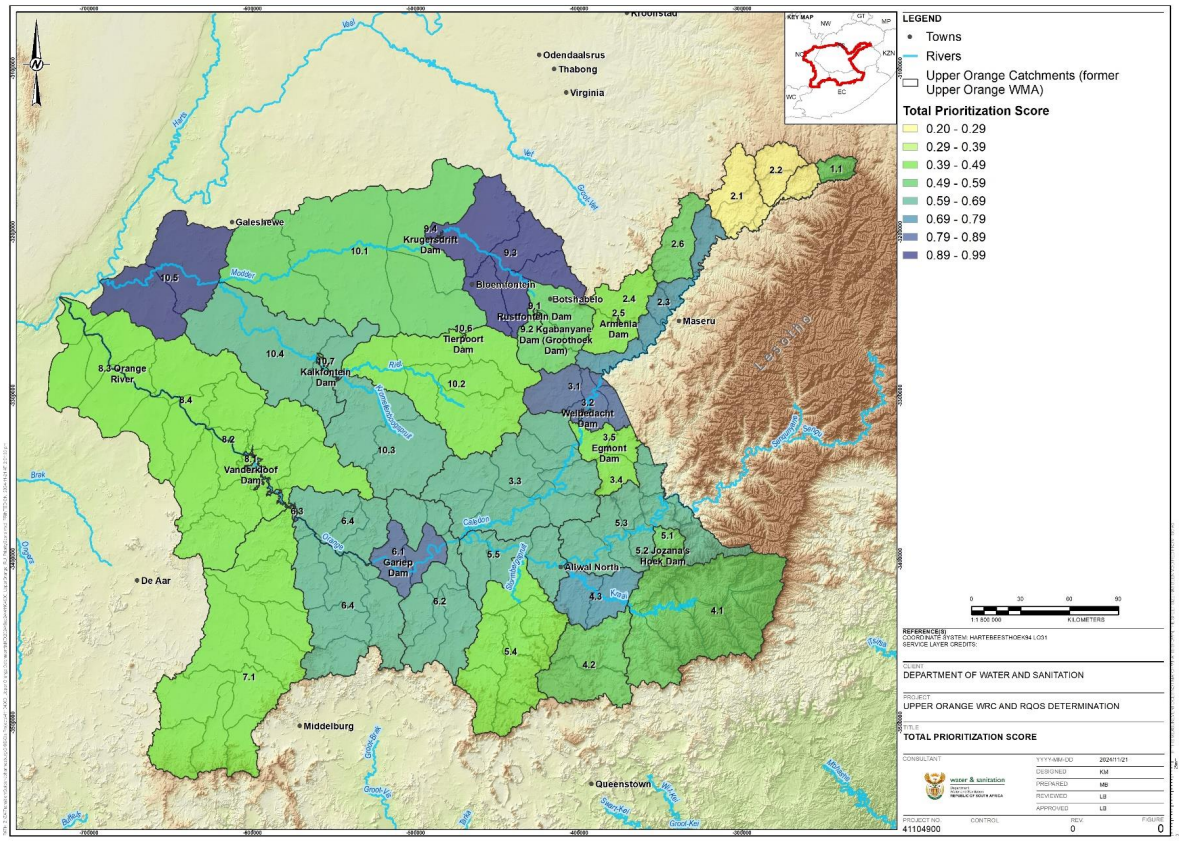



**Figure 11: RU Delineation – Total Prioritisation Score**

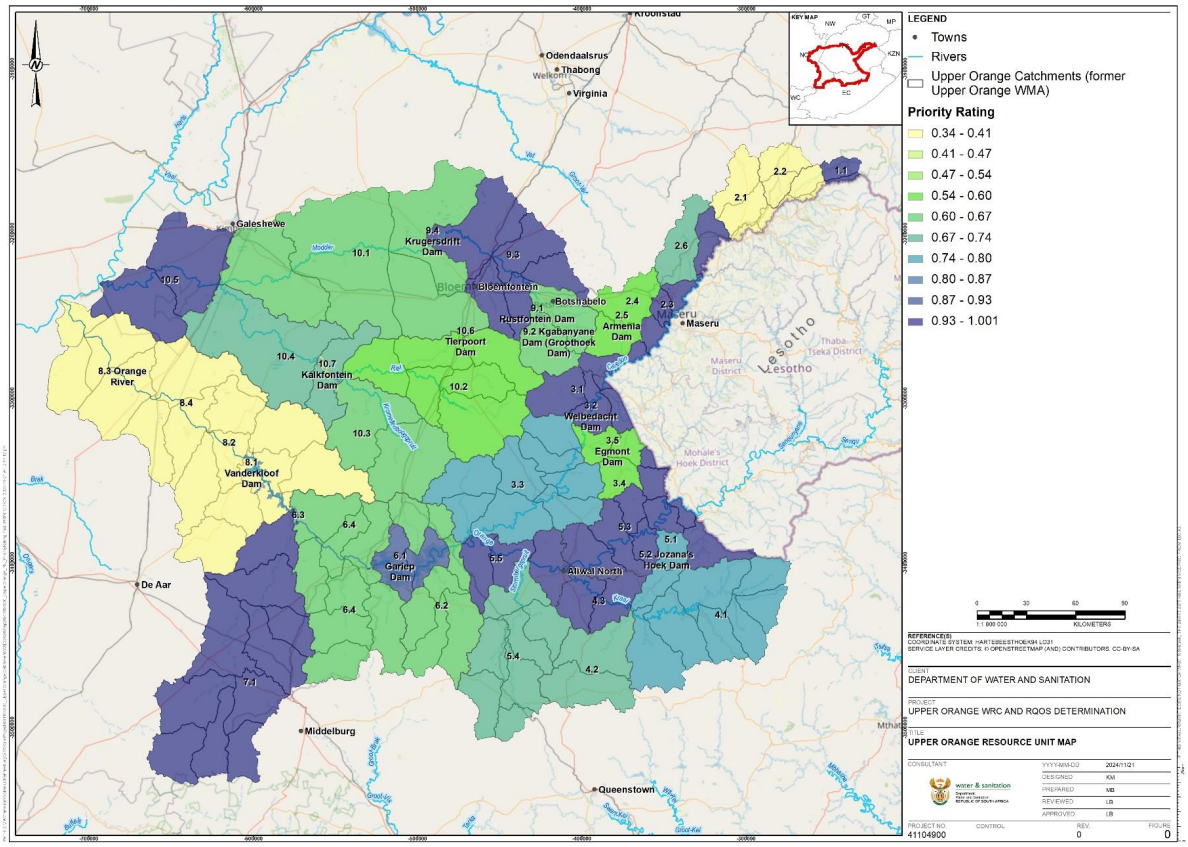



**Figure 12: RU Delineation – Overall prioritisation rating score**

# 7 GROUNDWATER RESOURCE UNITS

## 7.1 Previous hydrogeological delineations

The groundwater Reserve determination (DWS, 2024), that was based on the hydrogeological characteristics of the aquifer systems, was used in conjunction with the 2018 Strategic Groundwater Source Areas of South Africa (Le Maitre et al, 2018), to group quaternary catchments into resource unit clusters.

In addition to the hydrogeological characteristics, the following criteria were also used:

- Importance of the aquifer system(s) to users (degree of groundwater dependence)
- Threat posed to water resource quality for users (aquifer vulnerability)
- Threat posed to water resource quality for the environment (baseflow)
- Degree of use (stress index); and
- Geo-political boundaries (according to concentrations of bulk groundwater users).

This specific GRU delineation resulted in the differentiation of some of the quaternary catchments into 2 or 3 portions of the original catchment, which makes the final GRDM assessment, i.e. the water resource classification and resource quality objective settings more difficult.

### 7.1.1. 2024 Groundwater Resource Units Delineation

The two most important aspects/ characteristics of an aquifer system (or a groundwater unit) which are applied for water resource classification and RQOs determination are groundwater potential (for use), and groundwater quality.

Groundwater use is a direct indicator of the potential of the aquifer system (given normal climate conditions). Groundwater use in the Upper Orange River catchment is a function of (i) aquifer type (viz., intergranular, fracture, and fractured-weathered), (ii) aquifer potential (borehole yield classification), and (iii) potential groundwater recharge (rainfall depths).

Groundwater quality in the Upper Orange River catchment varies significantly and is affected by natural (geological), climatological (effective rainfall-recharge), and anthropogenic (human caused) aspects which include:

- Salinity affected by specific sedimentary rock formations, i.e., marine tillite and mudrock[2]
- Some aquifer systems need frequent fresh rainwater recharge to flush or dilute aquifer systems, i.e., dolomite, banded ironstone, quartzite, and sandstone formations; and
- Groundwater pollution due to poor solid waste management (rock/waste dumps), poor leachate management (tailings storage facilities), and poor wastewater management (wastewater treatment work discharges).

[2] Especially in the central and downstream part of the Catchment where the aquifer rock formation consists of the Karoo Supergroup Ecca Group mudrocks (marine-fluvial shale and siltstones) and the Dwylka Group formations (viz., marine mudstones and diamictites).

Most water supply schemes have been developed for sole water supplies – two or more boreholes on farms or smaller agricultural holdings, with as many as ten boreholes in some cases. As some of the surface water resources, especially in the western part of the catchment, are non-perennial systems, groundwater abstraction represents the main water source for some towns and rural communities, mines and irrigation schemes (bulk supply from one or more borehole or well fields consisting of 10 to 20 individual boreholes).

### 7.1.2. Delineation Approach and results

The 2024 Reserve determination (i.e., delineation of 14 GRUs as demarcated by GroundTruth, 2024), was used as baseline quaternary catchment (QC) clustering into groundwater resource units (GRU), i.e., using hydrogeological mapping results.

These delineations have been reviewed considering a quaternary catchment correlation with the preliminary surface water IUAs described in Table 2. As a result of the delineation process, 16 GRUs have been mapped for the Upper Orange River catchment. The GRUs were overlaid on the surface water IUAs, illustrated in

Figure 13.

There are, however, a few cases where specific hydrogeological characteristics of a quaternary catchment necessitated it to be transferred from one IUA to a neighbouring IUA. This was the case for two quaternary catchments, i.e., QC D21D to GRU 2 (now including IUA 1 and IUA 2) and QCs C52G and C52H into GRU 9.2 (from IUA 9 and IUA 10 respectively). These were solely based on their hydrogeological characteristics. The details of the GRUs are set out in Table 14 which also describes groundwater characteristics and strategic aquifer importance of all the groundwater resource units.

#### 7.1.2.1. Groundwater Resource Classification

As indicated above, the hydrogeological characteristics that were assessed in the 2024 Reserve determination were used as the most applicable criteria to demarcate the 16 GRUs into specific polygons, supported by Geographical Information Systems (GIS). These characteristics are based on the geological characteristics of the aquifer systems (representing the aquifer-type differentiation, indicated above), and the borehole yield classification (BYC).

These resource demarcations focused on the final correlation with the surface water IUAs and the major hydrogeological characteristics to group the quaternary catchments into the IUA demarcations for the ease of the final gazetting of groundwater classes and resource quality objectives.

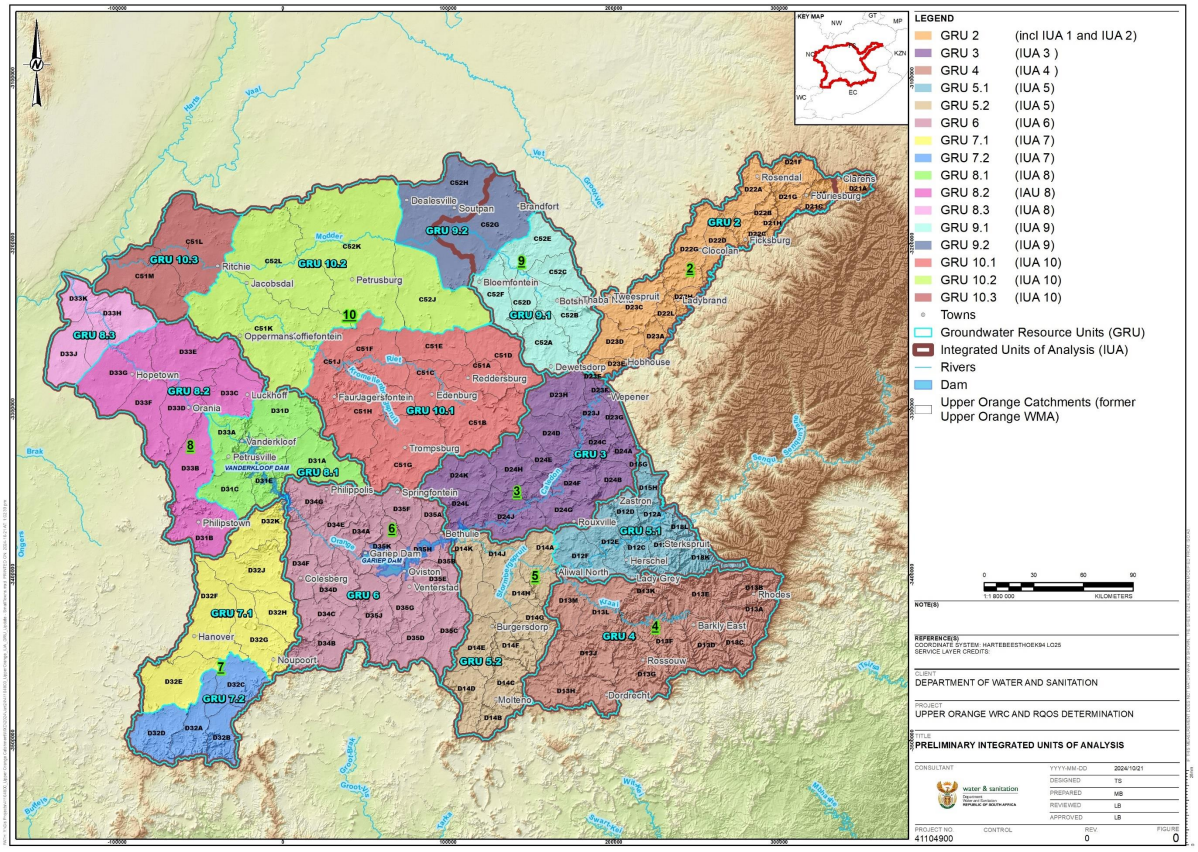



**Figure 13 - Upper Orange River Catchment - Groundwater Resource Units mapped with respect to the Integrated Units of Analysis**

#### 7.1.2.2. Groundwater Reserve

The 2024 Reserve determination assessment included an estimated groundwater Reserve (%) estimated for each quaternary catchment based on the following dataset assessments (DWS, 2024):

- Recharge (based on estimation and extrapolation)
- Groundwater use for Basic Human Needs (BHN) (25Litres/person/day, based on adjusted population counts from ward-level census data); and
- Ecological requirements (groundwater contribution to baseflow where a simplistic technique of baseflow separation, by University of Pretoria was used for 129 quaternary catchments with monthly surface flow data).

A review of the groundwater Reserve values was conducted in this assessment to adjust the figures (i) for the higher basic human need requirements (i.e., where groundwater is supplied for domestic purposes), and (ii) for the effect of rainfall variations since 1980 (due to climate variations/ changes). Groundwater Reserves for the catchment were reviewed in the light of the changing parameters, i.e., rainfall depths/patterns, population figures and water use figures, as the datasets that were used represent pre-2000 observations. For example, only a few quaternary catchments (38) have long-term groundwater quality time series data up to 2023. Therefore, setting of the groundwater quality Reserve for the whole Upper Orange River catchment is regarded as a low assurance level.

### 7.2 Resource Units Consideration for Prioritisation

The process followed to conduct the groundwater resource unit's prioritisation was based on the following criteria:

- Resource units where aquifer sustainability due to recharge and saturation levels (*viz*. water level trends) are a concern due to over abstraction and/or insignificant replenishment – this includes groundwater vulnerability (as per quaternary catchment)
- Resource units where groundwater quality is a concern due to natural elevated dissolved ionic concentrations – mainly sodium-chloride and fluoride as a result of the paleo-environmental conditions during sedimentation in the Karoo Basin; and
- Resource units where groundwater quality is a concern due to induced deterioration due to the production/ storage of concentrated waste material (i.e., mining/ industrial/ agricultural/ sewage processes).

There is a possibility that surface-groundwater interaction may be present in the upper part(s) of the catchment, i.e., abstraction from nearby borehole(s) could intercept surface water system(s), or nearby wetlands.

The most critical aspect considering the GRU's sustainable status of the groundwater systems are:

- Declining rainfall depths that impact aquifer recharge
- Ecological water requirements
- Groundwater use (annual abstractions at mines for dewatering and municipal wellfields), and
- Pollution of aquifer systems due to (a) poor waste management on mine/industrial sites, and (b) poor sewage treatment and discharges – specifically municipal wastewater treatment facilities.

Based on the groundwater system's Stress Index status, only two GRUs have quaternary catchments with a Category D or lower (i.e., an E Category) status, they are GRU 9.2 (QC C52H) and GRU 10.2 (QCs C52J and C52K). The remaining GRUs resource classifications are all Category C (Fair, only 3 QCs) and Category B (Good) to Category A (Natural).

There is a concern regarding the groundwater baseflow figures for GRU 4, i.e., the Kraai River system that is significantly higher than the total groundwater recharge. These are highlighted in Figure 14 . As per the GroundTruth 2024 dataset used for the Reserve determination (DWS, 2024), 11 of the 12 quaternary catchments in GRU 4, have negative allocable groundwater values, as do three quaternary catchments in GRU 5.1.

Figure 14 indicates the priority GRUs as:

- GRU4 (IUA 4) – Baseflow and the status of surface - groundwater interaction needs to be confirmed (QCs D13A-F and D13K)
- GRU 5.1 (IUA 5) – Baseflow and the status of surface - groundwater interaction needs to be confirmed (QCs D12A and D15H)
- GRU 5.2 (IUA 5) – Baseflow and the status if surface water-groundwater interaction needs to be confirmed (QCs D14A and D14F)
- GRU 9.2 (QCs in IUAs 9 and 10) – Verification of groundwater use and impacts (QCs C52G and C52H); and
- GRU 10.2 (IUA 10) – Verification of groundwater use and impacts (QCs C52J and C52K).

The remaining groundwater resource units can be regarded as low to insignificant cases based on their individual stress factor index status (SI) at this point in time, however, it is probably an appropriate opportunity to define resource quality objectives that can be implemented on request for (i) groundwater exploitation, (ii) groundwater quality deterioration, (iii) impact of rainfall depths due to climate variation, and/or (iv) other future water use exploitation(s).

**Table 14: 2024 Demarcated GRUs in the Upper Orange River catchment based on the 2024 Reserve determination results**

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1]<br>Bf[2]<br>Alloc.[3]<br>(Mm³/a) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| **IUA 1 & 2:**<br>GRU 2 | Karoo Supergroup: Clarens, Elliot and Molteno Formations consisting of massive sandstones, mudstone and feldspathic sandstone/grit respectively with underlying Beaufort Group formations consisting of sandstone and mudstone units.<br>Limited intrusive Karoo Dolerite (Jd) flat lying sills and subvertical dykes.<br>Aquifer system classified as a fractured type (d). | Recharge (±20 mm/a, with moderate contribution to baseflow.<br>Groundwater quality Class 0 (Ideal water quality type).<br>Borehole yield class (BYC= 0.5-2.0 L/s – d3).<br>Groundwater use is low – ±1.7 Mm3/a:<br>Stress index is a Natural category. | D21C, D21D, D21E, D21F, D21G, D21H, D22A, D22B, D22C, D22D, D22G, D22H, D22L, D23A, D23C, D23D, D23E and D23F. | 360<br>91<br>267 | 0.01% to 2.2% | A | SAI: Low.<br>BHN: 135,000 m³/a. |
| **IUA 3:**<br>GRU 3 | Karoo Supergroup formations: Beaufort Group formations consisting of sandstone and mudstone units.<br>Large intrusive Karoo Dolerite features (circular sills and subvertical dykes)<br>Aquifer system classified as a fractured type (d). | Recharge (±20 mm/a) but high contribution to baseflow.<br>Groundwater quality Class 0 (Ideal water quality type).<br>Borehole yield class (BYC = 0.5-2.0 L/s – d3).<br>Groundwater use is low – 3.9 Mm3/a.<br>Stress index is a Natural category. | D23G, D23H, D23J, D24A, D24B, D24C, D24D, D24E, D24F, D24G, D24H, D24J, D24K[A] and D24L. | 159<br>27<br>129 | 0.01% to 11.8% | A<br>[A] Outlier (B) | SAI: Low.<br>BHN: 39,000 m³/a. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| **IUA 4*:** GRU 4 | Karoo Supergroup: Drakensberg Basalts overlying Clarens, Elliot and Molteno Formations consisting of massive sandstones, mudstone and feldspathic sandstone/grit respectively with underlying Beaufort Group formations consisting of sandstone and mudstone units.<br>Intrusive Karoo Dolerite (Jd) flat lying sills and subvertical dykes.<br>Aquifer system classified as a fractured & intergranular (weathered) type (d). | Recharge (~20 mm/a) with high contribution to baseflow (baseflow indicated as higher-than recharge[B]).<br>Groundwater quality Class 0 (Ideal water quality type).<br>Borehole yield class (BYC = 0.5-2.0 L/s-d3) and BYC =0.1-0.5 L/s-d2✦).<br>Groundwater use is low – 2.5 Mm3/a.<br>Stress index is a Natural category. | D13A[B], D13B[B], D13C[B], D13D[B], D13E✦,[B], D13F✦,[B], D13G, D13H, D13J, D13K✦,[B], D13L and D13M.<br>[B] Allocable groundwater is in question due to proposed high contribution to baseflow. | 277<br>(299)<br>(25) | 0.01% to 2.5% | A | SAI: High due to SW-GW interaction and interflow dependence to wetland sites.<br>BHN: 64,000 $m^3/a$.<br>Note: Several QCs shows negative water balances (high baseflow figures). |
| **IUA 5:** GRU 5.1* | Karoo Supergroup: Drakensberg Basalts overlying Clarens, Elliot and Molteno Formations consisting of massive sandstones, mudstone and feldspathic sandstone/grit respectively with underlying Beaufort Group formations consisting of sandstone and mudstone units. | Recharge (~20 mm/a) with high contribution to baseflow.<br>Groundwater quality Class 0 (Ideal water quality type).<br>Borehole yield class (BYC = 0.5-2.0 L/s-d3) and BYC =0.1-0.5 L/s-d2✦).<br>Groundwater use is low – 1.6 Mm3/a. | D12A✦, D12B✦, D12C, D12D, D12E, D12F, D15H, D18L✦ and D18K✦. | 153<br>102<br>48 | 0.01% to 5.1& | A | SAI: High due to SW-GW interaction and interflow dependence to wetland sites and high BHN.<br>BHN: 165,000 $m^3/a$. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | Intrusive Karoo Dolerite (Jd) flat lying sills and subvertical dykes.<br>Aquifer system classified as a fractured & intergranular (weathered) type (d). | Stress index is a Natural category.<br>QC D12B, D15H and D18K has negative groundwater allocations due to extreme high baseflow values. | | | | | |
| GRU 5.2 | Karoo Supergroup formations Beaufort Group formations consisting of sandstone and mudstone units.<br>Large intrusive Karoo Dolerite features (circular sills) and sub-vertical dykes features present.<br>Aquifer system classified as a fractured type (b) and fractured & intergranular (weathered)[$] type (d). | Recharge lower (~15 mm/a, with moderate to low contribution to baseflow.<br>Groundwater quality Class 0 (Ideal water quality type).<br>Borehole yield class (BYC = 0.1-0.5 L/s – b3) and BYC = 0.5-2.0 L/s – d3)[$].<br>Groundwater use is low – 2.4 Mm3/a.<br>Stress index is a Natural category. | D14A[$], D14B, D14C, D14D, D14E, D14F, D14G, D14H, D14J and D14K. | 93<br>24<br>67 | 0.01% to 6.1%. | A | SAI: Low.<br>Insignificant use.<br>BHN: 36,000 $m^3/a$. |
| **IUA 6***<br>GRU 6.0 | Karoo Supergroup formations Beaufort Group formations consisting of sandstone and mudstone units.<br>Large intrusive Karoo Dolerite features (circular | Recharge (±10 mm/a, with contribution to baseflow becoming lower. Vulnerable to climate variances.<br>Groundwater quality Class 0 (Ideal water quality type), some | D34A, D34B, D34C, D34D[C], D34E, D34F[D], D34G, D35A, D35B, D35C, D35D[C], D35E, D35F, D35G, | 131<br>13.4<br>104 | Be-tween 3.4% and 32.4%. | A/B | SAI: Moderate.<br>BHN: 40,000 $m^3/a$.<br>Several municipalities are using single |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | sills) and sub-vertical dykes features present.<br>Aquifer system classified as a fractured type (b)[C] and fractured & intergranular (weathered) type (d)[D]. | QCs have a Class 1/2 water quality type [C].<br>Borehole yield class (BYC = 0.5-2.0 L/s - b3&d3[C]) and a BYC = 2.0-5.0L/s - d4[D]).<br>Groundwater use is low (i.e. <13 $Mm^3/a$.<br>Stress index is Natural to Good categories. | D35H, D35J[C] and D35K[D]. | | | | aquifer systems for supplies.<br>Area is impacted by climate variations and annual recharge depths varies >50% from the norm. |
| **IUA 7:**<br>GRU 7.1 | Beaufort Group (Karoo Supergroup) formations consisting of mudrock (silty mudstones) and sandstones.<br>Extensive Karoo Dolerite (Jd) intrusions (circular sills) and sub-vertical dykes.<br>Aquifer system classified as fractured and fractured-intergranular (weathered) types. | Recharge (<5 mm/a) with low contribution to baseflow. Vulnerable to climate variances.<br>Groundwater quality a Class 1, but changes to Class 1/2 (Good/ Marginal water quality types) along the northern boundary QCs related to primary salinity in the aquifer rock formation (underlying Ecca Group Mudstones).<br>Borehole yield class (BYC = 0.5 – 2.0 L/s in the fractured aquifer system-b3), BYC = 0.5-2.0 L/s in the fractured-intergranular aquifer system-d3).<br>Groundwater use is low - 1.8 $Mm^3/a$. | D32E, D32F, D32G, D32H[E], D32J and D32K. | 64<br>4.2<br>56 | 0.9% to 21.3%. | A/B and B/C[E] | SAI: Moderate to High (Hotspot areas at municipal well fields, groundwater Qn and Ql).<br>BHN: 15,000 $m^3/a$. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | | Stress index is a Natural category. | | | | | |
| **IUA 7:** GRU 7.2 | | Recharge (<10 mm/a) with low contribution to baseflow. Vulnerable to climate variances.<br>Class 1/2 (Good/ Marginal water quality types) in northern part of GRU 7.1 – probably related to primary salinity in the aquifer rock formation.<br>Borehole yield class (BYC = 0.5 – 2.0 L/s in a fractured aquifer system-b3), BYC = 0.5-2.0 L/s in a fractured & weathered aquifer system-d3).<br>Groundwater use is low - 1.8 $Mm^3/a$.<br>Stress index is a Natural category. | D32A, D32B, D32C and D32D. | 33.6<br>2.52<br>29.3 | 0.01% to 17% | A/B | SAI: Medium to high.<br>BHN: 8,000 $m^3/a$.<br>SWSA-gw area in D32B<br>Aquifer vulnerability and use. Recharge limitations. |
| **IUA 8:** GRU 8.1 | Karoo Supergroup formations: Beaufort Group[F] mudrock (silty mudstones) and sandstones, and Ecca Group[G] mudrocks (shale and silty sandstones). Extensive Karoo Dolerite (Jd) intrusions (circular sills) and sub-vertical dykes present. | Recharge (±5 mm/a) with low contribution to baseflow. Vulnerable to climate variances.<br>Class 1 (good) water quality type[F] toClass 2 (Marginal) water quality type[G] – the latter related to primary salinity in the Ecca Group | D31A[G], D31C[F], D31D[G], D31E[F] and D33A[G] | 55<br>5.5<br>47 | 0.7% to 9.4%. | A/B | SAI: Low.<br>Lower recharge and use.<br>BHN = 13,000 $m^3/a$ |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | Aquifer system classified as fractured[G] and fractured-intergranular[F] (weathered) types. | aquifer rock formation (mudstones).<br>Borehole yield class (BYC = 0.5 – 2.0 L/s in a fractured aquifer system-b3[G]) and BYC = 0.5-2.0 L/s in a fractured & weathered aquifer system-d3[F]).<br>Groundwater use is low - 2.6 $Mm^3/a$.<br>Stress index is a Natural category. | | | | | |
| **IUA 8:**<br>GRU 8.2 | Karoo Supergroup formations: Ecca Group[G] mudrocks (shale and silty sandstones) and Dwyka Group diamictite & boulder shale – underlain by Allanridge quartzite[H] of the Ventersdorp Supergroup. Extensive Karoo Dolerite (Jd) intrusions (occasional massive sills) and sub-vertical dykes present. Aquifer system classified as fractured type[H] with a fractured-intergranular (weathered) type[J]. | Recharge (<5 mm/a) with low contribution to baseflow. Vulnerable to climate variances.<br>Class 2 (Marginal) water quality type – the latter related to primary salinity in the Ecca Group and a Class 3 (Poor) water quality type in the Dwyka Group aquifer rock formation (marine diamictite and mudstone).<br>Borehole yield class (BYC = 0.5 – 2.0 L/s in a fractured aquifer system-b3) and BYC = 0.5-2.0 L/s in a fractured & weathered aquifer system-d3[J]).<br>Groundwater use is low - 1.1 $Mm^3/a$. | D31B, D33B, D33C, D33E[J], D33F and D33G[H,J]. | 88<br>1.92<br>85 | 0.1% to 0.6% | A | SAI: Low.<br>Lower recharge, use and primary salinity.<br>BHN=: 22,000 $m^3/a$. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | | Stress index is a Natural category. | | | | | |
| **IUA 8:** GRU 8.3 | Karoo Supergroup formations: Ecca Group[K] mudrocks (shale and silty sandstones) and Dwyka Group diamictite & boulder shale. Underlain by the Allanridge quartzite[H] of the Ventersdorp Supergroup. Aquifer system classified as fractured type. | Recharge (<5 mm/a) with low contribution to baseflow. Vulnerable to climate variances.<br>Class 2 (Marginal) water quality type[G] – the latter related to primary salinity in the Ecca Group and a Class 3 (Poor) water quality type in the Dwyka Group aquifer rock formation (marine diamictite and mudstone).<br>Borehole yield class BYC = 0.5-2.0 L/s in a fractured & weathered aquifer system-d3).<br>Groundwater use is low - 0.7 $Mm^3/a$.<br>Stress index is a Natural category. | D33H, D33K and D33J[K]. | 21<br>0.6<br>20.6 | 0.01% to 0.9%. | A | SAI: Low.<br>Lower recharge and primary salinity.<br>BHN = 10,000 $m^3/a$. |
| **IUA 9:** GRU 9.1 | Karoo Supergroup formations: Beaufort Group sandstone and mudrock (siltstone and shales). Extensive Karoo Dolerite (Jd) intrusions (flat lying and a few circular sills) and sub-vertical dykes present. | Recharge (±15 mm/a, with low contribution to baseflow.<br>Groundwater quality Class 0 (Ideal) and Class 1 (Good) water quality type). Hotspots expected in highly populated areas[L].<br>Borehole yield class: BYC – d2 = 0.1-0.5 L/s, and isolated areas[M] | C52A, C52B[L], C52C[L,M], C52D, C52E and C52F[L]. | 108<br>12<br>89 | 01& to 14% | A/B | SAI: High. Highly populated areas[L] Bloemfontein, Botshabelo and Thaba Nchu areas. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | Aquifer system classified as fractured-intergranular (weathered) type. | with BYC – d3 and d4 = 0.5 to 5.0 l/s.<br>Groundwater use is low – ±7 $Mm^3/a$:<br>Stress index is a Natural category. | | | | | BHN = 80,000 $m^3/a$ |
| **IUA 9:**<br>GRU 9.2 | Karoo Supergroup formations: Beaufort Group sandstones and mudrock (siltstone and shales), and Ecca Group[G] mudrocks (shale and silty sandstones).<br>Extensive Karoo Dolerite (Jd) intrusions (circular sills) and sub-vertical dykes present.<br>Aquifer system classified as fractured and fractured-intergranular[N] (weathered) types. | Recharge (±15 mm/a, with low-insignificant contribution to baseflow.<br>Class 2 (Marginal) water quality type and Class 3 (Poor) water quality. Class 4 (Saline) in many windblown depressions (pans).<br>Borehole yield class: BYC–d3 = 0.5-2.0 L/s) and BYC–b3 = 0.5-2.0L/s (C52H western part North of the Modder River).<br>Groundwater use is high – ±30 $Mm^3/a$:<br>Stress index is a Poor category.<br>Several pans present that may be groundwater driven – depression type in areas with shallow groundwater table(s). | C52G[N] and C52H[O] | 58<br>1.8<br>27 | 38%[N] and 64%O | D | SAI: High – high groundwater use figures.<br>BHN = 40,000m3/a |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| **IUA 10:** GRU 10.1 | Karoo Supergroup formations: Beaufort Group sandstone and mudrock (siltstone and shales). Extensive Karoo Dolerite (Jd) intrusions (flat lying and a few circular sills) and sub-vertical dykes present. Aquifer system classified as fractured[P] and fractured-intergranular[Q] (weathered) type. | Recharge (±10 mm/a, with high contribution to baseflow. Groundwater quality Class 0 (Ideal) and Class 1 (Good) water quality type. Borehole yield class: BYC–d2 = 0.1-5.0 L/s) in the fractured aquifer and BYC-b3 = 0.5-2.0 L/s in fractured & weathered aquifer[Q]). Hotspot areas with BYC -d3 & b4 = 0.5-2.0 L/s and 2.0-5.0 L/s in fractured and fractured-intergranular aquifers[P,Q]. Groundwater use is high – ±15 $Mm^3/a$: Stress index is a Natural to Good category. Several pans present that may be groundwater driven – depression type in areas with shallow groundwater table(s). | C51A[Q], C51B[Q], C51C[Q], C51D[Q], C51E[Q], C51F[P], C51G[Q], C51H[P,Q] and C51J[P]. | 162 20 127 | 3.0% to 18%. | A/B | SAI: Moderate. BHN = 70,000 $m^3/a$. |
| **IUA 10:** GRU 10.2* | Karoo Supergroup formations: Ecca Group mudrocks (shale and silty sandstones). Extensive Karoo Dolerite (Jd) intrusions (flat lying | Recharge (<10 mm/a, with insignificant contribution to baseflow. Groundwater quality Class 2 (Marginal) water quality type. | C52J[U], C52K[R,T], C52L[S] and C51K[S] | 181 1.56 114 | 13% to 68%. | B and D/E | SAI: High. SGWS in QC C52K. BHN = 120,000 $m^3/a$. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] ($Mm^3/a$) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | and a few circular sills) and sub-vertical dykes present.<br>Large area is known as the "Free State Kalkveld" area[R] due to the large deposits of surface limestone (calcrete) formation<br>Aquifer system classified as a fractured aquifer system. | Borehole yield class: BYC–b3 = 0.5-2.0 L/s) in the fractured aquifer system. In the Kalkveld area[R], BYC = b4 and b5 (2.0-5.0 and >5.0 L/s respectively).<br>Groundwater use is high – ±65 $Mm^3/a$:<br>Stress index varies from Good[S].to Poor[T] and Poor to Seriously Modified[U].<br>Several pans present that may be groundwater driven – depression type in areas with shallow groundwater table(s). | | | | | |
| **IUA 10:**<br>GRU 10.3 | Karoo Supergroup formations: Ecca Group mudrocks[V] (shale and silty sandstones) and Dwyka Group diamictite & boulder shale[W].<br>Underlain by the Allanridge quartzite of the Ventersdorp Supergroup[X] (.<br>Aquifer system classified as fractured type[V&W] and fractured and-in`tergranular type[X]. | Recharge (<5 mm/a, with insignificant contribution to baseflow.<br>Groundwater quality Class 2 (Marginal) water quality type.<br>Borehole yield class: BYC–b3 = 0.5-2.0 L/s[V] and BYC-b2 (0.1-2.0L/s[W]). Isolated areas consisting of the Ventersdorp Supergroup Allanridge quartzite[X] have BYC -d3 (0.5-2.0L/s).<br>Groundwater use is insignificant – ±0.442 $Mm^3/a$: | C51L[V&W] and C51M[V&W] | 31<br>0.84<br>30 | 0.1% to 2.0% | | SAIL Low.<br>BHN = 20,000 $m^3/a$. |

| GRU | Primary Hydrogeological Characteristics | Secondary Hydrogeological Characteristics | Quaternary Catchments | Re[1] Bf[2] Alloc.[3] (Mm³/a) | Stress Index (%) | Present Status Cat. (Qn) | Strategic Aquifer Importance (SAI) |
|---|---|---|---|---|---|---|---|
| | | Stress index varies from Good[S].to Poor[T] and Poor to Seriously Modified[U].<br>Several pans present that may be groundwater driven – depression type in areas with shallow groundwater table(s). | | | | | |
| | [1] Estimated groundwater recharge in Mm³/a, [2] Groundwater Baseflow estimation (Univ. Pretoria) in Mm³/a, and [3] Allocable Groundwater (still available for allocation in Mm³/a).<br>***** One or more of the quaternary catchments GRUs are heavily over-utilised (Category E & F).<br>~ Based on statistical averages.<br>Qn implies that the PSC is based only on the groundwater quantities.<br>Ql implies groundwater quality (based on its hydrochemical composition). | | | | | | |

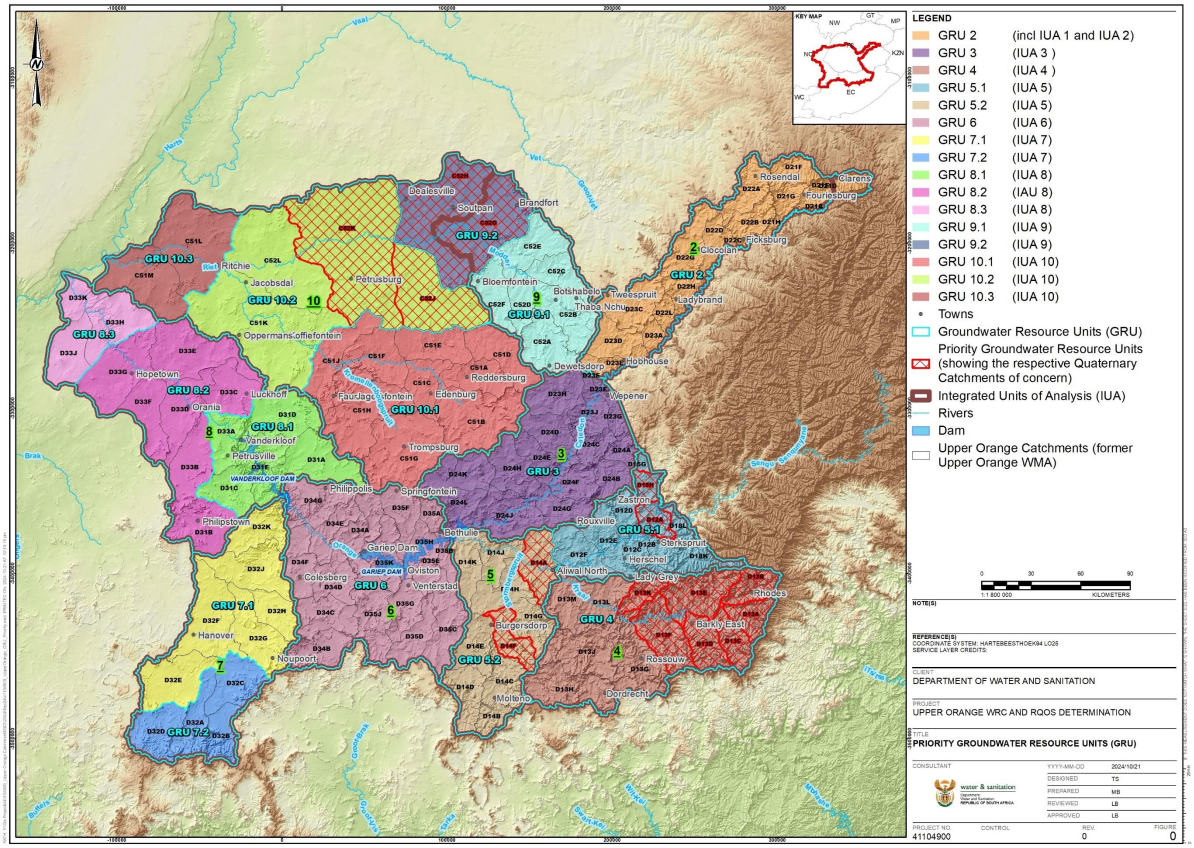



**Figure 14 - Showing the priority GRUs with the specific Quaternary Catchments of concern**

# 8 WETLANDS

The Upper Orange River catchment covers an area of approximately 10,352,148 hectares (ha) and according to the NWM5 dataset (Van Deventer *et al*., 2018) wetland habitat (including rivers) covers an area of approximately 139,046.90 ha, 1% of the Upper Orange River catchment.

Based on the NWM5 and the results of the DWS Reserve Determination Study (DWS, 2022b), five different hydrogeomorphic (HGM) wetland types have been described as occurring in the Upper Orange River WMA. These include:

- Seeps
- Depressions/ Pans
- Floodplains
- Channelled Valley Bottom systems; and
- Unchanneled Valley Bottom systems.

Riverine systems were also mapped and categorized as wetland/watercourse types by the NWM5 (Van Deventer *et al*., 2018) and were thus included in the overall calculations of wetland area for this study.

Depression/ pan wetlands were found to be the most extensive wetland type within the Upper Orange River catchment, making up 51% of the total wetland habitat mapped (Table 16). Their characteristics are largely associated with a combination of geology, rainfall and temperature (DWS, 2022b). Riverine systems make up the second most extensive wetland/ watercourse type mapped in the catchment (39%). Floodplain and channelled valley bottom wetlands cover 3% and 4% of the catchment area respectively. Most of these systems are associated with the main systems running through the catchment such as Caledon, Modder, Riet, Kraai, Seekoei and Orange rivers.

The wetlands within the Upper Orange River catchment occur across five ecoregions, and seven different bioregions, the largest bioregion being the Dry Highveld Grassland Bioregion followed by the Upper Karoo Bioregion. The bulk of the wetlands are found within these two bioregions.

## 8.1 Wetland characteristics

Wetlands can be described as areas of inundated land or areas that are saturated for extended periods of time. They are intermediate zones between terrestrial lands and aquatic ecosystems, usually occurring when the water table is located just below the surface, illustrated in Figure 15. Certain plants have adapted to wetland conditions, such as growing in anaerobic soil (Ramachandra and Kumar, 2008). The spaces between soil particles usually become filled with water due to the soil becoming increasingly wet. A typical characteristic of wetlands is their ability to store water and allow drainage to occur at an extremely slow rate, which means the soil becomes waterlogged, which leads to anaerobic conditions. Anaerobic conditions usually occur in waterlogged wetland soils due to the rapid use of oxygen by organisms and plant roots. Wetlands are therefore characterized by soil saturation together with redoximorphic features; high

clay and organic matter content in soils; a suite of characteristic wetland vegetation types and particular topographic settings in which they occur.

Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance. In the identification of wetland areas more than one distinguishing characteristic must be present before positive identification of wetlands is done.

Four specific wetland indicators are used to identify/verify wetland areas:

- Terrain unit,
- Vegetation,
- Soil: texture (sand & clay), colour (hue, chroma and value), organic matter; and
- Degree of saturation.

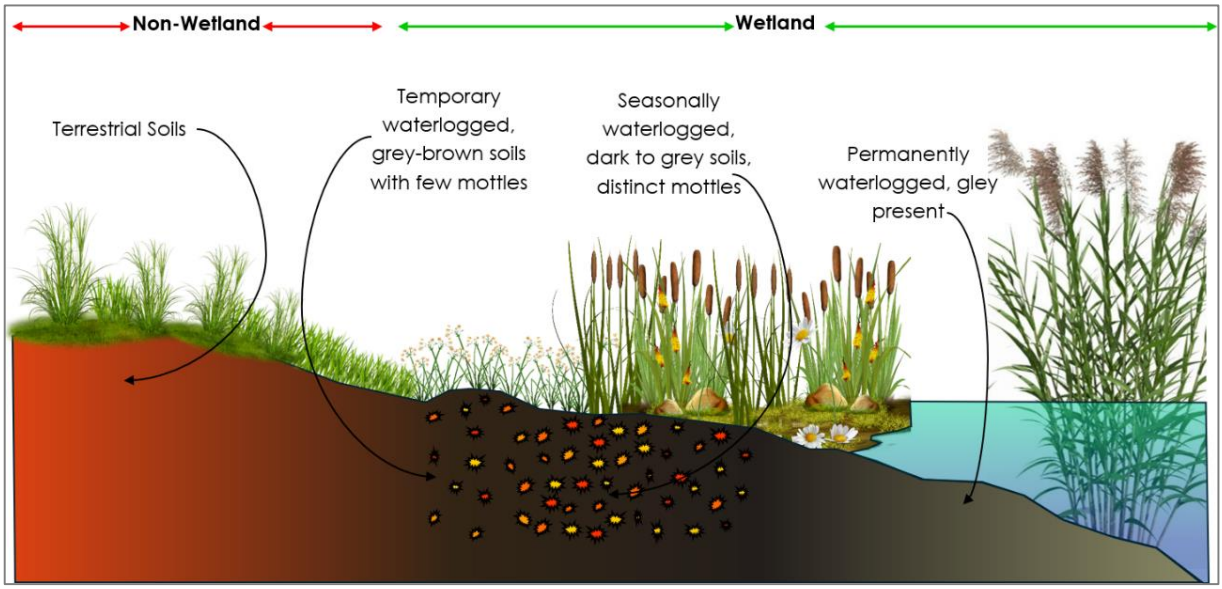
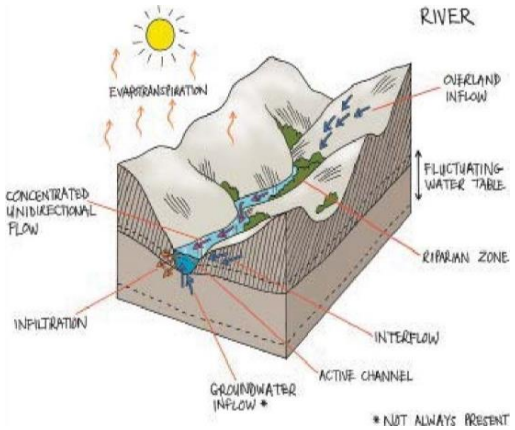
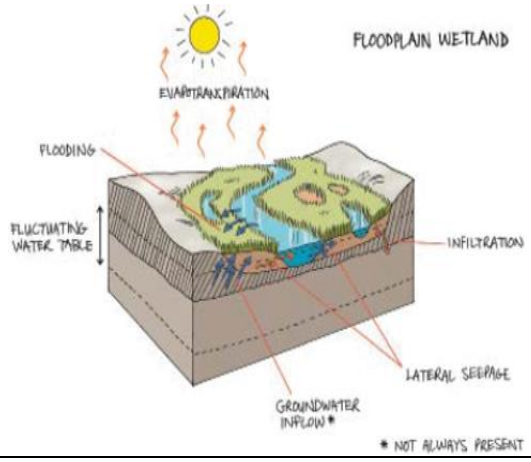
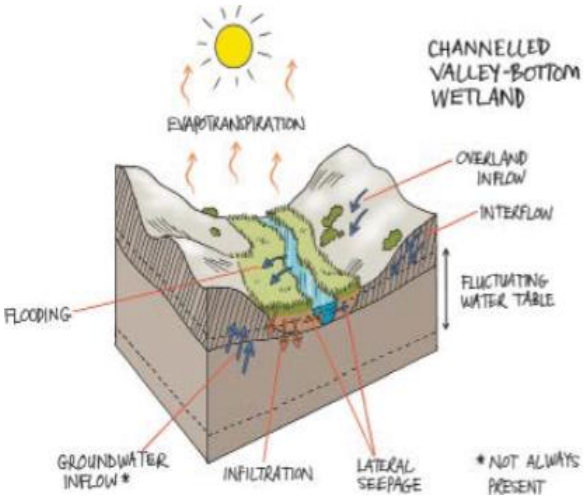


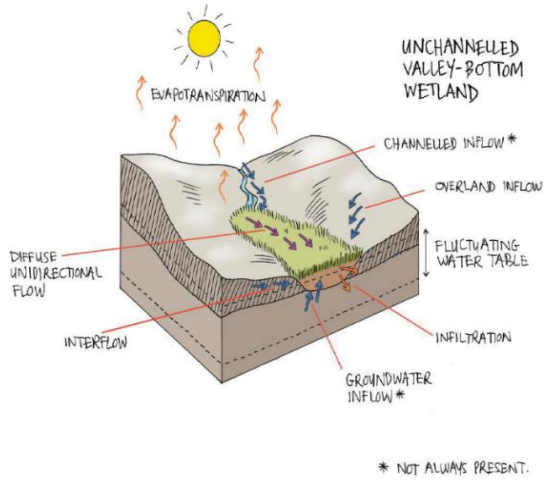
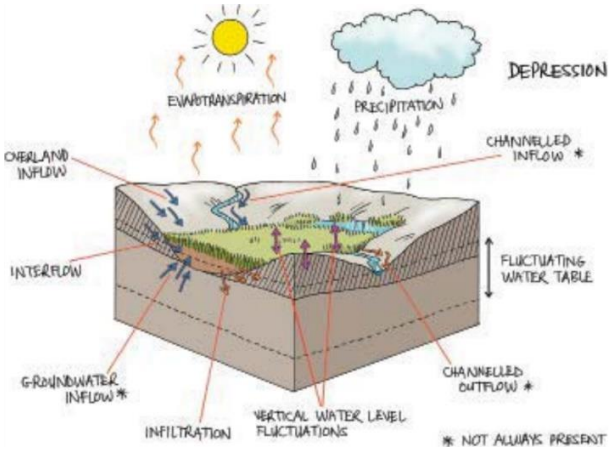
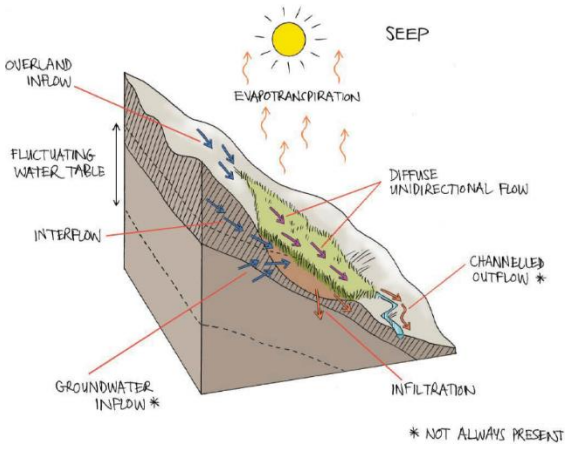

**Figure 15: Cross sectional diagram of a wetland, indicating how the soil moisture and vegetation indicators change moving along a gradient of decreasing wetness, from the middle to the edge of the wetland**

## 8.2 Wetland Classification

For further understanding of the description of the various wetland classifications, DWAF (2008) and Ollis *et al*., (2013) created a generic description which is illustrated in Table 15.

**Table 15: Classification of Hydrogeomorphic (HGM) wetland types (DWAF, 2008; Ollis *et al.*, 2013)**

| Classification | Illustration | Description |
|---|---|---|
| **River** |  | A river system defined as the concentrated, unidirectional flow within a distinct active channel, either permanently or periodically. Dominant water sources for rivers include concentrated surface flow from upstream channels and tributaries. Other inputs can include diffuse surface or subsurface flow, interflow, and/or groundwater inflow. The riparian zone is the portion of land directly adjacent to the active channel (i.e. on the banks of the river), which is influenced by river-induced or river-related processes. |
| **Floodplain Wetland** |  | A wetland area located on mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, and intermittently inundated by overtopping of the associated channel. Characteristic depositional features of floodplain wetlands include point bars, scroll bars, oxbow lakes and levees. |
| **Channelled Valley Bottom** |  | Channelled valley-bottom wetlands must be considered as wetland ecosystems that are distinct from, but sometimes associated with, the adjacent river channel itself, which must be classified as a 'river'. These valley-bottom wetlands are characterised by their location on valley floors, the absence of characteristic floodplain features and the presence of a river channel flowing through the wetland. |

| Classification | Illustration | Description |
|---|---|---|
| **Unchanneled Valley Bottom** |  | Unchanneled valley-bottom wetlands are characterised by their location on valley floors, an absence of distinct channel banks, and the prevalence of diffuse flows. In some cases, an unchanneled valley bottom wetland could occur at the downstream end of a seep, where a slope grades into a valley near the head of a drainage line. Water characteristically moves through the wetland in the form of diffuse surface or subsurface flow, but the outflow may be in the form of either diffuse or concentrated surface flow |
| **Depression** |  | Depression systems are wetlands or aquatic ecosystem with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates. Most depressions occur either where the water table intercepts the land surface (such as on coastal plains along the South African coastline), or in semi-arid settings where a lack of sufficient water inputs prevents areas where water accumulates from forming a connection with the open drainage network. |
| **Hillslope Seepage Wetland** |  | Wetland area situated on a gentle to steep sloping land that facilitates the dominance of colluvial, unidirectional movement of material and water (mainly in the form of interflow) downslope. Water inputs are primarily via subsurface flows from an up-slope direction. Seeps are characterised by their association with geological formations (lithologies) and topographic positions that either cause groundwater to discharge to the land surface or rain-derived water to 'seep' down-slope as subsurface interflow. |

## 8.3 Methodology

The preliminary Priority Wetland list was sourced from the high confidence Reserve Determination Study (DWS, 2022b). The methods used to identify priority wetland resource units for the Reserve study were reliant on existing wetland coverages (Nel et al., 2011 and Van Deventer et al., 2019) and modification of previous approaches used to define strategically important wetland areas within the broader landscape (Van Deventer et al., 2019). Additional spatial layers were considered and incorporated into a multi-criteria analysis (MCA) to broadly define those wetlands that were considered more important, based on a selected list of variables viewed as important from a wetland ecological, functioning, social and/or biodiversity perspective. The following information was used in the identification of priority wetlands for consideration in the Reserve study (DWS, 2023):

- National Wetland Map 5 spatial dataset (Van Deventer et al. 2019)
- National Freshwater Ecosystem Priority Areas (NFEPAs) wetland shapefile (Nel et al., 2011)
- Important Bird Areas (IBAs) (BirdLife South Africa, 2016)
- Crane sightings and nest sites (Endangered Wildlife Trust, 2019)
- Wetlands that interacted with the surface and groundwater SWSAs (Lötter & Maitre, 2021)
- Wetlands with a Present Ecological State (PES) of A/B (Van Deventer et al. 2019)
- Hydrogeomorphic (HGM) unit type, which was used to determine the level to which each system may provide services associated with (cf. Van Deventer et al. 2019):
    - Flood attenuation
    - Stream flow regulation
    - Erosion control
    - Sediment trapping; and
    - Water quality enhancements (assimilation of nutrients).
- Those systems classified as Critically Endangered or Endangered (Nel et al., 2012)
- Wetlands located upstream of important water supply dams; and
- Identified water-stressed catchments/ basins from the river RU process of the Reserve study (DWS, 2022a), and
- Site visits.

The reference conditions of each wetland resource units (WRU) were determined using a variety of appropriate assessment tools such as the WET-Health framework. The PES for each wetland was determined using the WET-Health version 2 assessment tool (MacFarlane et al., 2020) and either a Level 1B or a Level 2 WET-Health assessment was undertaken for each WRU depending

on the pre-determined level of assessment (determined in Step 2). The hydrological, geomorphic, water quality and vegetation components of each WRU were assessed as part of the PES assessment. The EIS and the recommended ecological category (REC) of each WRU were determined using the approach defined in Rountree et al. (2013).

The potential impacts of developments in each WRU and their associated catchments were also considered, specifically in terms of any potential changes to water inputs and outputs.

## 8.4 Priority Wetlands

Based on the IUA delineation, the IUA with the largest number of wetlands is IUA 08 (Vanderkloof Dam) with 2.5% of wetland habitat relative to the size of the IUA, followed by IUA 10 (Modder/Riet), with 2% of wetland habitat. IUA 10 also has the highest number of priority wetlands. The IUA with the least wetlands mapped is IUA 1 (0.14%), which is also the smallest IUA in size (approx. 43.53 ha) (Table 16).

The DWS (2022b) Reserve Determination Study, prioritised several wetland systems in the Upper Orange River catchment and four additional wetlands have been identified and will be mapped and assessed over the next few months. Table 17 briefly describes each of the wetlands with the associated ecological category, if available. It is noted that while the Jagersfontein DCVB wetland was assessed as a C ecological category, this was just prior to the spill from the upstream tailings facility and has been highly impacted.

**Table 16: Wetland type and extent (area) with percentage of area per IUA (source: GIS coverage of Van Deventer *et al*., 2018) and wetland condition**

| Catchment (IUA) | | Area (ha) of IUA | Area of wetlands in IUA (ha) | % Wetland area in IUA | Wetland type | | | | | | | | | | | | Wetland condition | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Depression | | Floodplain | | Seep | | Channelled VB | | Unchanneled VB | | River | | A/B | | C | | D/E/F | |
| | | | | | ha | % | ha | % | ha | % | ha | % | ha | % | ha | % | ha | % | ha | % | ha | % |
| **1** | Golden Gate | 30,718 | 43.53 | 0.14 | - | - | 34.63 | 0.11 | - | - | 1.99 | 0.01 | - | - | 6.92 | 0.02 | - | 0 | 31.91 | 73 | 4.70 | 11 |
| **2** | Caledon/ Leeu River | 631,886 | 3 022.03 | 0.48 | 1 170.17 | 0.19 | - | - | 109.18 | 0.02 | 681.96 | 0.11 | 700.88 | 0.11 | 359.84 | 0.06 | 619.22 | 20 | 427.85 | 14 | 1,615.11 | 53 |
| **3** | Caledon River | 822 797 | 4 935.94 | 0.60 | 887.86 | 0.11 | 2 509.67 | 0.31 | 12.45 | 0.00 | 40.67 | 0.0 | 42.69 | 0.01 | 1 442.61 | 0.18 | 476.27 | 10 | 2,646.64 | 54 | 370.43 | 8 |
| **4** | Kraai River | 934 709 | 4 902.46 | 0.52 | 555.53 | 0.06 | 407.61 | 0.04 | 199.88 | 0.02 | 743.24 | 0.08 | 553.52 | 0.06 | 2 442.68 | 0.26 | 916.69 | 19 | 555.45 | 11 | 987.64 | 20 |
| **5** | Upper Orange River | 1 024 091 | 6 904.29 | 0.67 | 142.31 | 0.01 | 99.41 | 0.01 | 39.66 | 0.00 | 150.59 | 0.01 | 36.76 | 0.00 | 6 435.56 | 0.63 | 154.84 | 8 | 99.22 | 1 | 214.67 | 3 |
| **6** | Gariep Dam | 1 064 786 | 4 090.80 | 0.38 | 126.75 | 0.01 | - | - | 92.34 | 0.1 | 63.29 | 0.01 | 42.08 | 0.00 | 3 766.34 | 0.35 | 177.73 | 24 | 7.28 | 0 | 139.45 | 3 |
| **7** | Seekoei River | 915 159 | 9 811.74 | 1.07 | 804.37 | 0.09 | - | - | 308.67 | 0.03 | 352.70 | 0.04 | 59.23 | 0.01 | 8 286.77 | 0.91 | 914.23 | 2 | 130.73 | 1 | 480.01 | 5 |
| **8** | Vanderkloof Dam | 1 449 349 | 36 231.46 | 2.50 | 13 937.18 | 0.96 | - | - | 199.71 | 0.01 | 101.23 | 0.01 | 492.45 | 0.03 | 21 500.89 | 1.48 | 7,830.19 | 0 | 1,021.21 | 3 | 5,879.17 | 16 |
| **9** | Upper Modder River | 632 039 | 6 122.45 | 0.97 | 2 859.67 | 0.45 | 418.69 | 0.07 | 246.91 | 0.04 | 1 813.85 | 0.29 | 35.45 | 0.01 | 747.89 | 0.12 | 1,859.07 | 8 | 678.49 | 11 | 2,837.00 | 46 |
| **10** | Modder/ Riet River | 2 846 614 | 62 982.20 | 2 | 50 721.99 | 2 | 156.05 | 0.00 | 1 873.43 | 0.00 | 999.72 | 0.00 | 134.91 | 0.00 | 9 096.09 | 0.00 | 29,145.03 | 9 | 8,498.05 | 13 | 16,243.03 | 26 |
| | | **10 352 148** | **139 046.90** | **1.3** | **71 205.83** | **51** | **3 626.05** | **3** | **3 082.23** | **2** | **4 949.23** | **4** | **2 097.96** | **2** | **54 085.60** | **39** | **42,093.27** | **30** | **14,096.83** | **10** | **28,771.20** | **21** |

## Table 17: Prioritised wetlands

| IUA | | Wetland name | Description | Ecological Category |
|---|---|---|---|---|
| **1** | Golden Gate | No prioritised wetlands | | |
| **2** | Caledon/ Leeu River | **Brandwater floodplain** | 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. | **C** |
| | | **Rantsho wetland complex** | 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. | **C** |
| **3** | Caledon River | **Sandspruit wetland** | Wetland near the town of Wepener that receives the entire runoff and the discharge from the town's WWTW pass through this still reasonably intact wetland before entering the Caledon River, its importance in terms water quality enhancement is likely to be high. | **Not assessed** |
| **4** | Kraai River | **Tiffindell Seep** | High-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. | **A** |
| | | **Klein-Wildebeespruit wetland complex** | 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. | **D** |
| | | **Luckhof depression wetland complex** | 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 | **B** |

| IUA | | Wetland name | Description | Ecological Category |
|---|---|---|---|---|
| | | | wetlands flow 7in a south-easterly direction into the Lemoenspruit River 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. | |
| | | **Otto du Plessis Pass wetland UCVB and CVB** | Extensive hillslope seeps and is an unusually large wetland for its high altitude. Much of the wetland vegetation remains intact. | **Not assessed** |
| | | **Wolwespruit headwaters** | 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 River. 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 both crane species and possibly also a breeding site for the Crowned Cranes. | **C** |
| | | **Barkley Pass wetland complex** | 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 River which is a tributary of the Kraai River – an extremely important water source for the Orange River, found in IUA 4. | **A** |
| **5** | Upper Orange River | **Maletswai, CVB/UVB wetland complex** | 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. | **Not assessed** |
| **6** | Gariep Dam | No wetlands prioritised | | |
| **7** | Seekoei River | **Gordonville CVB/UVB** | Wetland 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. | **Not assessed** |
| **8** | Vanderkloof Dam | **Philipstown unchanneled valley-bottom (UCVB) wetland complex** | Wetland complex approximately 190 ha and a depression wetland approximately 1 100 ha in size found at IUA 8. The upstream catchment areas of both wetland units are in a relatively natural condition with little to no human impact. | **C** |

| IUA | | Wetland name | Description | Ecological Category |
|---|---|---|---|---|
| **9** | Upper Modder River | **Aardoringspruit** | Large wetland complex that includes a large wetland flat and a DCVB wetland which encompasses the Aardoringspruit River. The confluence of the Aardoringspruit and Keeromspruit Rivers 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 Aardoringspruit wetland complex is found at IUA 9. | **C** |
| | | **Kaalspruit wetland complex** | Wetland complex comprising several depression wetlands, and a discontinuously channelled valley-bottom (DCVB) wetland located along the Kaalspruit River, 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. | **C** |
| **10** | Modder/ Riet River | **Soutpan Depression wetland complex** | Large complex of depression wetlands located at IUA 10 and consists 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. | **B** |
| | | **Jagersfontein DCVB wetland** | Large contiguous series of wetlands in IUA 10 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. | **C** |

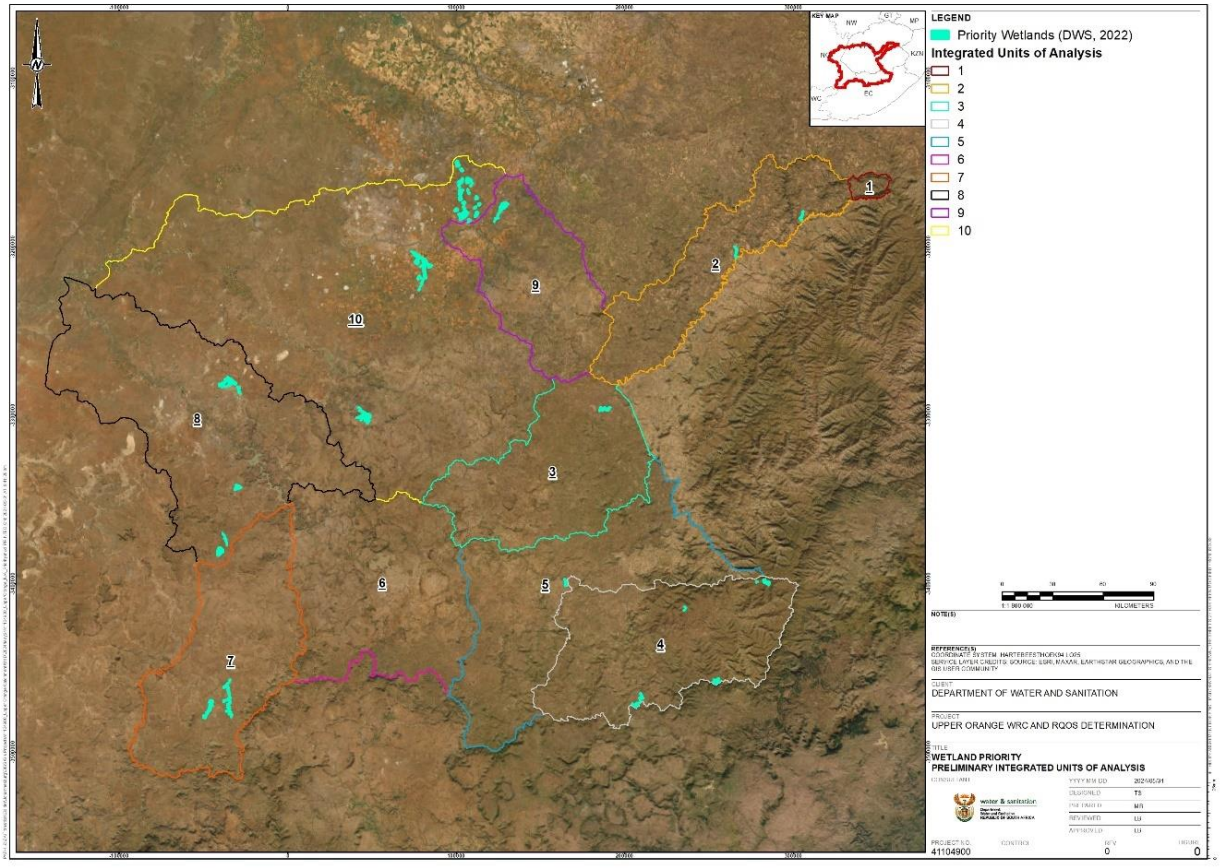



**Figure 16: Priority wetlands mapped in the Upper Orange River catchment**

# 9 PROPOSED SURFACE WATER RQO MONITORING SITES

The ideal sites for monitoring of surface water related RQOs is at the outlet of the resource unit that will allow cumulative impacts to be monitored. This will enable the catchment managers to ultimately use the RQOs to set amongst others, relevant source related water quality limits and land-use management practices, for upstream water users, to still enable the RQOs to be achieved.

There are many EWR sites or hydrological, biological or water quality nodes from the Reserve determination study that are proposed to be used, however in certain cases there are no EWR sites or nodes that can be used for a particular resource unit. In these cases, new sites are proposed.

However, it will only be once the sub-components and indicators are identified and agreed upon in the next steps (steps 4 and 5) of the RQO determination process that the sites can be finalised, and this will be done in collaboration with the catchment managers.

**Table 18: Proposed surface water RQO monitoring sites**

| Surface water Resource Unit | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| **IUA 1: Golden Gate** | | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | UO_EWR 01_R | -28.557796 | 28.405709 |
| **IUA 2: Caledon/ Leeu River** | | | | |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | UO_EWR02_R | -28.68034 | 28.139926 |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | Weir D2H037 (WQ site: D23 101817) site on the Caledon River | -29.610357 | 27.064005 |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | UO_EWR 03_R | -29.101205 | 27.570751 |
| **IUA 3: Caledon River** | | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | A site is proposed just upstream of Welbedacht Dam and downstream of | -29.807334 | 26.937420 |

| Surface water Resource Unit | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| | | the Rietspruit confluence | | |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | D2R004 (WQ site: D24 101820) near the Dam wall | -29.9089 | 26.86056 |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | UO_EWR 04_I is too far upstream so propose a new lower site near the outlet of the RU. | -30.517928 | 26.074946 |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | Will require a new lower site on the Caledon River at the outlet of the RU, downstream of the Witspruit confluence | -30.023631 | 26.855741 |
| **IUA 4: Kraai River** | | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit, Wolwespruit and Karringmelkspruit | Would require a new site on the Kraai River at RU outlet downstream of Karringmelkspruit confluence | -30.903509 | 27.129140 |
| **4.2** | Holspruit and tributaries Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachusspruit | UO_EWR 07_FV | -30.917621 | 27.800753 |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit | UO_EWR 08_I | -30.69007 | 26.74157 |
| **IUA 5: Upper Orange River** | | | | |

| Surface water Resource Unit | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | UO_EWR 02_I | -30.5178445 | 27.3690799 |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | D1R001 (WQ site: D12 101803) | -30.63667 | 27.36917 |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | UO_EWR03_I | -30.6528889 | 26.8230496 |
| **5.4** | Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | UO_EWR 05_R. is too high in the catchment, so propose a new site | -30.634325 | *26.487208 |
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | Weir D1H003 is too high in the RU so propose a new lower site | -30.516262 | *26.093637 |
| **IUA 6: Gariep Dam** | | | | |
| **6.1** | Gariep Dam | D3R002 near dam wall (WQ site: D34 101834) | -30.6231 | 25.50722 |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | D3H013 very high in catchment - propose site at the R717 bridge | -30.503265 | 25.200023 |
| **IUA 7: Seekoei River** | | | | |
| **7.1** | Seekoei River | UO_EWR05_I | -30.534359 | 24.962895 |
| **IUA 8: Vanderkloof Dam** | | | | |
| **8.1** | Vanderkloof Dam | D3H024 on right bank canal (WQ site: D33 101832) | -29.9869 | 24.72224 |
| **8.2** | Orange River below Vanderkloof Dam | Will require a new site near the RU outlet | -29.844826° | 24.529641° |
| **8.3** | Orange River mainstem | UO_EWR 10_I | -29.1620 | 23.695944 |

| Surface water Resource Unit | | Proposed site for surface water monitoring | Coordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| **IUA 9: Upper Modder River** | | | | |
| **9.1** | Rustfontein Dam on the Modder River | C5R003 (WQ site: 90840) | -29.2713 | 26.6161 |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Renosterspruit, Doringspruit, Rietspruit and Stinkhoutspruit | UO_EWR06_R | -28.807191 | 26.109695 |
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | C5R004 (WQ site: C52 90841) | -28.8833 | 25.95611 |
| **IUA 10: Modder/ Riet Rivers** | | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | UO_EWR_20_FV but may need a slightly lower site, propose C5H035 (WQ site: C52 90831) | -29.0286 | 24.63839 |
| **10.2** | Fouriespruit and tributaries including Fouriespruit Dam, Rietspruit and tributaries, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | UO_EWR 06_I | -29.535065 | 25.52457 |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit | UO_EWR22_FV | -29.653814 | 25.434994 |
| **10.4** | Riet River | Propose a site on the Riet River downstream of Kalkfontein Dam at C5RIET_JACOB REMP site | -29.099692° | 24.698801° |
| **10.5** | Main stem Riet River to Vaal River confluence | C5H014 (WQ site: C51 90817) | -29.0333 | 23.98333 |
| **10.7** | Kalkfontein Dam | C5R002 (WQ site: C51 90839 ) | -29.4959 | 25.2223 |

## 10 SUMMARY AND CONCLUSIONS

Considering the various components and considerations assessed for resource unit's delineation and prioritisation and based on the understanding and expert knowledge of the Upper Orange catchment area, the results of the resource unit's delineation and preliminary prioritisation process resulted in the following as summarised in Table 19.

- Forty (40) river resource units have been delineated, and 31 have been prioritised
- Groundwater priority RU areas have been identified with areas of high stress index and aquifers of strategic importance identified in IUA 4, IUA 5, IUA 9 and IUA 10.
- Sixteen wetlands/ wetland complexes have been prioritised in the catchment area, four of which are in the process of being mapped and assessed.
- Sampling sites for surface water monitoring have been proposed, however these will only be finalised once the surface water RQOs have been agreed upon.

The evaluation of the resource unit's prioritisation was circulated to catchment managers and specialists and subsequently was circulated for PSC review.

Resource quality objectives for the prioritised and selected rivers and groundwater resource units and wetlands/ wetland complexes will now be determined for the sub-components and indicators that are still to be selected in Steps 4 and 5 of the RQO determination process.

**Table 19: Summary of surface water, groundwater and wetlands prioritised for RQO determination**

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | |
|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands |
| **IUA 1: Golden Gate** | | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | X | | |
| **IUA 2: Caledon/ Leeu River** | | | | |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | X | | Brandwater floodplain |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | X | | |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | X | | Rantsho wetland complex |
| **IUA 3: Caledon River** | | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | X | | Sandspruit wetlands |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | |
|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | X | | |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | X | | |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | X | | |
| **IUA 4: Kraai River** | | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit and Wolwespruit | X | GRU 4.1 (QCs D13A-F and D13K) | Tiffendell seep; Klein Wildebeespruit wetland complex; Luckoff depression wetlands; Otto du Plessis Pass wetlands; Wolwespruit headwaters wetland complex |
| **4.2** | Holspruit and tributarie Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachusspruit | X | | |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit | X | | |
| **IUA 5: Upper Orange River** | | | | |
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | X | | |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | X | | |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | X | GRU 5.1 (QCs D12A and D15H) | Maletswai wetland complex |
| **5.4** | Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, | X | GRU 5.2 (QC D14A) | |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | |
|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands |
| | Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | | | |
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | X | GRU 5.2 (QC D14F) | |
| **IUA 6: Gariep Dam** | | | | |
| **6.1** | Gariep Dam | X | | |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | X | | |
| **IUA 7: Seekoei River** | | | | |
| **7.1** | Seekoei River | X | | Gordonville wetland complex |
| **IUA 8: Vanderkloof Dam** | | | | |
| **8.1** | Vanderkloof Dam | X | | |
| **8.2** | Orange River below Vanderkloof Dam | X | | |
| **8.3** | Orange River mainstem | X | | |
| **8.4** | Tributaries draining to the Orange River on RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit | | | Philipstown wetland complex; Barkley Pass wetland complex |
| **IUA 9: Upper Modder River** | | | | |
| **9.1** | Rustfontein Dam on the Modder River | X | | |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Renosterspruit, Doringspruit, Rietspruit and Stinkhoutspruit | X | GRU 9.2 (QC C52G) | Aardoringspruit wetlands |
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | X | | |
| **IUA 10: Modder/ Riet Rivers** | | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | X | GRU 9.2 (QC C52H) and GRU 10.2 (C52J and C52K) | Kaalspruit wetland complex; Soutpan Depression wetland complex |
| **10.2** | Fouriespruit and tributaries including Fouriespruit Dam, Rietspruit and tributaries, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | X | | |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit | X | | Jagersfontein DCVB wetland |

| Surface water Resource Unit | | Resource Units prioritised for RQOs | | |
|---|---|---|---|---|
| | | Surface Water | Groundwater | Wetlands |
| **10.4** | Riet River | X | | |
| **10.5** | Main stem Riet River to Vaal River confluence | X | | |
| **10.7** | Kalkfontein Dam | X | | |

## 11 REFERENCES

BirdLife South Africa 2016. Important Bird Areas 2016. [Vector geospatial dataset]. Available from https://www.birdlife.org.za/what-we-do/important-bird-and-biodiversity-areas/

Department of Water Affairs and Forestry (1999). Resource Directed Measures for Protection of Water Resources. Volume 3. River Ecosystems. Version 1.0, Pretoria

Department of Water Affairs and Forestry (2007). Development of the Water Resource Classification System (WRCS), Vol. 1-5. Chief Directorate: Resource Directed Measures, Pretoria, South Africa

Department of Water Affairs and Forestry. (2008). Updated manual for the Identification of Wetlands and Riparian Areas. Prepared by: Rountree, M. Batchelor, MacKenzie, J. & Hoare, D. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa

Department of Water Affairs (2010) National system for classifying water resources Gazetted on 17 September 2010, Gazette No. 33541, Regulation 810

Department of Water Affairs (2011) Procedures to develop and implement Resource Quality Objectives. Department of Water Affairs, Pretoria, South Africa

Department of Water Affairs (2013) National database of the PES/EIS of sub-quaternary (SQ) river reaches for D1, D2, D3 and C5.

DWA, 2015. Department of Water and Sanitation (DWS) (2015). Development of Reconciliation Strategies for Bulk Water Supply Systems: Orange River. Final Reconciliation Strategy. Report Number: P RSA D000/00/18312/11. Pretoria

Department of Water and Sanitation, South Africa (DWS), 2022a. A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange Catchment: Resource Units Report. No: RDM/WMA13/00/CON/COMP/0422

Department of Water and Sanitation (DWS) (2022b) A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange River Catchment: Wetland Report. No: RDM/WMA13/00/CON/COMP/0922

Department of Water and Sanitation (DWS) (2024) A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange River Catchment: Groundwater Report. No: RDM/WMA13/00/CON/COMP/1022

Department of Water and Sanitation (DWS) (2024a). Determination of Water Resource Classes and associated Resource Quality Objectives in the Upper Orange River Catchment: Status Quo and delineation of Integrated Units of Analysis and Resource Units Report. Draft - Version 01. Report No: RDM/WMA13/00/CON/CLA/0224

Endangered Wildlife Trust (2019) Crane sightings and nest sites 2019. [Vector geospatial dataset]

Government Gazette, Notice 19182. National Water Act, Act No. 36 of 1998. 26 August 1998

Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L., Nel, J.L., Maherry, A. and Witthüser, K. (2018) Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater. Report No. TT 743/1/18, Water Research Commission, Pretoria

Lötter, M.C. & Le Maitre, D. 2021. Fine-scale delineation of Strategic Water Source Areas for surface water in South Africa using Empirical Bayesian Kriging Regression Prediction: Technical report. Prepared for the South African National Biodiversity Institute (SANBI), Pretoria. 33 pages

Macfarlane DM., Ollis DJ and Kotze D. 2020. WET-Health (Version 2): A refined suite of tools for assessing the present ecological state of wetland ecosystems. WRC Report No. TT 820/20, Water Research Commission, Pretoria

Nel, J., Driver, AL., Strydom, W., Maherry, A., Petersen, C., Hill, L., Roux, D., Nienaber, S., Van Deventer, H., Swartz, E., and Smith-Adao, L. (2011) ATLAS of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. WRC Report No. K5/1801.

Nel J.L., Driver, A. and Swartz, E.R. (2012) South African National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A, Council for Scientific and Industrial Research: Stellenbosch, South Africa

Ollis, D., Snaddon, K., Job, N., & Mbona, N. (2013). Classification System for Wetlands and Other Aquatic Ecosystems in South Africa: User Manual: Inland Systems. South African National Biodiversity Institute

Rountree, M.W., H. Malan and B. Weston (2013) Manual for the Rapid Ecological Reserve Determination for Inland Wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission Study. Report No 1788/1/13. Water Research Commission, Pretoria

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847

Van Deventer, H., Van Niekerk, L., Adams, J., Dinala, MK., Ridhwannah, G., Lamberth, S., Lotter, M., Mbona, N., MacKay, F., Nel, J., Ramjukadh, C-L., Skowno, A., and Weerts, S. 2019. National Wetland Map 5 – An improved spatial extent and representation of inland aquatic and estuarine ecosystems in South Africa. 10.1101/640441

# APPENDIX A:

# Resource Units Prioritisation Scoring and Sub-Criteria Maps

| | IUA and Resource Units | Position In IUA | Importance for Users (Current and anticipated future use) | | | | | Threat Posed to Users | Ecological Importance | | | | Threat Faced by Ecological Component | Management Considerations | Practical Considerations | | | Priority Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cultural Services to Society | Supporting Livelihoods | Strategic Requirements | Supporting and Regulating Services | Contributing to the Economy | Threat Posed to Users | High or Very High EIS | EC Or PES of A/B | National Freshwater Ecosystem Priority Areas | Priority Biodiversity Plans | Threat posed to Ecological Components | PES Lower than a D Category or lower than gazetted category | Availability of data | Accessibility For Monitoring | Safety Risk | |
| **IUA 1: Golden Gate** | | | | | | | | | | | | | | | | | | |
| **1.1** | Little Caledon River with Caledon River in the D21A portion in SA | 0 | 1 | 1 | 0 | 0.5 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0.5 | 1 | 1 | 1.0 |
| **IUA 2: Caledon/ Leeu River** | | | | | | | | | | | | | | | | | | |
| **2.1** | Little Caledon River and Caledon River along the Lesotho Border including tributaries Moolmanspruit and Meulspruit, and the Meulspruit Dam | 0 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 0.5 | 1 | 1 | 0.3 |
| **2.2** | Swartspruit and Brandwater River, tributaries of the Caledon River | 1 | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 1 | 1 | 0 | 0 | 0.5 | 1 | 1 | 0.7 |
| **2.3** | Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledorespruit and Bokpoortspruit, including Cathcartdrift Dam | 1 | 1 | 1 | 0.5 | 0.5 | 1 | 0.5 | 0.5 | 0 | 1 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 1.0 |
| **2.4** | Leeu River and tributaries Klein-Leeu River and Mokopu River, and including Lovedale and Newberry dams | 0 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 1 | 0 | 1 | 0.5 | 1 | 1 | 0.6 |
| **2.5** | Armenia Dam on the Leeu River | 0 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 1 | 0.5 | 0 | 0.5 | 1 | 1 | 0.5 |
| **2.6** | Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.7 |
| **IUA 3: Caledon River** | | | | | | | | | | | | | | | | | | |
| **3.1** | Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 | 1.0 |
| **3.2** | Welbedacht Dam in the Caledon Nature Reserve | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 1 | 1 | 0.5 | 1 | 1 | 0.9 |
| **3.3** | Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 0.8 |
| **3.4** | Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit | 1 | 0.5 | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 0.8 |
| **3.5** | Egmont Dam | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 1 | 0.5 | 1 | 0 | 1 | 1 | 0.4 |
| **IUA 4: Kraai River** | | | | | | | | | | | | | | | | | | |
| **4.1** | Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeesspruit, Diepspruit, Three Drifts, Joggemspruit, Vlooikraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit and Wolwespruit | 0 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0 | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.8 |
| **4.2** | Holspruit and tributarie Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachusspruit | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.7 |
| **4.3** | Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| **IUA 5: Upper Orange River** | | | | | | | | | | | | | | | | | | |
| **5.1** | Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit | 0 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 0.8 |

| IUA and Resource Units | | Position In IUA | Importance for Users (Current and anticipated future use) | | | | | Threat Posed to Users | Ecological Importance | | | | Threat Faced by Ecological Component | Management Considerations | Practical Considerations | | | Priority Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cultural Services to Society | Supporting Livelihoods | Strategic Requirements | Supporting and Regulating Services | Contributing to the Economy | Threat Posed to Users | High or Very High EIS | EC Or PES of AIB | National Freshwater Ecosystem Priority Areas | Priority Biodiversity Plans | Threat posed to Ecological Components | PES Lower than a D Category or lower than gazetted category | Availability of data | Accessibility For Monitoring | Safety Risk | |
| **5.2** | Jozana's Hoek Dam on the Sterkspruit | 0 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 1 | 0.5 | 1 | 0 | 1 | 1 | 0.7 |
| **5.3** | Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarpspruit, Kop-en-pootjiespruit and Wilgerspruit | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0.5 | 0 | 0.5 | 1 | 1 | 0.5 | 0 | 0.5 | 1 | 1 | 0.9 |
| **5.4** | Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandslaagte and Wikopspruit | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 0.5 | 1 | 0 | 1 | 1 | 0.7 |
| **5.5** | Orange River and tributaries Gladdegrond, Melkspruit, Sanddrifspruit, Modderbuirspruit and Palmietspruit | 1 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 1 | 0 | 0 | 1 | 1 | 0.5 | 0 | 0.5 | 1 | 1 | 1.0 |
| **IUA 6: Gariep Dam** | | | | | | | | | | | | | | | | | | |
| **6.1** | Gariep Dam | 1 | 0.5 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0.5 | 1 | 1 | 0.5 | 1 | 1 | 0.9 |
| **6.2** | Orange River and tributaries Rooirantjies, Oudagspruit, Winnaarbakespruit, Brandspruit, Broekspruit, Bossiespruit, Swarthoekspruit and Brakspruit | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 1 | 0.5 | 1 | 0 | 0.5 | 1 | 0.6 |
| **6.3** | Main stem Orange River between Gariep and Vanderkloof dams | 1 | 0.5 | 1 | 1 | 1 | 0.5 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| **6.4** | Orange River and tributaries Suurbergspruit, Donkerpoortspruit, Oorlogspruit, Klipfonteinspruit, Rietkuilspruit and Vanderwaltfonteinspruit | 0 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0.5 | 1 | 0.6 |
| **IUA 7: Seekoei River** | | | | | | | | | | | | | | | | | | |
| **7.1** | Seekoei River | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 0 | 1 | 0.5 | 1 | 1 | 1.0 |
| **IUA 8: Vanderkloof Dam** | | | | | | | | | | | | | | | | | | |
| **8.1** | Vanderkloof Dam | 1 | 0.5 | 1 | 1 | 1 | 1 | 0.5 | 0 | 0 | 1 | 1 | 0.5 | 0 | 0 | 1 | 1 | 0.8 |
| **8.2** | Orange River below Vanderkloof Dam | 1 | 0.5 | 1 | 1 | 1 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1.0 |
| **8.3** | Orange River mainstem | 1 | 0.5 | 1 | 1 | 1 | 0.5 | 0.5 | 0 | 0 | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 | 1.0 |
| **8.4** | Tributaries draining to the Orange River on RU8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit | 0 | 0.5 | 0.5 | 0 | 0 | 0.5 | 0 | 0 | 0 | 1 | 1 | 0.5 | 1 | 0 | 1 | 1 | 0.4 |
| **IUA 9: Upper Modder River** | | | | | | | | | | | | | | | | | | |
| **9.1** | Rustfontein Dam on the Modder River | 1 | 0.5 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0 | 1 | 0.5 | 0.5 | 1 | 0.5 | 1 | 1 | 0.9 |
| **9.2** | Kgabanyane Dam (Groothoek Dam) on the Kgabanyane River | 0 | 0.5 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0 | 1 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 0.6 |
| **9.3** | Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Renostersprui, Doringspruit, Rietspruit and Stinkhoutspruit | 1 | 1 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| **9.4** | Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G | 1 | 0.5 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |

| IUA and Resource Units | | Position In IUA | Importance for Users (Current and anticipated future use) | | | | | Threat Posed to Users | Ecological Importance | | | | Threat Faced by Ecological Component | Management Considerations | Practical Considerations | | | Priority Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cultural Services to Society | Supporting Livelihoods | Strategic Requirements | Supporting and Regulating Services | Contributing to the Economy | Threat Posed to Users | High or Very High EIS | EC Or PES of AIB | National Freshwater Ecosystem Priority Areas | Priority Biodiversity Plans | Threat posed to Ecological Components | PES Lower than a D Category or lower than gazetted category | Availability of data | Accessibility For Monitoring | Safety Risk | |
| **IUA 10: Modder/ Riet Rivers** | | | | | | | | | | | | | | | | | | |
| **10.1** | Modder River and tributaries Klein Kaalspruit and Kaalspruit | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0 | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.9 |
| **10.2** | Fouriespruit and tributaries including Fouriespruit Dam, Rietspruit and tributaries, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 1 | 1 | 0.5 | 1 | 0.5 | 1 | 1 | 0.8 |
| **10.3** | Kromellenboogspruit and tributaries Vanzylspruit and Prosesspruit | 0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0.5 | 0 | 1 | 0.5 | 1 | 1 | 0.5 | 1 | 1 | 0.7 |
| **10.4** | Riet River | 1 | 0.5 | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0 | 0 | 1 | 1 | 1 | 0.5 | 1 | 1 | 0.9 |
| **10.5** | Main stem Riet River to Vaal River confluence | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| **10.6** | Tierpoort Dam | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 1 | 0 | 1 | 1 | 0.6 |
| **10.7** | Kalkfontein Dam | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 0 | 0.5 | 0.5 | 1 | 0 | 1 | 1 | 0.7 |

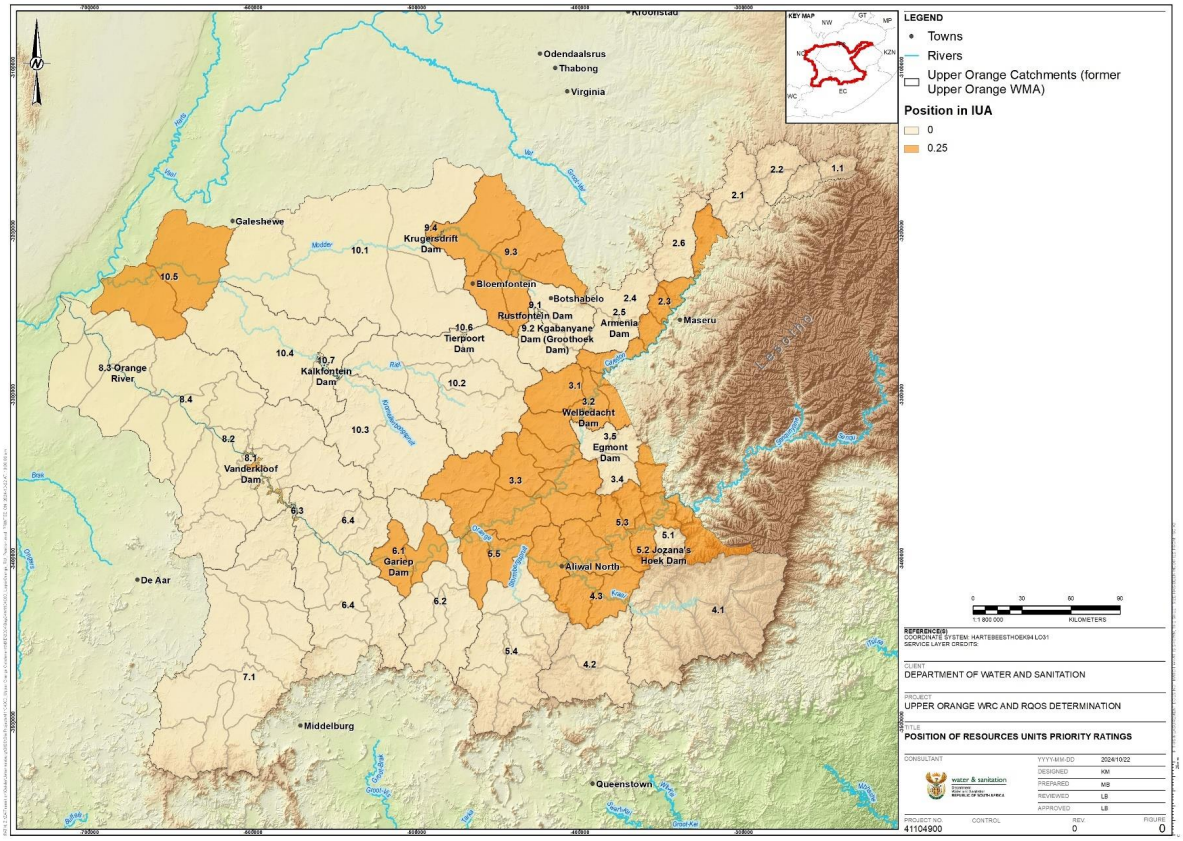



**Figure A.1: Scoring of Position of RU**

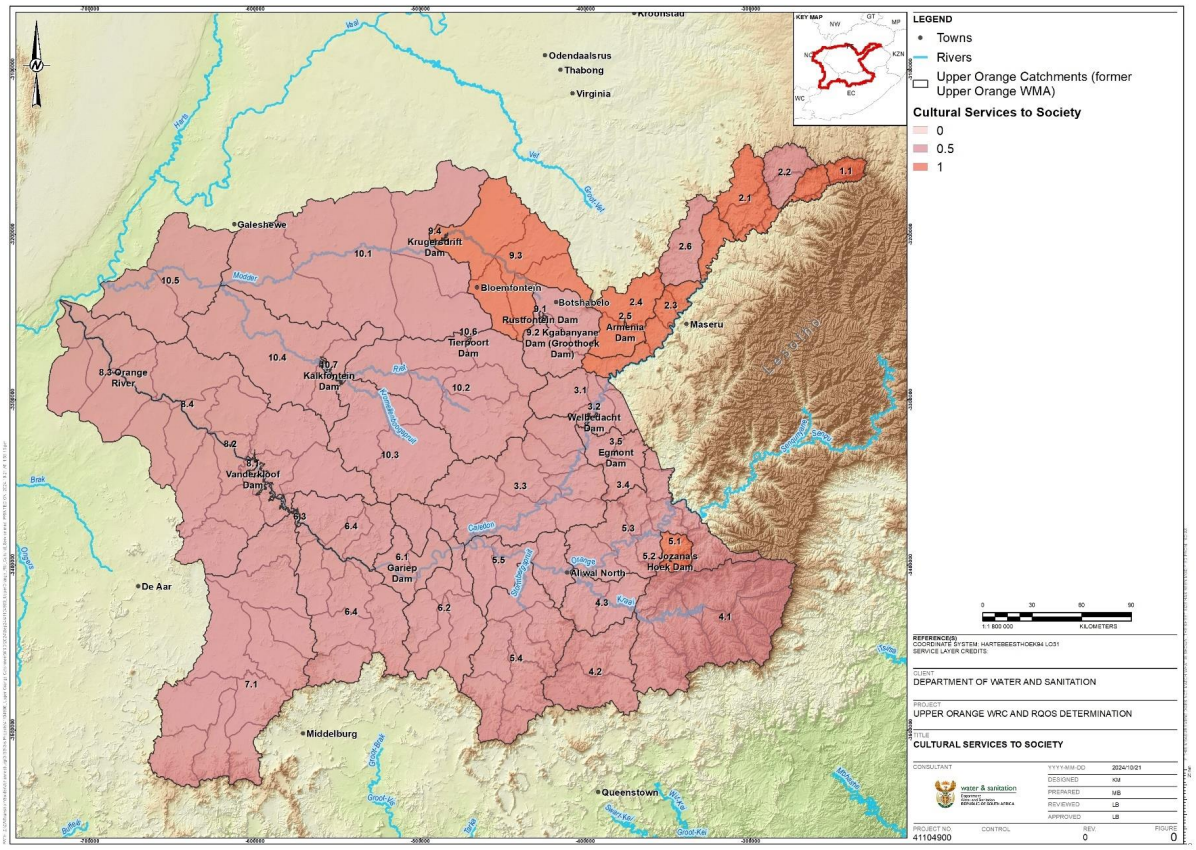



**Figure A-2: Scoring of Cultural services to society**

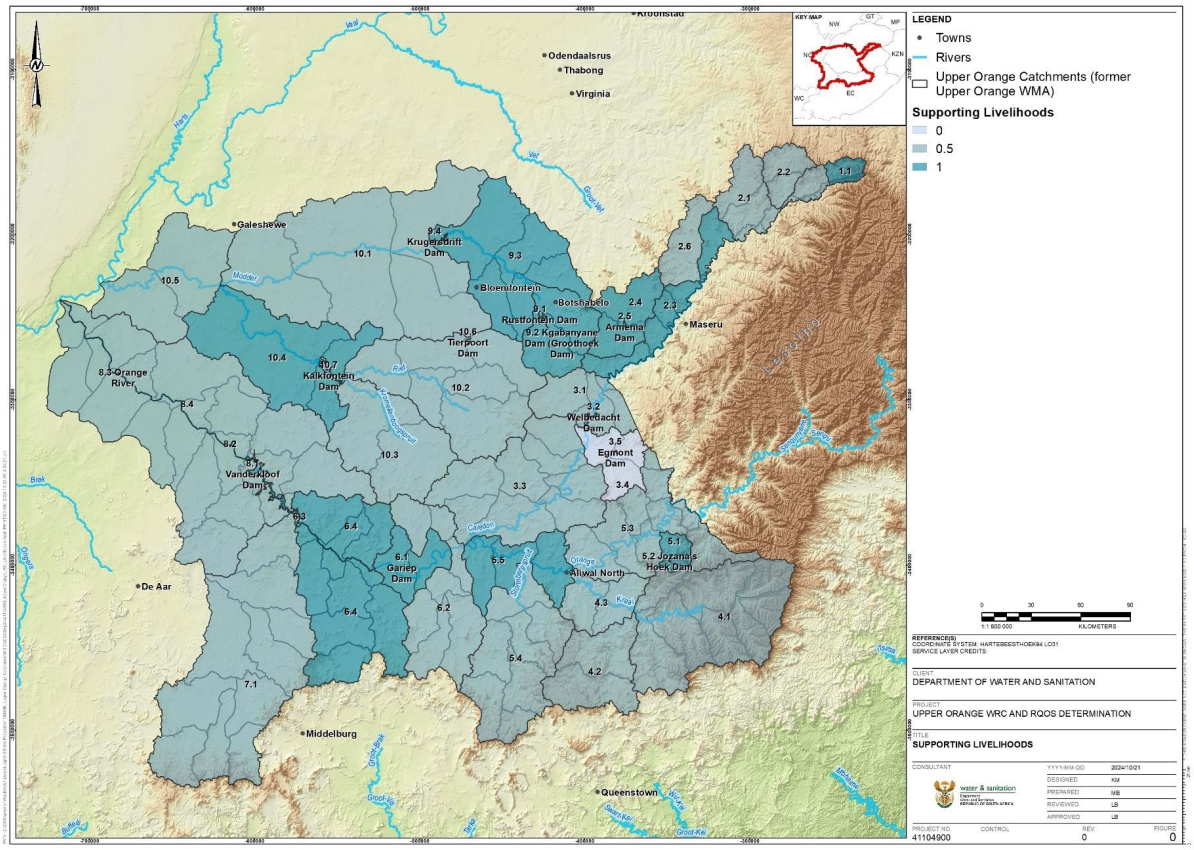



**Figure A.3: Scoring of Supporting livelihoods**

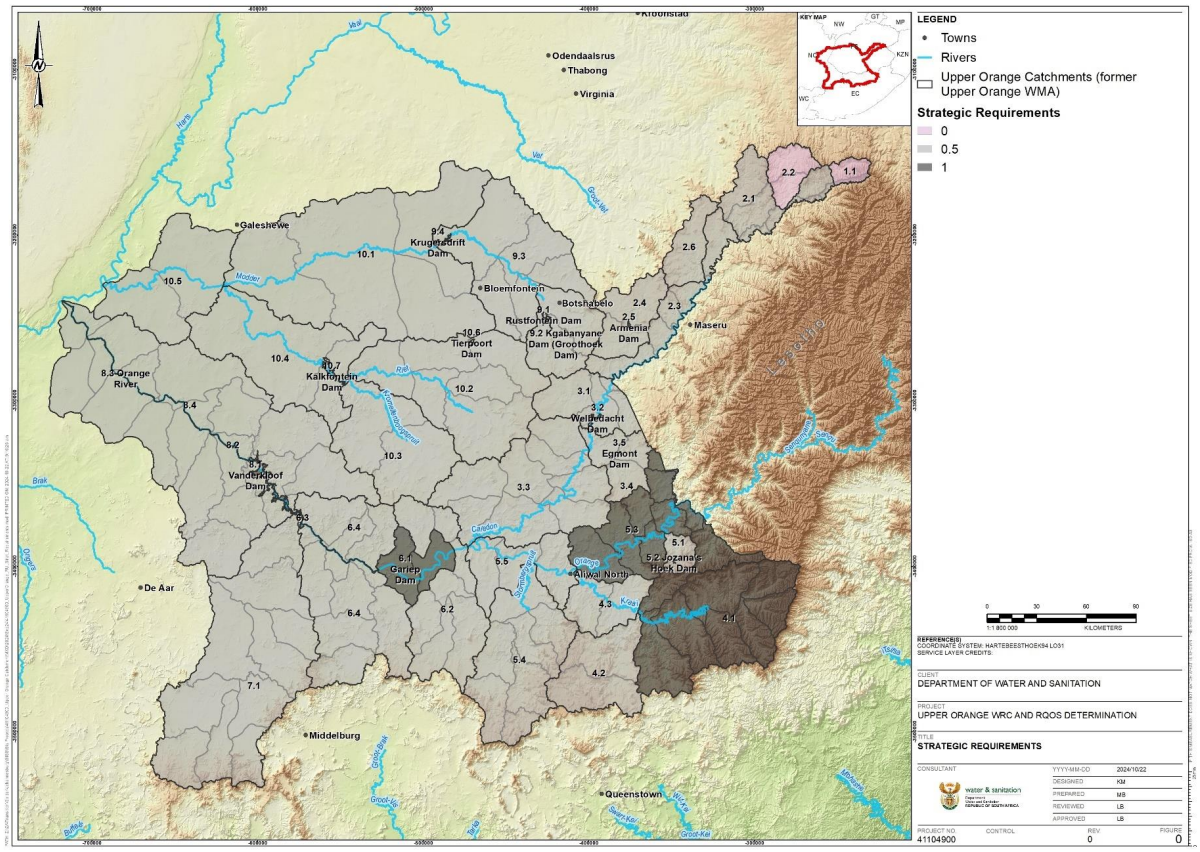



**Figure A.4: Scoring of Strategic requirements**

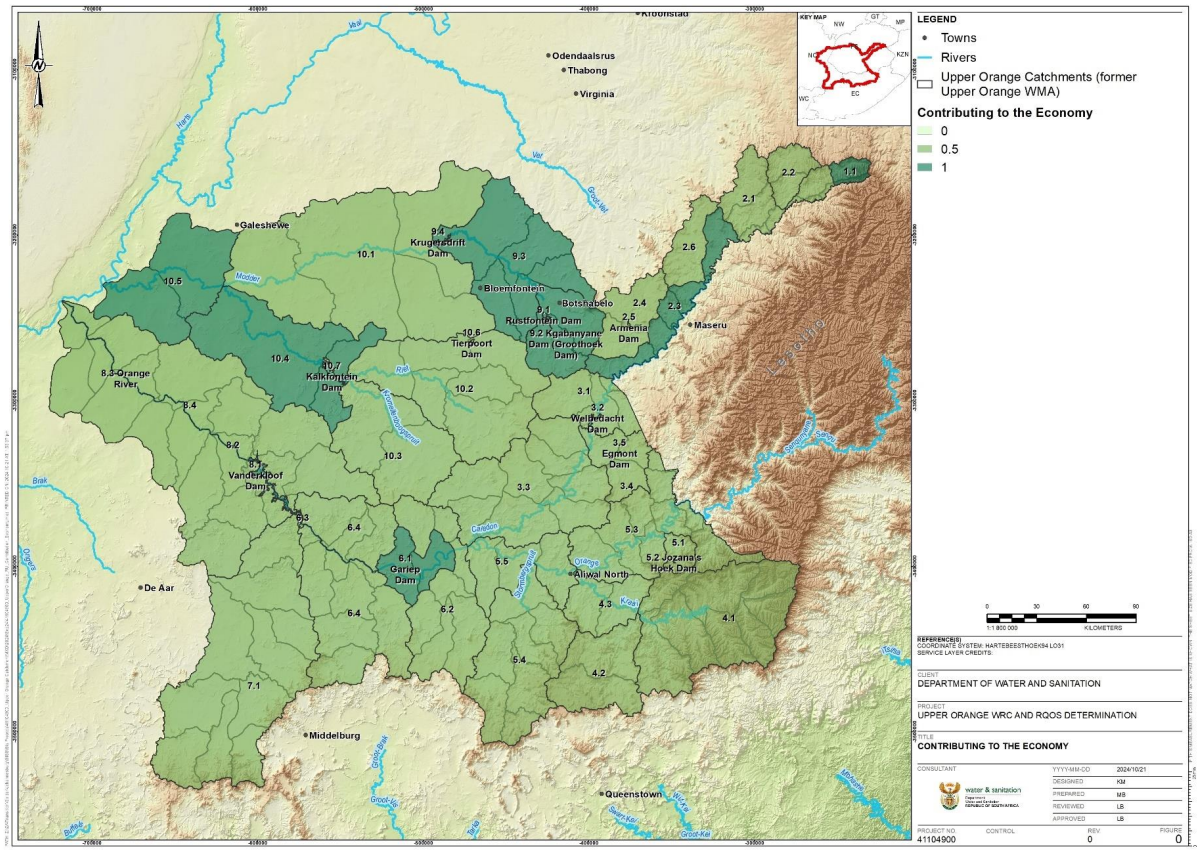



**Figure A.5: Scoring of Contribution to the Economy**

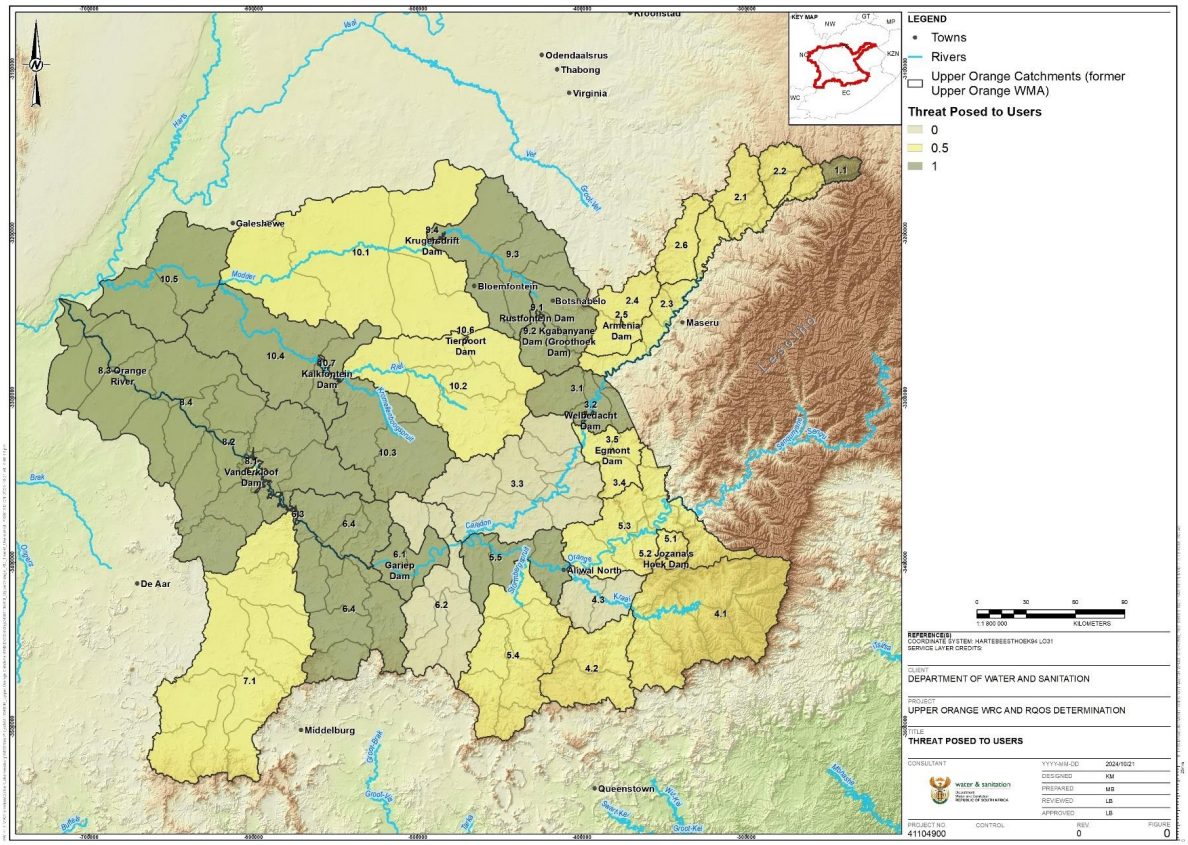



**Figure A.6: Scoring of Threat posed to users**

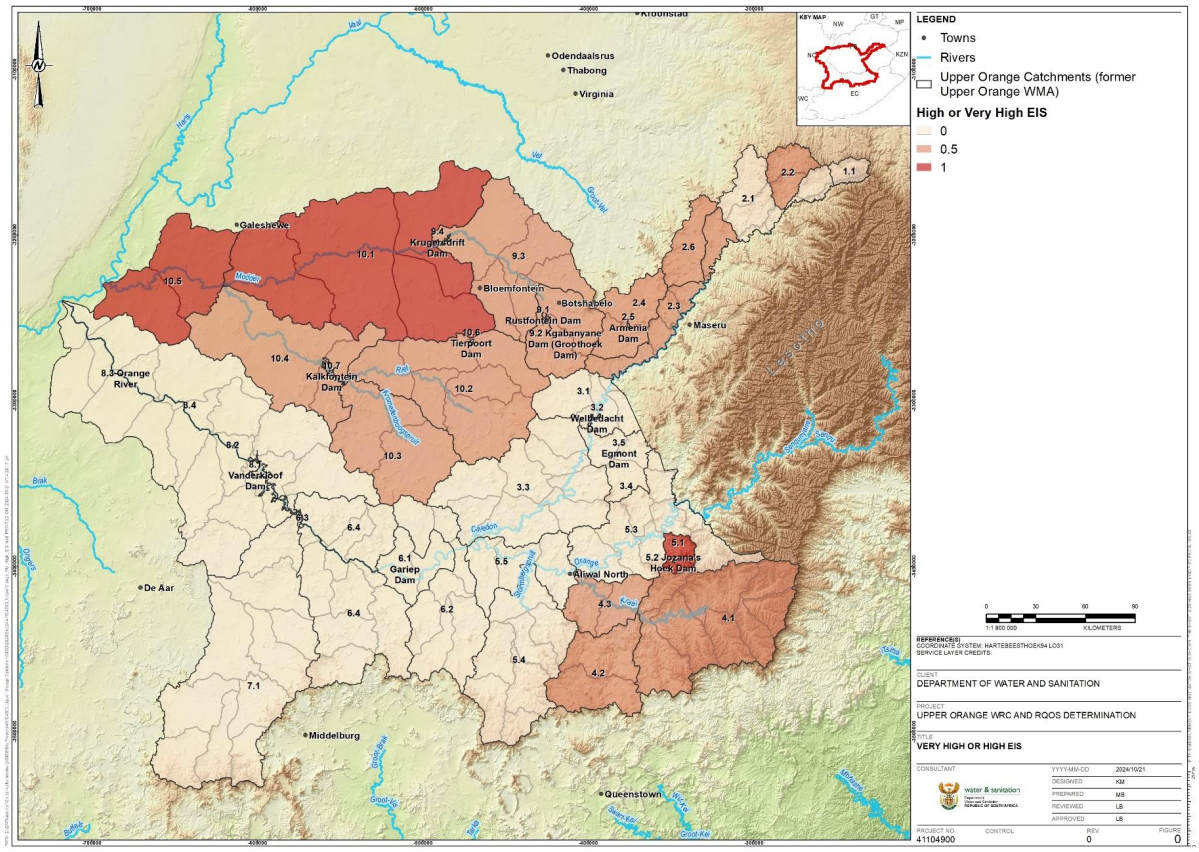



**Figure A.7: Scoring of High Ecological Importance and Sensitivity**

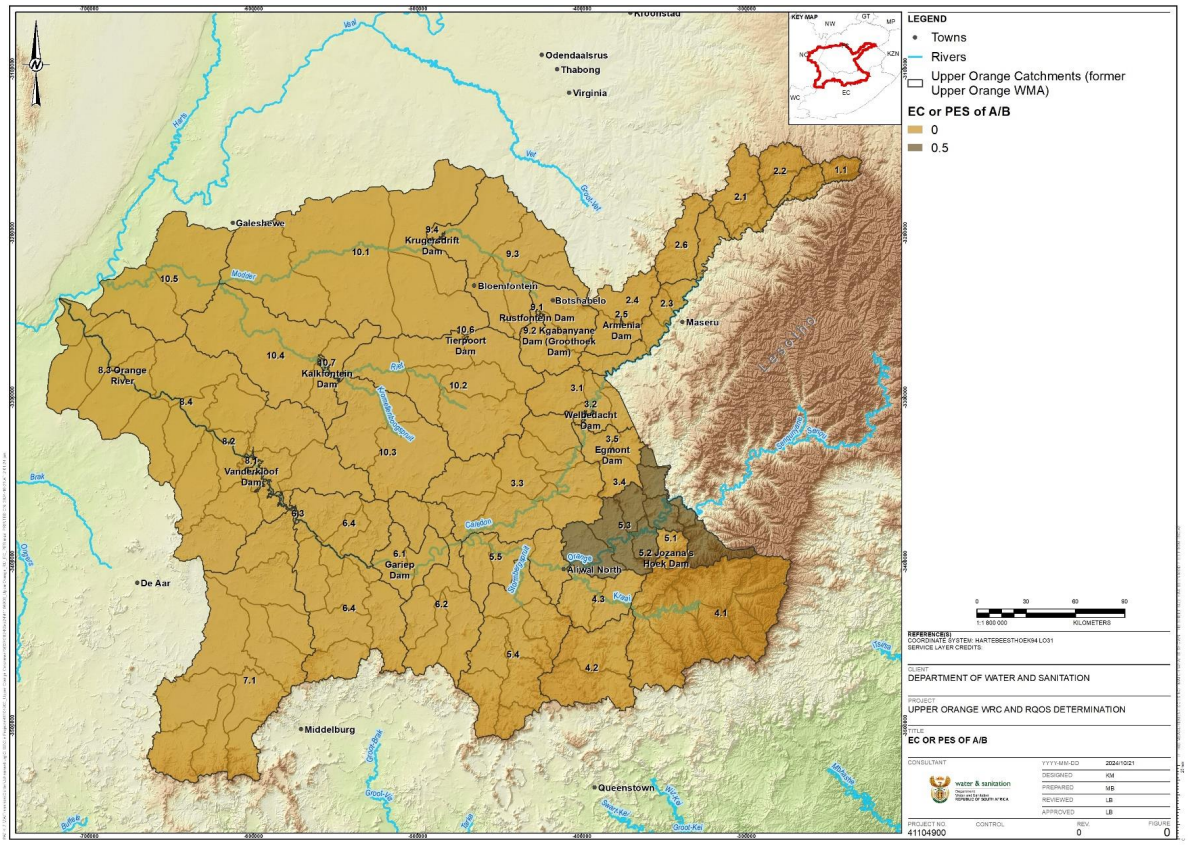



**Figure A.8: Scoring of Ecological Category or PES of A/B**

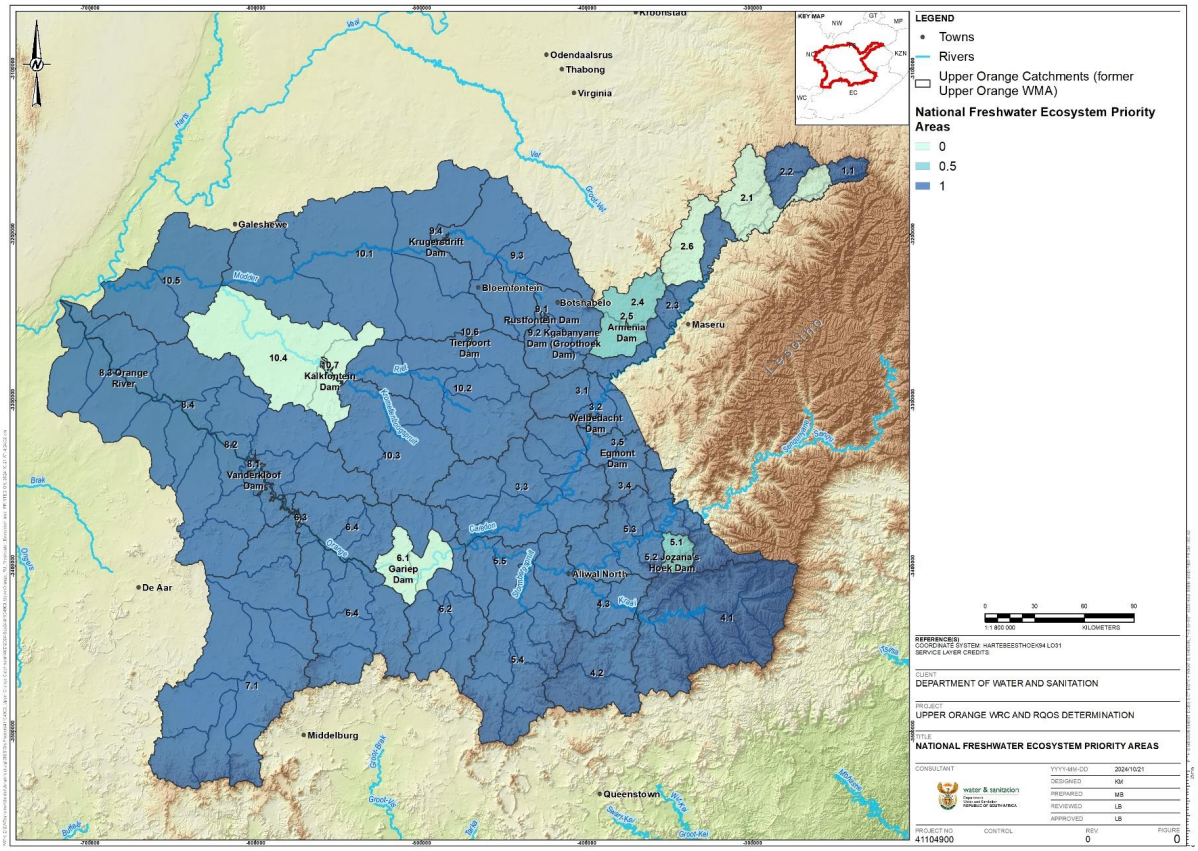



**Figure A.9: Freshwater Ecosystem Priority Areas**

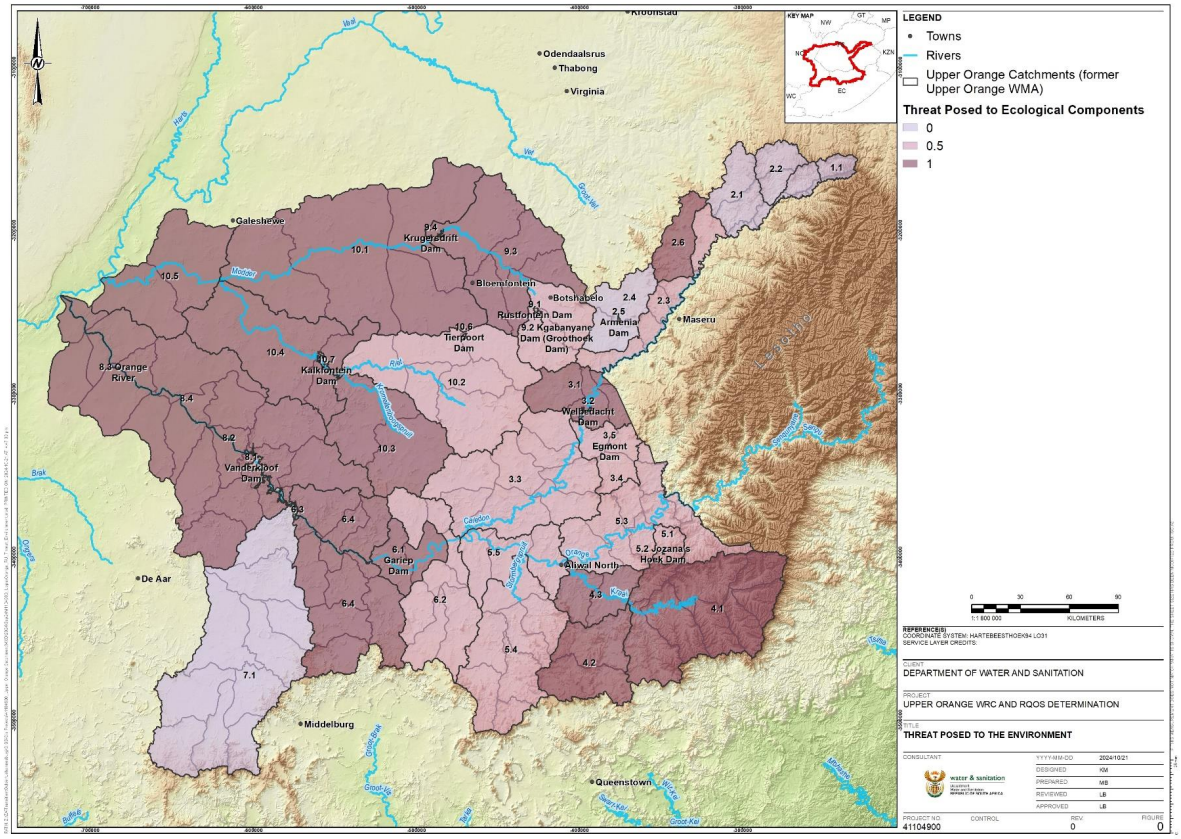



**Figure A.10: Threat Posed to Ecological components**

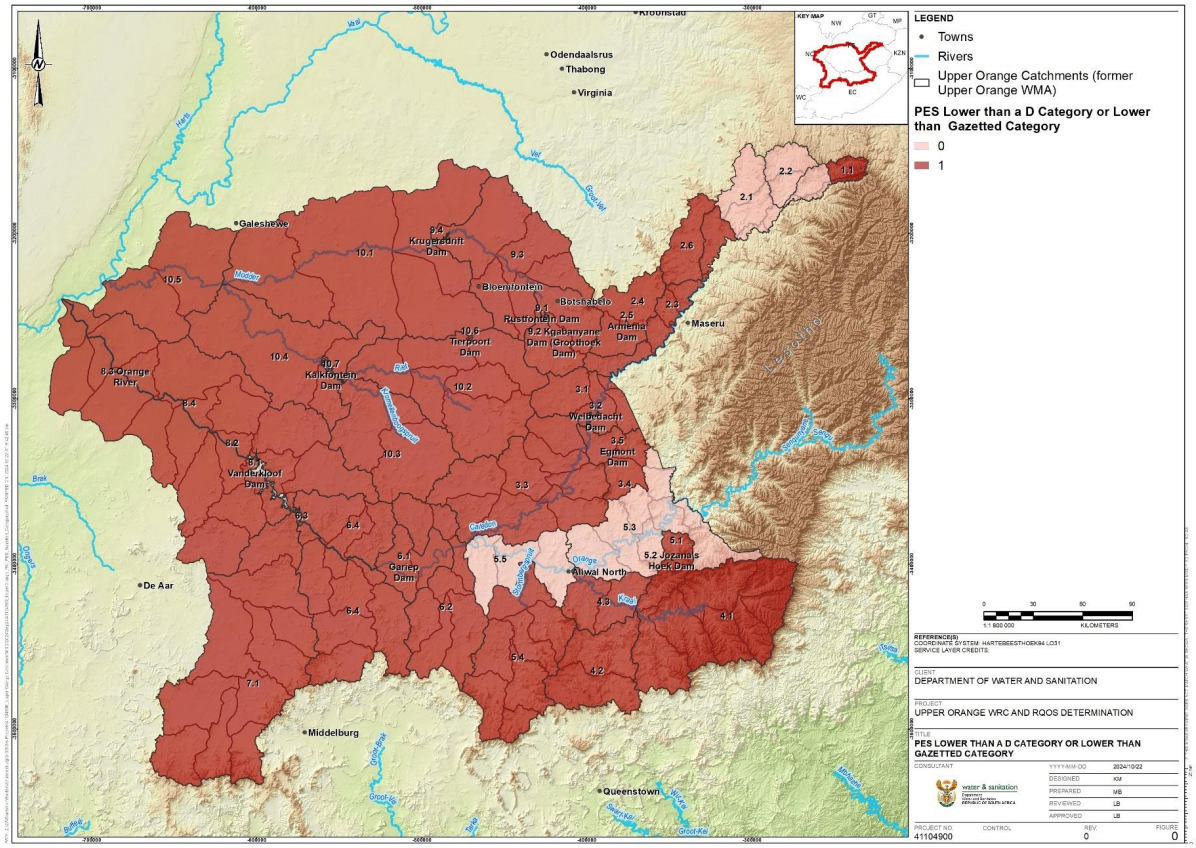



**Figure A.11: PES lower than D or lower than gazetted category**

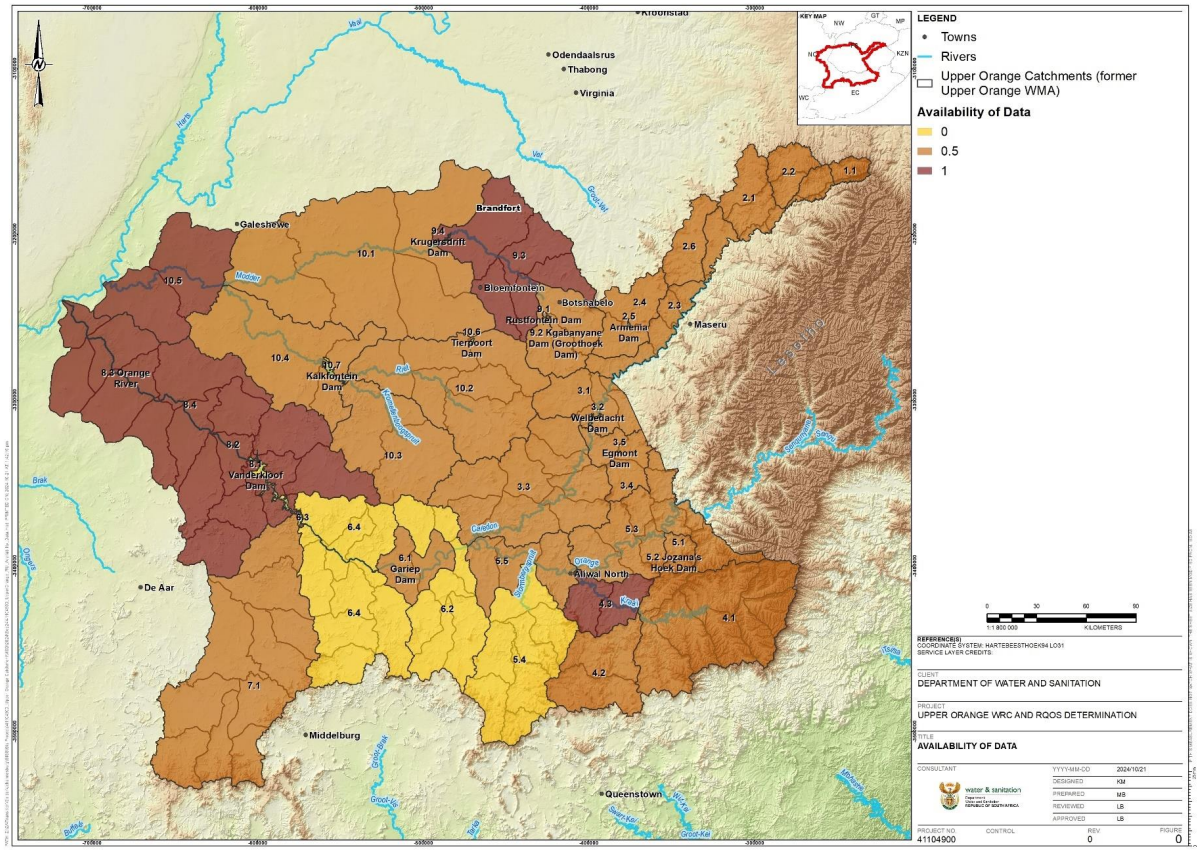



**Figure A.12: Availability of Data**

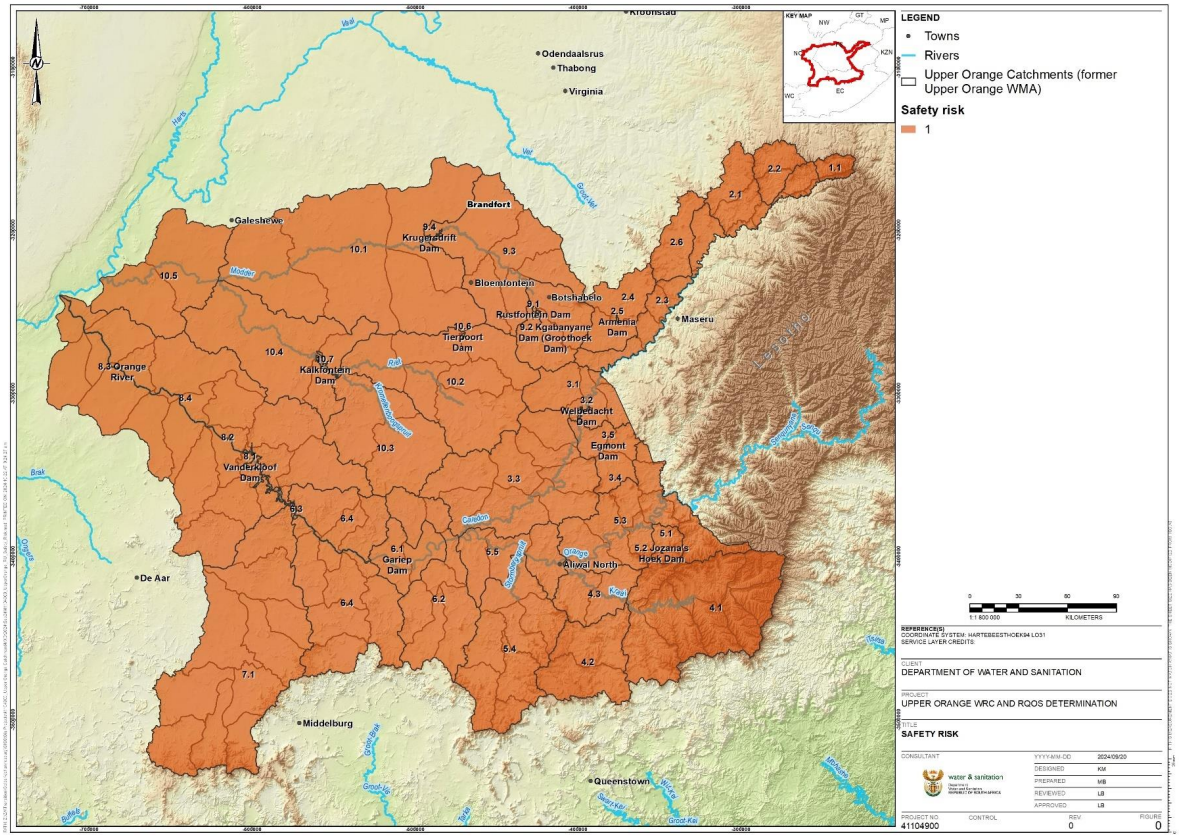



**Figure A.13: Safety Risk**

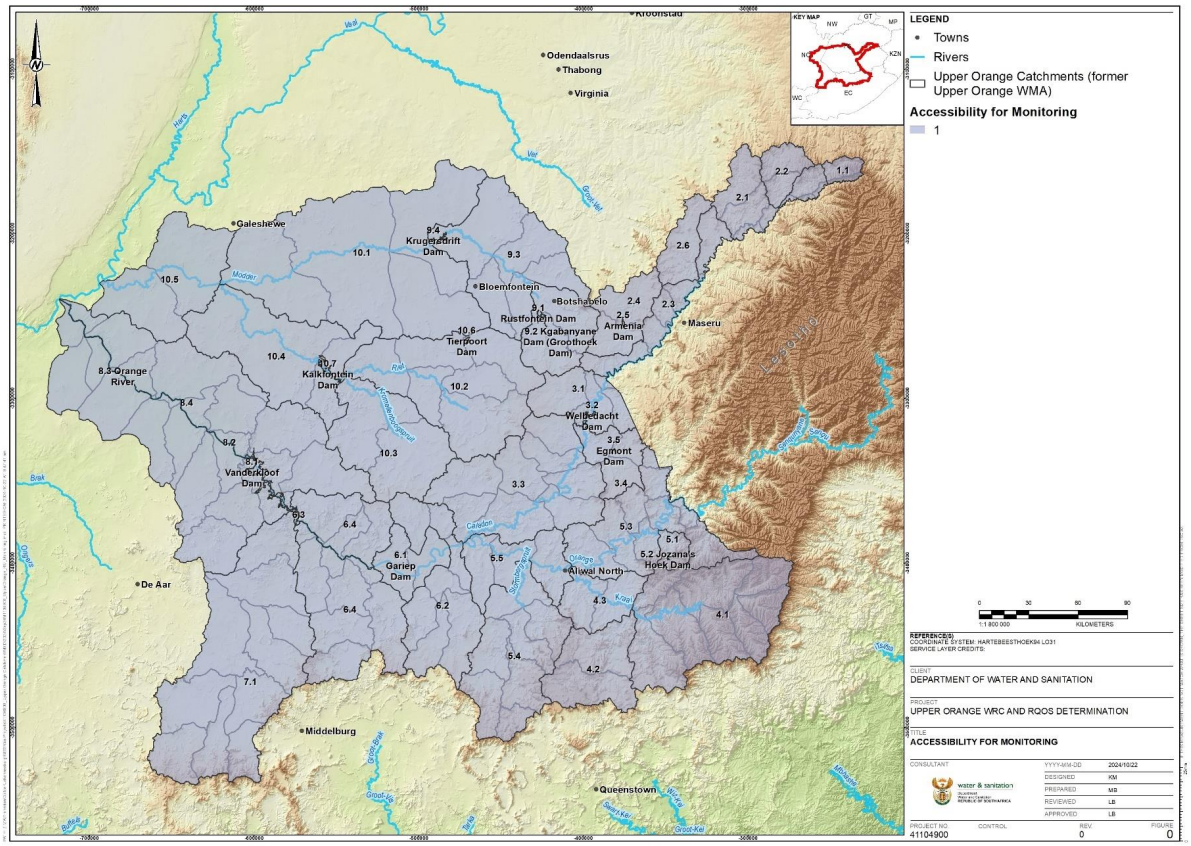



**Figure A.14: Accessibility for Monitoring**

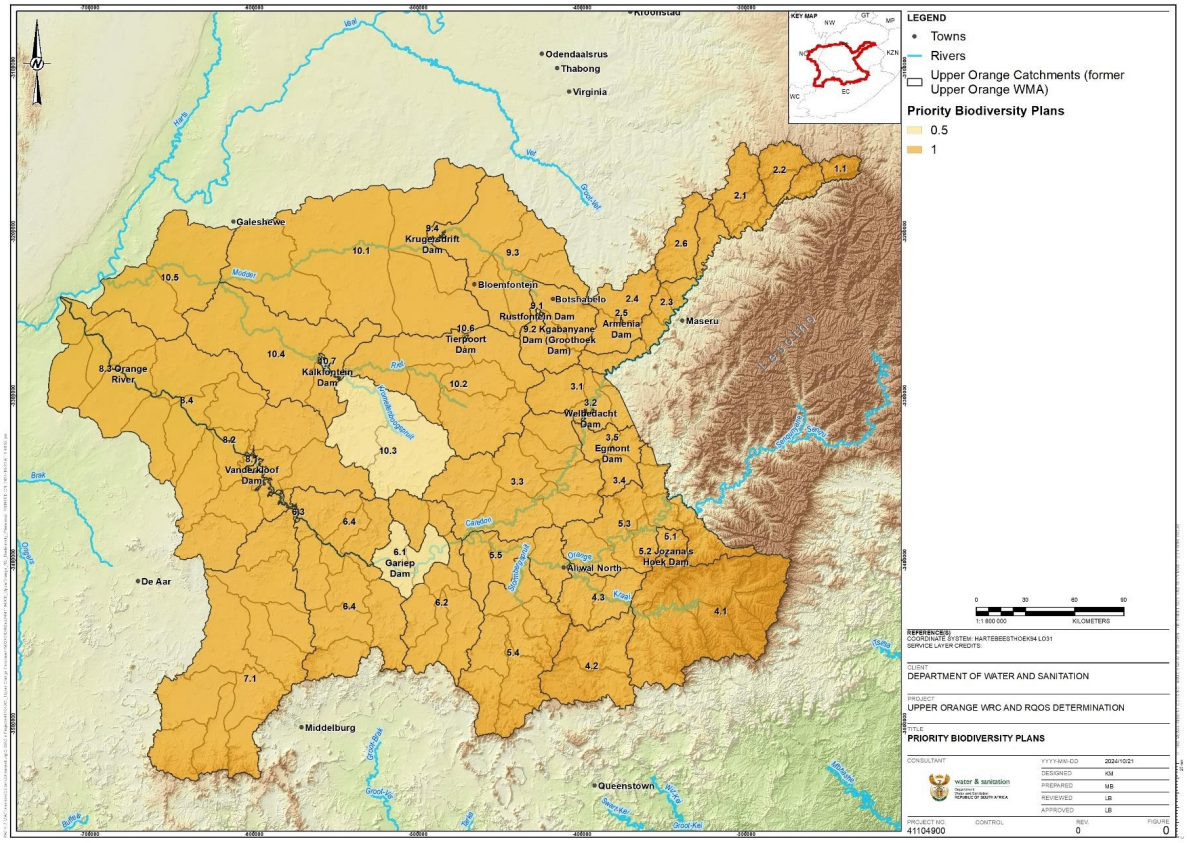



**Figure A.15: Priority Conservation Plans**

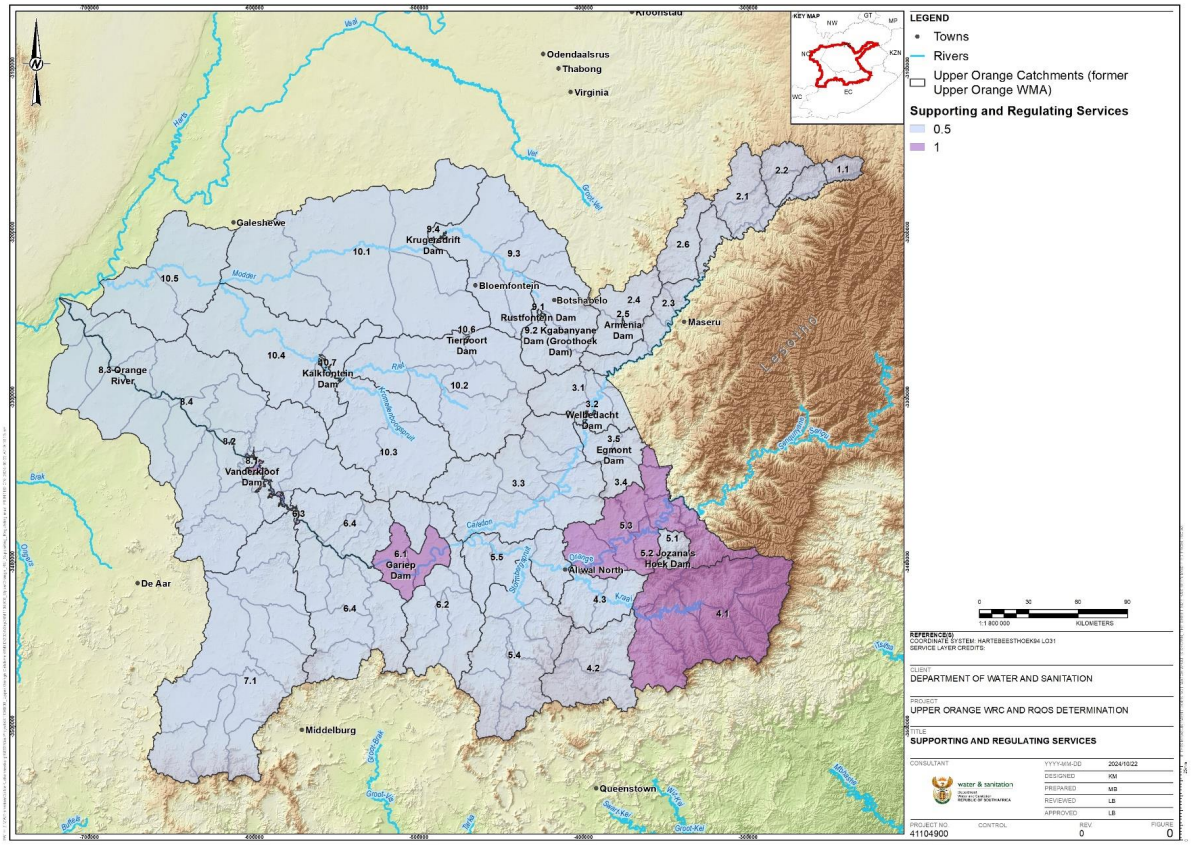



**Figure A.16: Supporting and Regulating Services**