

**DEPARTMENT OF WATER AND SANITATION**

**Chief Directorate: Water Ecosystems Management**

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

**INCEPTION REPORT  
WP 11438**

**Study Report No.  
RDM/WMA13/00/CON/CLA/0123**

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**Bold** type indicates this report.

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## TERMINOLOGY AND ABBREVIATIONS

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<b>Acronym</b>	<b>Description</b>
BAS	Best Attainable State
BID	Background Information Document
BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
CRA	Comparative Risk Assessment
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EcoSpecs	Ecological Specifications
EFZ	Estuarine Functional Zone
EGSAs	Ecosystem Goods, Services and Attributes
ERC	Ecological Recommended Category
ESFs	Ecosystem Service Frameworks
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FECS-CS	Final Ecosystem Goods and Services Classification System
FRAI	Fish Response Assessment Index
GDP	Gross Domestic Product
GGP	Gross Geographic Product
GIS	Geographic Information System
GRA	Groundwater Resources Assessment
HGM	Hydrogeomorphic
IFR	Instream Flow Requirements
IHI	Index of Habitat Integrity

<b>Acronym</b>	<b>Description</b>
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
JBS	Joint Baseline Survey
Kd	Karoo Dolerite (intrusive rock formation enhancing groundwater yield potential)
MEA	Millennium Ecosystem Assessment
MIRAI	Macroinvertebrate Response Assessment Index
MPA	Marine Protected Area
NFEPA	National Freshwater Ecosystem Priority Areas
NGO	Non-Governmental Organisation
NWA	National Water Act
ORASECOM	Orange-Senqu River Commission
PES	Present Ecological State
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RDM	Resource Directed Measures
RUs	Resource Units
SANBI	South African National Biodiversity Institute
SEA	Socio-Economic Assessment
SeCT	Socio-Economic Classification Tool
SWS	Social Wellbeing Score
TEC	Target Ecological Category
TEEB	The Economics of Ecosystems and Biodiversity

<b>Acronym</b>	<b>Description</b>
TOR	Terms of Reference
WARMS	Water Use Authorisation and Registration System
WMA	Water Management Area
WRC	Water Resource Classification
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model

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## 1 INTRODUCTION

The Chief Directorate: Water Ecosystems Management (WEM) of the Department of Water and sanitation (DWS) has initiated a study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Lower Orange River Catchment.

Water Resource Classification, the Reserve and Resource Quality Objectives (RQOs) are protection-based measures that make up Resource Directed Measures (RDM), the protection principles contained in Chapter 3 of the National Water Act (Act No. 36 of 1998). The classification system including the Reserve is intended to ensure comprehensive protection of all water resources.

An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical and affordable. Once the water resources class and the Reserve have been established, RQOs are established to give effect to determined water resources classes and the Reserve.

The definition of a water resource, as in the NWA, includes a watercourse, surface water, estuary, or aquifer. A watercourse is defined as a river or spring, a natural channel in which water flows regularly or intermittently, a wetland, lake or dam into which, or from which, water flows; and any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

### 1.1. Water Resource Classification

Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other. The goal of the classification process is the implementation of the water resource classification system which has as its final product the selection of one of three water resource classes (Table 1). The purpose of the water resource class is to establish clear goals relating to the quantity and quality of the relevant water resource, and conversely, the degree to which it can be utilised by considering the economic, social, and ecological goals from an integrated water resource management perspective. The catchment needs to be managed to these goals.

Water resource classification places the following principles at the forefront of implementation:

- Maximising economic returns from the use of water resources,
- Allocating and distributing the costs and benefits of utilising the water resource fairly, and
- Promoting the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

**Table 1: Water Resource Classes**

<b>Class</b>	<b>Description of use</b>	<b>Ecological Category</b>	<b>Description of resource</b>
I	Minimally used	A-B	Water resource is one which is minimally used, and the overall condition of that water resource is minimally altered from its pre-development condition
II	Moderately used	C	Water resource is one which is moderately used, and the overall condition of that water resource is moderately altered from its pre-development condition
III	Heavily used	D	Water resource is one which is heavily used, and the overall condition of that water resource is significantly altered from its pre-development condition

## 1.2. Resource Quality Objectives

The purpose of the resource quality objectives (RQOs) is to establish clear goals relating to the quality of the relevant water resources. In determining resource quality objectives, a balance must be sought between the need to protect and sustain water resources on the one hand, and the need to develop and use them on the other.

Resource quality objectives provide statements about:

- what the quantity of water should be (water level, pattern, timing),
- what the water quality should be (physical, chemical, biological),
- what the condition of the instream and riparian (riverbank) habitat should be, and
- what the condition of the aquatic (water) animal and plant life should be.

## 1.3. Study Objective

It is understood that the main objective of the study is to coordinate the implementation of the water resources classification system (WRCS), as required by Regulation 810 in Government Gazette 33541 and using the relevant DWS documentation and procedures. This will entail:

- Undertaking the classification of all significant water resources in the Lower Orange Catchment in the Orange Water Management Area (WMA 6), and
- Determining the associated Resource Quality Objectives (RQOs) for the prioritised units.

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

The water resource classes and associated RQOs will assist the DWS make informed decisions regarding the authorisation of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of the present and proposed developments, as well as ensure that economic, social and ecological goals are attained.

The study team understands that this study is linked to the previous Reserve determination studies and other water resource management initiatives that have been undertaken by both the DWS and Orange-Senqu Commission (ORASECOM) or are currently underway. These include the ecological water requirements (EWR) determination undertaken by the DWS for surface water, groundwater, wetlands and the estuary in the Lower Orange Catchment (2018), the ORASECOM Basin-wide Integrated Water Resources Management Plan (2010/ 2011) and Aquatic Ecosystem Health Joint Basin Survey (2011, 2015, 2021), as well as the Reconciliation Strategy Study undertaken in 2014/ 2015 and the current update underway.

In determining classes and associated RQOs, socio-economic factors and ecological goals will be considered by evaluating the magnitude of impacts in the present as well as the current system operation and proposed future developments.

It is recognised that the successful determination of the water resource classes and RQOs will depend on the integration of several disciplines with respect to the water resources, with the water uses and the needs of the water users present in the catchment, through consultative processes. Specialist technical assessment and stakeholder engagement are therefore the two key components of the process.

#### **1.4. Purpose of this Report**

The inception report has been produced to better define the scope of work for the study, document any changes from the proposal to the scope of work, highlight related considerations that could influence the study, confirm the study programme and indicate any key challenges resulting from the initial assessments and reviews undertaken during the inception phase of the project.

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## **2 STUDY AREA**

The Orange River catchment, comprising the Upper Orange and Lower Orange catchments and forming part of the recently gazetted Vaal-orange WMA (WMA04), is the largest catchment in the country (Figure 1). This catchment covers nearly 50% of the country and forms part of the Orange-Senqu River Basin (Figure 2), which straddles four International Basin States with the Senqu River originating in the highlands of Lesotho, with contributions from Botswana in the north-eastern part of the Basin, the Fish River in Namibia and the largest area situated in South Africa. The Orange River is an international resource shared by these four countries. It is the largest river in South Africa and has significant interdependencies with other WMAs as well as other countries. The two main tributaries are the Senqu/Upper Orange (Lesotho/South Africa) and the Vaal rivers. The headwaters of the Senqu rise in the Maluti mountain range in Lesotho Highlands, while the Vaal River, rises on the eastern highveld escarpment in north-east South Africa. At the confluence of the Upper Orange and Vaal rivers at Douglas, the Orange River flows in a westerly direction approximately 2 200km to the west coast entering the Atlantic Ocean through the Orange River Estuary at Alexander Bay. A smaller tributary, the Fish River (from Namibia), joins the Orange River in the Lower Orange catchment.

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 Africa. It also supplies thermal power stations on the Highveld, irrigation schemes covering large areas along the Vaal, middle and lower Orange Rivers. Some 16 million people are dependent on secure water supplies from this basin.

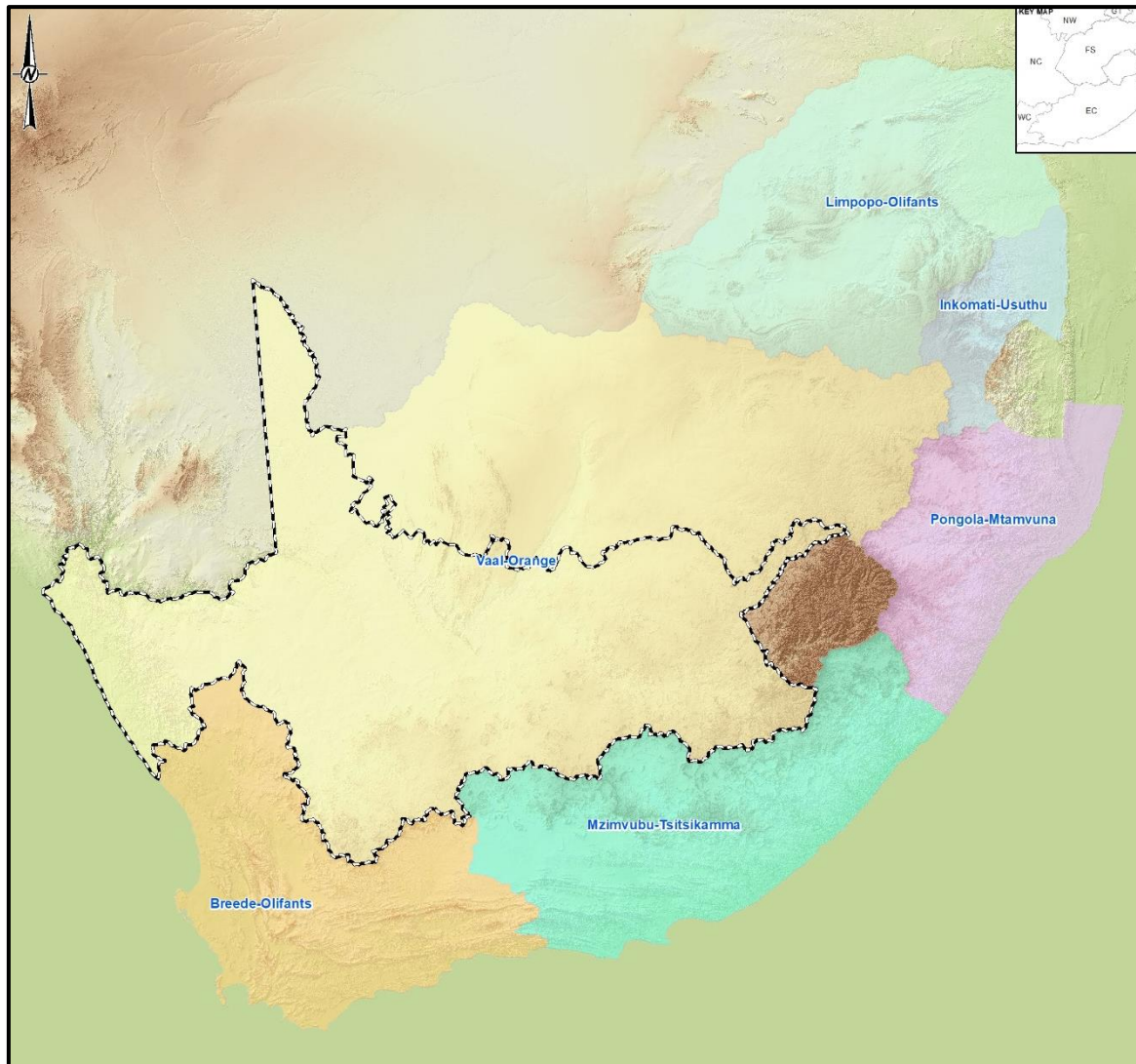
The study area for this undertaking is the catchment of the Lower Orange River illustrated in Figure 3. It comprises only the South African portion of the Lower Orange River Catchment that includes the tertiary catchment areas portions of C92B, C92C, portions of D41, D42, D51 to D58, D61, D62, D71 to D73 (excluding some portions D73), D81, D82 and primary catchment F with some exclusions as set out in Table 2 (and shown in Figure 3). The lower portions of quaternary catchments C92B and C92C (lower Vaal) are included in this catchment as it follows the boundary of the Orange Vaal Water User Association. Quaternary catchment F60A is also included.

The Lower Orange includes the stretch of Orange River between the Orange-Vaal confluence and Alexander Bay. The Orange River, which forms a green strip in an otherwise arid but beautiful landscape, also forms the border between South Africa and Namibia, over a distance of approximately 550 km. Other tributaries are:

- the Ongers, Sak and Hartebeest rivers from the south draining from the Karoo,
- the Molopo and Nossob Rivers in Namibia, Botswana and the Northern Cape Province which have not contributed to the Orange River in recorded history as the stream bed is impeded by sand dunes (DWS, 2015); and
- the Fish River draining the southern part of Namibia.

Tributaries such as the Ongers, Sak and Fish Rivers are draining arid and semi-arid regions. The flows in these rivers are very infrequent and will only contribute to the Orange River's flow during

periods of relative high rainfall. The contribution from these rivers to the firm yield of the Orange River is small (DWS, 2015).

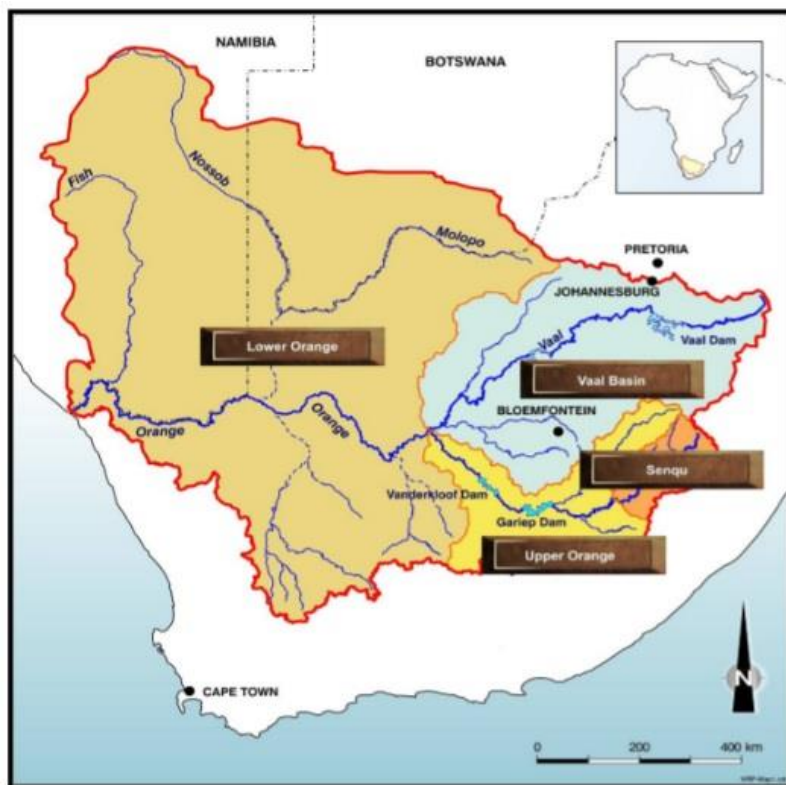


**Figure 1: Orange River Catchment within Vaal- Orange WMA (WMA04) in South Africa**

There are a number of highly intermittent water courses along the coast which drain directly to the ocean. The Lower Orange catchment is the largest, but also the driest and most sparsely populated catchment in South Africa. The area is mostly arid with rainfall varying from 400mm in the east to 50 mm on the west coast. The topography of the area is in general flat, including large pans or endoreic areas that do not contribute to runoff reaching the main Orange River. The average mean annual evaporation for this area is 2600 mm/a (DWS, 2016).

Water is abstracted for irrigation, urban and mining use along the main stem of the Orange River at various points, and for stock watering in the Kalahari. Water is also transferred via pipelines to the Aggenys mines and to the town of Springbok.

Mining operations in the Lower Orange include underground and surface mines as well as quarries. Products of the mining industry in the Lower Orange are predominantly alluvial diamonds, copper and salt. Base metals are also mined. There are a few quarries providing stone aggregate and gravel. Minerals and water from the Orange River are the key elements for economic development in the region, and still remain so.



**Figure 2: Orange-Senqu River Basin**

Irrigation is by far the dominant water use sector in the Lower Orange, representing 90% of the total requirements for water. There are many well-structured irrigation schemes located within the study area which in most cases use storage weirs in the main rivers as the source of water supply. There is however also a large component of individual irrigators abstracting water directly from the river, from farm dams and from boreholes to supply irrigation developments. The importance of the agriculture sector is attributable to the climate which is particularly suitable for the growing of some high-value crops, together with the availability of water along the Orange River - mainly grapes in Lower Orange (table grapes, dried fruit and wine grapes). These pockets of vineyard land stretch over a distance of more than 300 kilometres between Groblershoop and Blouputs. dates, raisins, flowers, vegetables, grain and fodder crops. Five wineries have been established in Kakamas, Keimoes, Grootdrink and Groblershoop. Other water user requirements include water for stock farming (mainly cattle sheep and goat farming) and supplying domestic water to towns and rural communities and to a limited extent water for mining purposes.

Groundwater is an extremely valuable source particularly in the Lower Orange catchment. It is the most important source of bulk water supply to local towns and rural settlements in the Lower Orange as these towns and settlements are located far from the surface water bulk supply network. The recreational use of the lower Orange River has gained in intensity over the past 25 years. The rafting and canoeing industry in this remote area has developed into an extremely popular experience for tourists (ARTP JMB, 2008).

The DWS recently in the National Water Resource Strategy-3 (DWS, 2023) proposed that the Orange and Vaal WMAs are managed as a single unit /WMA, WMA 04 (C and D primary drainage regions). The adoption of the new WMAs was gazetted on 1 September 2023 (Gazette 3855, Notice No. 49225).

**Table 2: Sub-catchment areas of the Lower Orange River catchment**

Secondary Catchment	Tertiary Catchment	Quaternary catchments	River/s	Catchment area <sup>(1)</sup> (km <sup>2</sup> )	
				Gross	Net
C9	C92	C92B, C92C	Vaal	3938	1324
D4	D41	D41A-M	Molopo, Kuruman	54 045	30173
	D42	D42A- D42E	Molopo, Kuruman, Nossob, Auob	33898	31872
D5	D51	D51A-D51C	Renoster, Dorps, Kariega, Boesmanfontein se laagte	2192	2192
	D52	D52A-D52F	Vis, Visrivier-oos, Visrivier-wes, Muiskraal, Kookfontein, Hottentotsfontein se Laagte	2750	2750
	D53	D53A-D53J	Harbees, Mottels, Klein-Lat, Rugseers, Rooiput se Leegte, NRougas se Loop, Driekop se, Tuins, Graafwaters, Sandnoute, Rietfontein, Brulkolk se Holte, Sout, Souts se Laagte, Steenkampsvei se Holte	23050	20527
	D54	D54A-D54G	Hartbees, Holsloot, Kalksloot, Carnarvonleegte, Boesak, Bitterpoortloop, Boesak, Renosterpoort se Leegte, Bloudrif, Ysterdoringspan, Bidderslaagte, Vernuekpan, Hartogskloof, Bloubosleegte, Keelafsnyleegte, Brandholteloop, Bastersput se Leegte, Lekkerleleegte, Elandsfontein	23622	15640
	D55	D55A-D55M	Sak, Brak, Sout, Klein-Sak, Rietfontein, Damfontein se, Klein-Brak, Slangfontein, Soutpoort, Reitzvilleleegte, Kareebergleegte, Alarmleegte, Stofkraalleegte, Platkuil, Gansvlei, Palmietfontein se Loop, Draaiwal se	19398	19225

Secondary Catchment	Tertiary Catchment	Quaternary catchments	River/s	Catchment area <sup>(1)</sup> (km <sup>2</sup> )	
				Gross	Net
			Leegte, Beeswaterleegte, Hongerkloof se Leegte, Ploegfontein se Leegte, Witleegte, Rietfonteinleegte, Tulbaghlaagte, Wielkolkslaagte		
	D56	D56A-D56J	Riet, Portugals, Klein-Riet, Wolwe, Nuweveld, Karee, Elands, Valslaagte, Leenderts	6303	6303
	D57	D57A-D57E	Sak, Soutsloot, Swartbosleegte, Rooidam se Laagte, Soutsloot, Kettingkop se Laagte, Knapsaklaagte, Bosduiflaagte	10165	6197
	D58	D58A-D58C	Vis, Renoster, Klein-Vis, Dassiesstraatlaagte	763	763
D6	D61	D61A-D61M	Ongers, Brak, Klein-Brak, Lakenrivier, Brakpoort, Pretoriuskuil se Leegte, Visgatspruit, Vis, Groen, Biesiekuilleegte, Gaafwaterspruit	13405	12426
	D62	D62A-D62J	Ongers, Brak, Sand, Elandsfontein, Renostervleispruit, Hondeblafspruit	20328	12178
D7	D71	D71A-D71D	Orange, Withoekskloof, Lanyon spruit	7390	4792
	D72	D72A-D72C	Prieska, Karabeelooop, Rooilooop, Kat, Marydale	6742	5714
	D73	D73A-D73F	Orange, Sout, Brak, Groenwaterspruit, Skeifonteinspruit, Soutloop, Eselfontein, Helbrandleegte, Kareeboom, Vaalputs, Kameel, Neusspruit	25968	11080
D8	D81	D81A-D81G	Orange, Slang, Brak, Brabees, Wegsteek se Laagte, Bak, Bul, Nous, Kaboep, Koeiamlaagte, T_Goob se Laagte	12809	10975
	D82	D82A-D82L	Orange, Mik, Fontein se, Nam se Laagte, Kirrie, Matjies, Koubank, Kosies, Geelfontein, Groen, Kahams, Abiekwa, Gannakouriep, Bloubos, Annis, Khubus	20212	18185
F	F10	F10A-F10C	Holgat, Gaigas, Kook	2725	1335
	F20	F20A-F20E	Kamma, Kwaganap	3137	2899
	F30	F30A-F30G	Buffels, Brak, Gasab, Papkuils, Klein-Nou, Jaagleegte, Jagleegte, Drodab, Melk, Wolwepoort, Skaap, Doring, Stry	9756	9460
	F40	F40A-F40H	Wildeperdehoek se Brak, Swartlintjies, Spoeg, Bitter, Brand, Outeep	5346	3783

Secondary Catchment	Tertiary Catchment	Quaternary catchments	River/s	Catchment area <sup>(1)</sup> (km <sup>2</sup> )	
				Gross	Net
	F50	F50A - F50G	Hartbees, Groen, Swart-Doring	4869	4600
	F60	F60A	Brak, Sout, Klein-Goerap, Bitterfontein, Vorsbrak	572	386

<sup>1</sup>WR2012 data

## Water Resources

The bulk of the surface water in the Lower Orange catchment is found in the main stem of the Orange River, with virtually all water coming from the Upper Orange catchment. Most of the runoff generated in the Lower Orange comes from the Fish River in Namibia and only enters the main Orange River close to the River mouth.

## Dams/Weirs

There is very limited regulation capacity in the Lower Orange catchment. Although no large dams are present in the Lower Orange catchment, Boegoeberg, Neusberg and Vioolsdrift storage weirs are used for the regulation of flows into canal systems for irrigation purposes.

Two small dams are located in the Orange tributaries sub-areas:

- Smartt Syndicate Dam on the Ongers River; and
- Rooiberg Dam on the Hartebeest River.

## Water Supply Schemes/Developments:

The Lower Orange River provides a significant resource to the Northern Cape Province, and is used for industrial, agricultural, recreational and domestic purposes. While most of the Province is unsuitable for dry land cropping, the Orange River Valley, especially at Upington, Keimoes and Kakamas, is an intensively cultivated grape and fruit growing country. The major user of the Northern Cape's freshwater resources is the irrigated agriculture sector, being the largest water user. Mining activities consists mainly of the extracting of alluvial diamonds and a variety of minerals (zinc, etc.).

Both surface and ground water resources are used to supply the irrigation water requirements, with the bulk of the demands being supplied from surface water. There are many well-structured irrigation schemes located within the study area with the Orange River as the source of water supply. There is however also a large component of individual irrigators abstracting water directly from the river, from farm dams and from boreholes to supply irrigation developments (DWS, 2015).

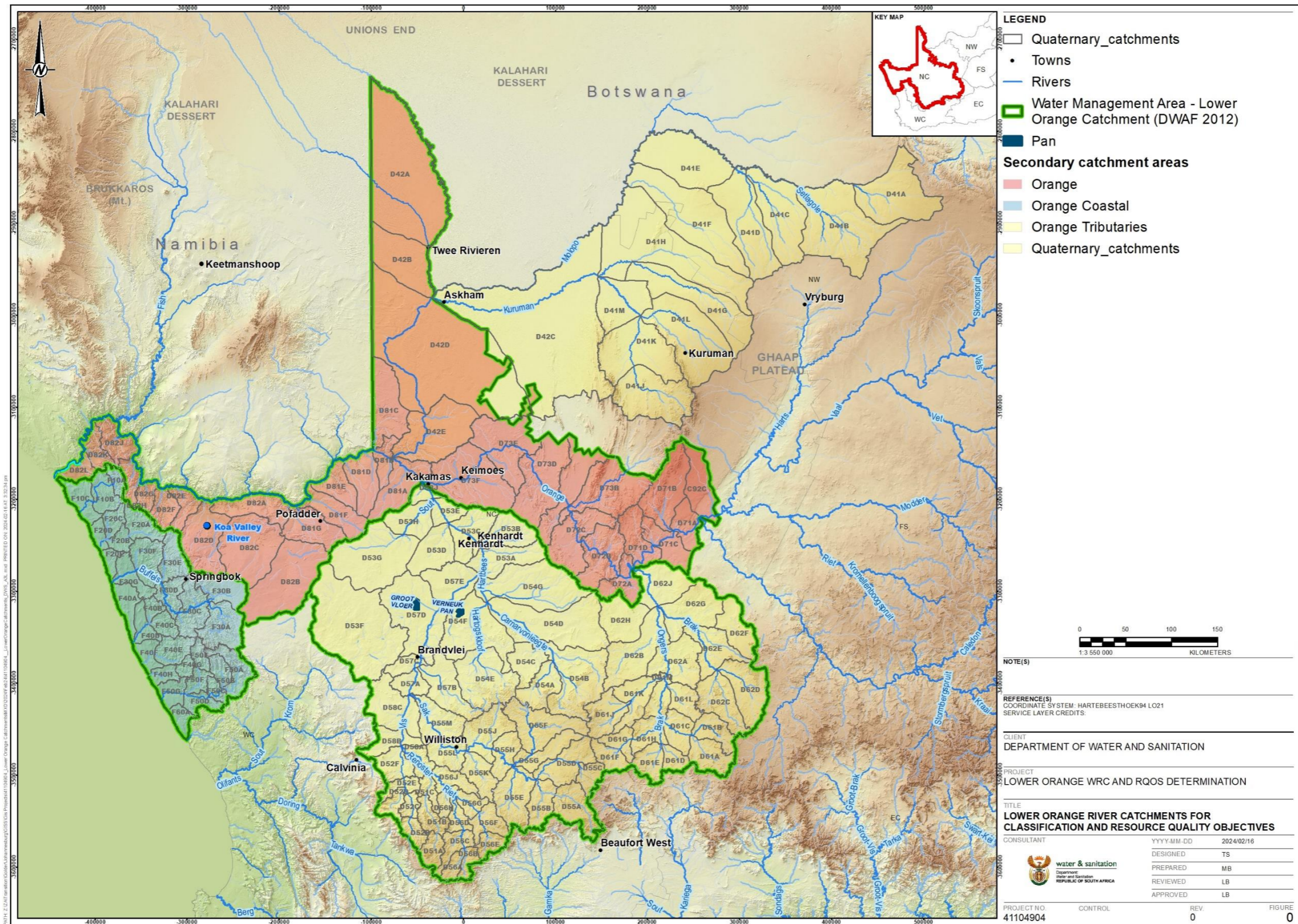


Figure 3: Lower Orange River catchment – Study Area extent and Locality (South African Portion)

The Orange River Project is the largest water supply scheme and comprises of a large number of sub-schemes that are all supplied from the same resource, Gariiep and Vanderkloof dams in the Upper Orange. Approximately 44 million m<sup>3</sup>/a is supplied to irrigators located in Namibia along the Lower Orange River (DWS, 2016). However, there has been a request by the Namibian Government to increase the irrigation requirement to 75 million m<sup>3</sup>/a (personal communication, DWS, Directorate NWRP at inception meeting of 6 February 2024). This still has to be confirmed.

The major water supply schemes/development include the:

- Middle Orange Irrigation Area,
- Boegeberg Dam Irrigation Area,
- Karos-Geelkoppan Rural Water Supply Scheme,
- Upington Irrigation Area,
- Kakamas Irrigation Area,
- Pelladrift Water Supply Scheme (Aggeneys and Pofadder),
- SA Irrigation Small Schemes,
- Namibia Irrigation Small Schemes, and
- Springbok Regional Water Supply Scheme.

Violsdrift Dam is a proposed new water resource development that is planned on the Lower Orange River. Studies show that this re-regulation dam will provide the most savings in operational requirements and will contribute to the river mouth's ecological water requirements.

### **Inter-basin transfers**

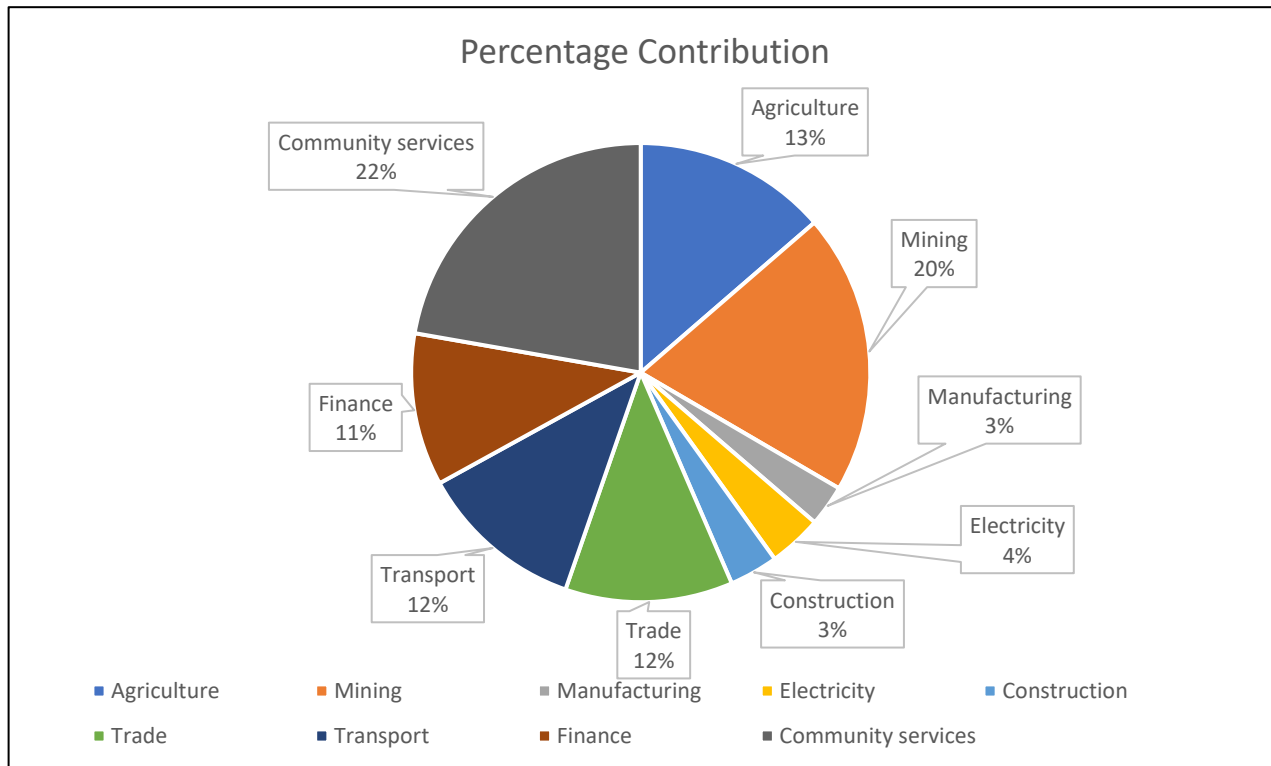
There are no inter-basin transfers out of the Lower Orange catchment. The Orange River system is not supported by any other sub-system.

### **Socio-Economics**

The Lower Orange River catchment can be subdivided by its 3 district municipalities (DM), Pixley ka Seme DM, Z F Mgcawu DM and Namakwa DM. Most of the towns and settlements are scattered adjacent to the Orange River, as much of the area is dry and arid with little or no development. Upington is one of Lower Orange's developed towns. About 86% of the households within the Lower Orange catchment live in formal dwellings. 64% of these households have piped water within the dwelling and 82% have flushing toilets (Stas SA, 2022).

Most of the economic activities in the Lower Orange River catchment occur in towns and farms adjacent to the Orange River. The estimated Gross domestic Product (GDP of the catchment was about R42 billion in the year 2018 (IDPs, 2019). The largest economic sector by GDP was Community Services which contributed about 22% to the catchment's GDP. The second largest economic sector by GDP was mining, which contributed about 20% and this is shown in Figure 4. Mining activities are conducted in Aggeneys (Black Mountain Mine), Okiep (Narrap Mine), Concordia, Koingnaas (West Coat Resources) and many other small mines scattered in the region. Mining activities include the extraction of alluvial diamonds, copper, asbestos, alumni

silicate, limestone, dolomite, and other minerals and metals. (Lower Orange ISP, 2004; Stats SA2018; IDPs 2019).



**Figure 4: GDP contribution by economic sector (year 2018)**

The agriculture sector contributes about 13% to the Lower Orange River catchment’s GDP (IDP, 2019). Most of this agriculture occurs along the Orange River. The agriculture in this area is irrigated and normally grow grapes. Other agriculture-related products from this region include dates, raisins, wine, flowers, vegetables, grain and fodder crops (Lower Orange ISP, 2004). Agriculture employs about 20% of the workforce in the catchment, making it the second employer after Community Services (35%) as shown in Figure 5 (IDPs 2019).

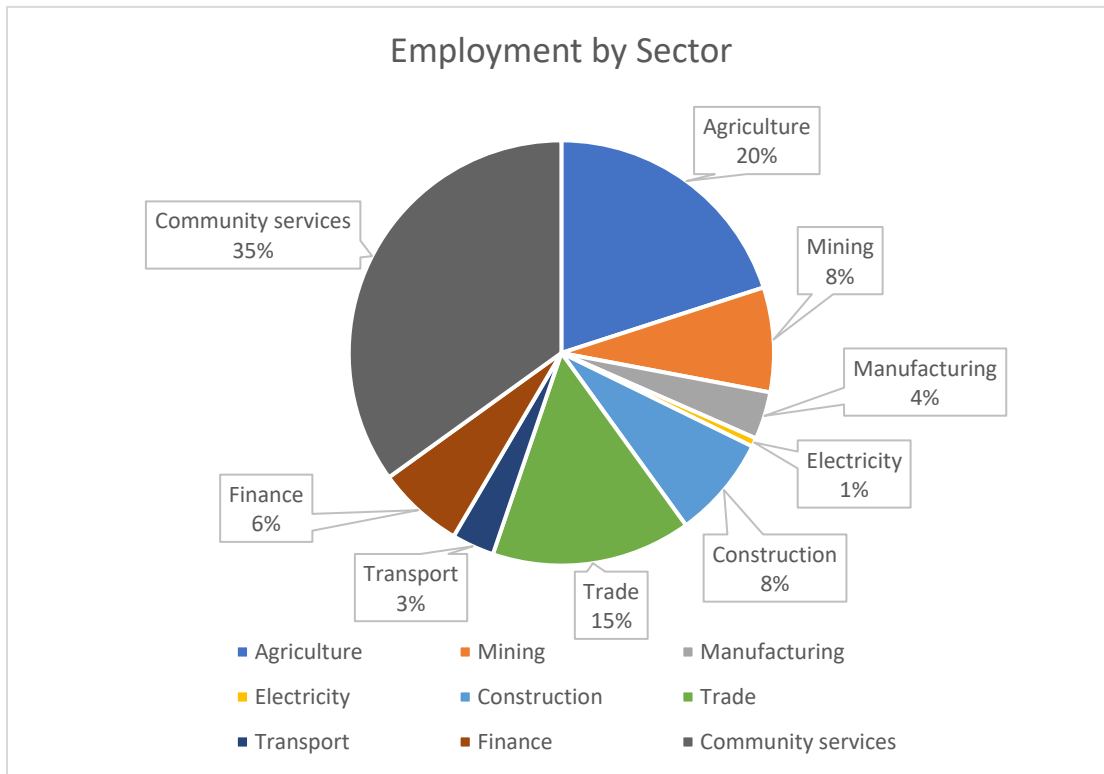


Figure 5: Employment by sector (year 2018)

### Estuary and Conservation Areas

Among the more valued natural resources in the river basin is a transboundary Ramsar protected wetland at the mouth of the Orange River. Important nature conservation areas include the Kgalagadi Transfrontier Park, the Ai-Ais-Richtersveld Transfrontier Park, and the Au-grabies Falls National Park.

The estuary of Orange proclaimed a Ramsar site by both South Africa and Namibia is one of the very few areas of sheltered shallow water along southern Africa’s arid Atlantic coastline, and is a site considered important primarily for sustaining substantial numbers of water birds, including an appreciable number of Red Data-listed species such as the Cape Cormorant, Damara Tern and Hartlaub’s Gull. The Orange River Mouth is regarded as the 2<sup>nd</sup> most important estuary in South Africa in terms of its ecological and conservation importance (<https://rsis.ramsar.org/ris/744>).

The critical biodiversity areas for the catchment and the Orange River mouth are shown in Figure 6 and

Figure 7 respectively.

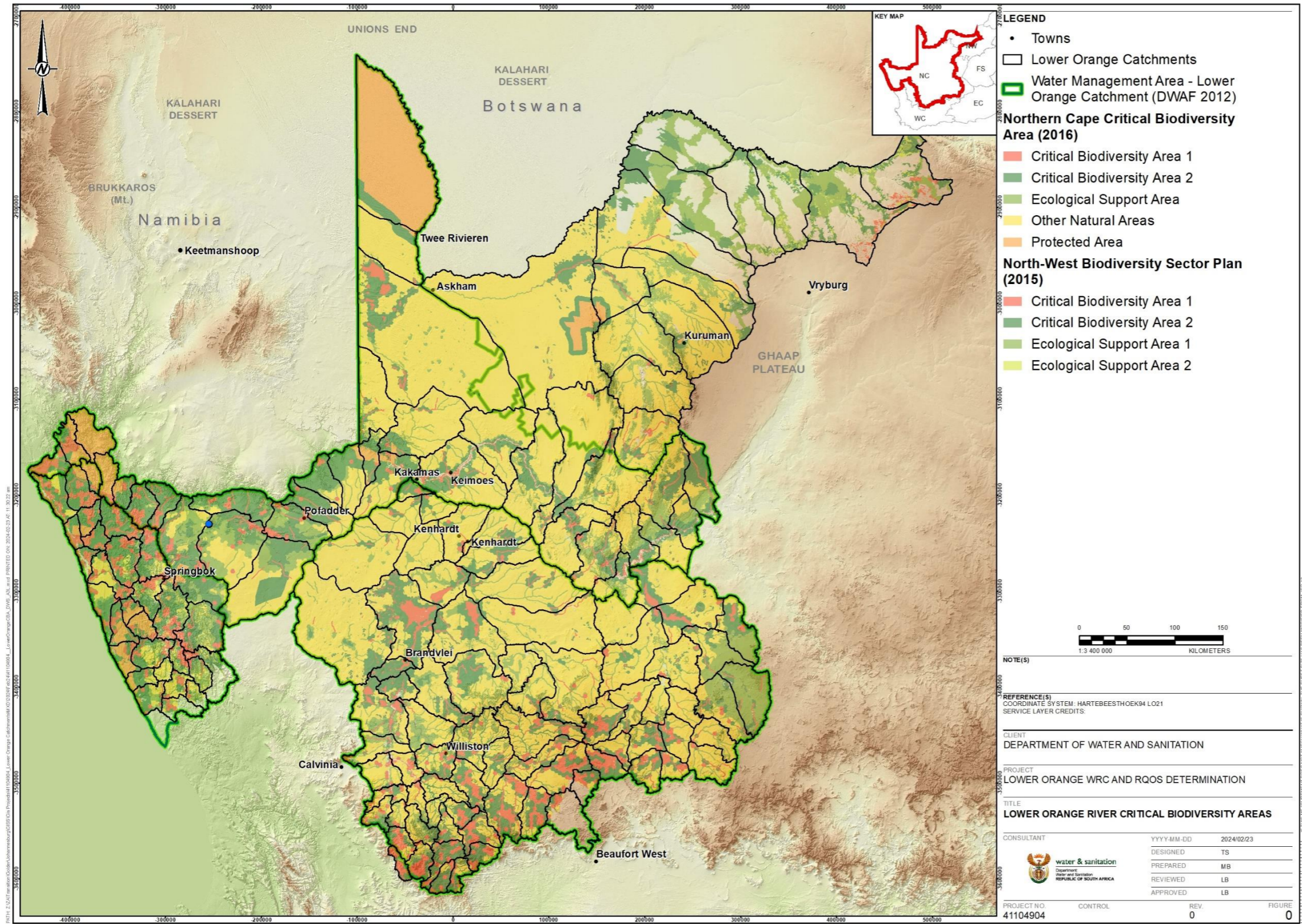


Figure 6: Lower Orange Study Catchment Critical Biodiversity Areas

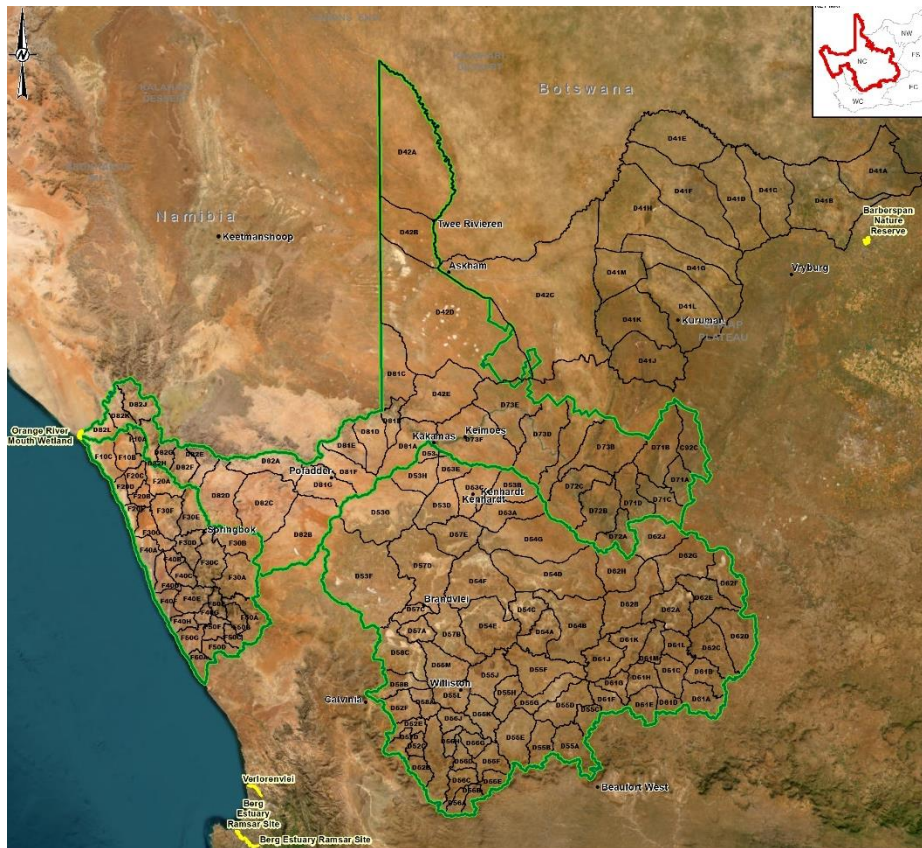


Figure 7: Orange River Mouth/Wetland (Ramsar Site)

## Groundwater

Groundwater occurrences in the Lower Orange catchment occurs in a large range of aquifer systems varying from younger semi-consolidated (Cenozoic) sedimentary sequences, large spatial sequences of Karoo Supergroup (Palaeozoic) and Nama Group (Namibian) sedimentary sequences that overly highly variable meta-sedimentary and metamorphic rocks towards the lower part of the Lower Orange.

The groundwater (aquifer) systems in the Lower Orange are described as follows in terms of (i) rock-type compositions, (ii) borehole yield class classification, and (iii) water quality types:

- Aquifer Type (a): Intergranular Aquifer Type –
  - Semi-consolidated [younger] Kalahari Group (T-Qk) saturated sediments referenced as the Kalahari Group Aquifers underlying non-perennial drainage systems at places such as the lower Molopo River, Aoub and Nossob Rivers – as well as several isolated paleo valley systems (*viz.* the Koa River paleo-channel system and the Buffels River (West Coast) paleo-channel system).
  - Saturated zone consists of (i) coarse sandstones, and (ii) fine to medium grained gravel (partly calcified).

- Borehole Yield Class (highest) range(s): a3 and a2 (depending on saturated thickness).
- Aquifer water quality(T-Qk): “Ideal” to “Good”, but also highly saline (brackish) if underlain by Dwyka Group Mudrock (diamictite); and
- Aquifer water quality (others): “Good” to “Marginal” due to (i) evaporating (saline) pans in upstream areas, and (ii) marine aerosols on West Coast Area.
- Aquifer Type (b): Fractured contact-zone aquifers occurring on a very wide range and regarded merely as “water bearing zones” between parent rock formations of different compositions and ages due to tectonic-driven events, *i.e.*, metamorphism, jointing and/or fracturing, and includes:
  - Secondary intrusions: – Karoo Dolerite (dikes/sills) intruded into Karoo sediments (diamictites, mudrock and sandstones), Nama Group sediments and quartzites.
    - Borehole Yield Class (highest) range(s): b3 and b4.
    - Aquifer water quality: Highly variable if in contact with Karoo Diamictites (a typical saline rock formation), but could contain a “good”/“marginal” water type in a sandstone/quartzite rock formation combinations.
  - Secondary jointed/fractured/folded): – merely two competent rock types (*i.e.*, fractured gneiss–quartzite contact, folded granite-gneiss fracturing, different arenaceous-quartzite sedimentary rock contact zones, older/younger sedimentary rocks in contact with metamorphic rocks, and [generally] rocks with different lithological and stratigraphical horizons.
    - Borehole yield Class (highest) range(s): b3 and b4.
    - Aquifer water quality: Merely “Marginal” due to variable water-rock interactions and frequency of rainwater recharge (fresh water flushing in aquifer system).
- Aquifer Type (b): Fractured (hard rock formations) aquifer types occurs over a wide area in the Lower Orange catchment and consist of the following rock formations:
  - Karoo Supergroup Sediments: Arenaceous sandstones – slightly fractured due Neo-Tectonic movements in the Crust –
    - Borehole Yield Class (highest) range(s): b2 and b3.
    - Aquifer water quality: Merely “Marginal” with several “Poor” water quality “Hot Spot” areas (Unacceptable water quality type with elevated nitrate and fluoride).
  - Nama Group Sediments: Quartzites and minor sandstones – slightly fractured due to folding and warping:
    - Borehole Yield Class (highest) range: b2

- Aquifer water quality: Merely “Marginal” with several “Poor” water quality “Hot Spots”. Major ion species causing elevated salinity is dissolved rock salts, *i.e.*, sodium-chloride (NaCl).
- Mokolian Period (Proterozoic Eon): Granitoids, andesite-volcanics, meta-arenaceous rocks and calc-silicates-quartzites.
- Borehole Yield Class (highest) range: b2.
- Aquifer water quality: Merely “Marginal” with several “Poor” water quality “Hot Spots”. Major ion species causing elevated salinity is dissolved rock salts, *i.e.*, sodium-chloride (NaCl).
- Aquifer Type (d): Fractured and Intergranular aquifer types occur over a large area in the lower parts of the Lower Orange WMA and represents merely the basement rock formations (Mokolian Period).
  - Borehole Yield Class (highest) range(s): b2 and b3.
  - Aquifer water quality: Variable between “Good” and “Marginal” with several areas (large hot spots) where the quality is “Poor”.
- Aquifer Type (c): Karst aquifers are isolated and occur in (i) the southern part of the Ghaap Plateau dolomite rock formations and (ii) the highly faulted Doornberg Fault Zone in the Prieska-Groblershoop areas to as far west as Kenhardt. These are high yielding aquifer systems, but small compared to the other aquifer types in the catchment. These might be a significant surface water groundwater interaction as the Orange River flows directly over the outcrop areas.
  - Borehole Yield Class (highest) range(s): c3 and c4
  - Good aquifer water quality

Apart from large groundwater mapping surveys in the Lower Orange catchment, several smaller groundwater exploration programmes have been conducted – merely for the augmentation of existing groundwater supply schemes, and additional groundwater development schemes for water supplies to municipalities and rural communities. Most important ones are:

- Nonzwakazi (De Aar),
- Bonteheuwel (Carnarvon),
- Amandelboom (Williston),
- Bushmanland Rural Towns (*viz.*, Leliefontein, Kamieskroon, Soebatsfontein, Kharkhams, etc.),
- Kenhardt,
- Rietfontein (Mier Area, D42D),
- Kalahari Gemsbok National Park (D42A);
- Vanwyksvlei; and

- Brandvlei.

All these towns and villages are solely depending on groundwater resources and in some cases potable water is piped from farms several kilometres away from the towns/villages.

Although the Borehole Yield Classes mentioned in the Aquifer Type specification above, the median yield class is “2”, or between 0.1 and 0.5 l/s.

Groundwater quality in the Lower Orange catchment varies from “good” to “marginal” with several areas with a “poor” water quality type – these areas are referenced as “hot spot” areas where the groundwater quality is characterised by (i) high salinity due to natural conditions and (ii) impacted due to anthropogenic pollution, i.e., mining, agriculture, industrial and municipal waste pollution. These sites will be highlighted specifically in the RQO assessment providing guidelines supported by numeric ranges and associated narratives to improve the water quality conditions.

Groundwater quality of the Lower Orange aquifers are highly variable and is merely a function of the following aspects:

- Argillaceous (clayey) aquifer rock-types such as the Karoo Supergroup (Ecca Group) mudrock, Nama Group sandstones;
- Large evaporation pans in the upstream areas of surface drainages, *i.e.* Hakskeen Pan, Groot Pan and Verneuk Pan; and
- Impact of saline marine aerosols along the West Coast where intergranular aquifers are present.

The salinity of the above-mentioned aquifers is, however, a function of the recurrence rate of aquifer storage recharge – which could be impacted (*viz.*, becoming less effective) by climate variation(s). Groundwater quality is becoming a concern for bulk water supply to municipalities that are merely using “sole source” water supply schemes.

It is also necessary to address the natural and/or induced toxicity levels of the groundwater resources. Elevated levels of nitrate and fluoride have been noted in several areas – these dissolved constituents represent a health risk especially where the groundwater resource is a sole water supply source for water users.

Groundwater resources in the lower Molopo River (downstream of Andriesvale) and the Aoub-Nossob Rivers are highly depending on occasional flooding in these systems for groundwater replenishment of the Kalahari Group Aquifers underlying the river channels (where they traverses).

## **Wetlands**

Six wetland types have been identified in the Lower Orange Catchment. They include seeps, depressions (pans), unchanneled valley bottom, channelled valley bottom, floodplain and flats, which are associated with major rivers in the catchment (Orange, Molopo, Auob and Nossob). Wetlands systems are associated with the Orange River mouth (which is a RAMSAR site).

Seeps and depressions are found in the northern part of the northern and southern Kalahari and the Ghaap Plateau; depressions in the southern part of the southern Kalahari (includes some flats, seeps and unchannelled valley bottom wetlands); depressions and unchannelled valley bottom wetlands in the eastern and western Nama Karoo, seep and channelled valley bottom wetlands in the southern Namaqua Highlands and southern Western Coastal Belt (includes some flats and floodplain wetlands); and floodplain wetlands occur along the Nossob, Auob, Molopo and Orange rivers.

High priority depressions/pans are numerous in the catchment, some of which are extensive (e.g. Verneuk Pan, Grootvloer, Boesmankop and Bitterputs - in excess of thousands of hectares (DWS, 2016)). Floodplains are typically restricted to in-channel features and do not consist of typical meandering floodplains on riverbanks. Channelled valley bottom wetlands are most prevalent in the eastern and central extents of the Orange Tributaries Secondary Catchment Area, and southern extent of the Orange Coastal Secondary Catchment Area, associated with the Brak and Buffels River catchments respectively.

Seeps also occur at a lower density in the catchment, with most extensive areas being situated along the headwaters of the Harts and Vis rivers.

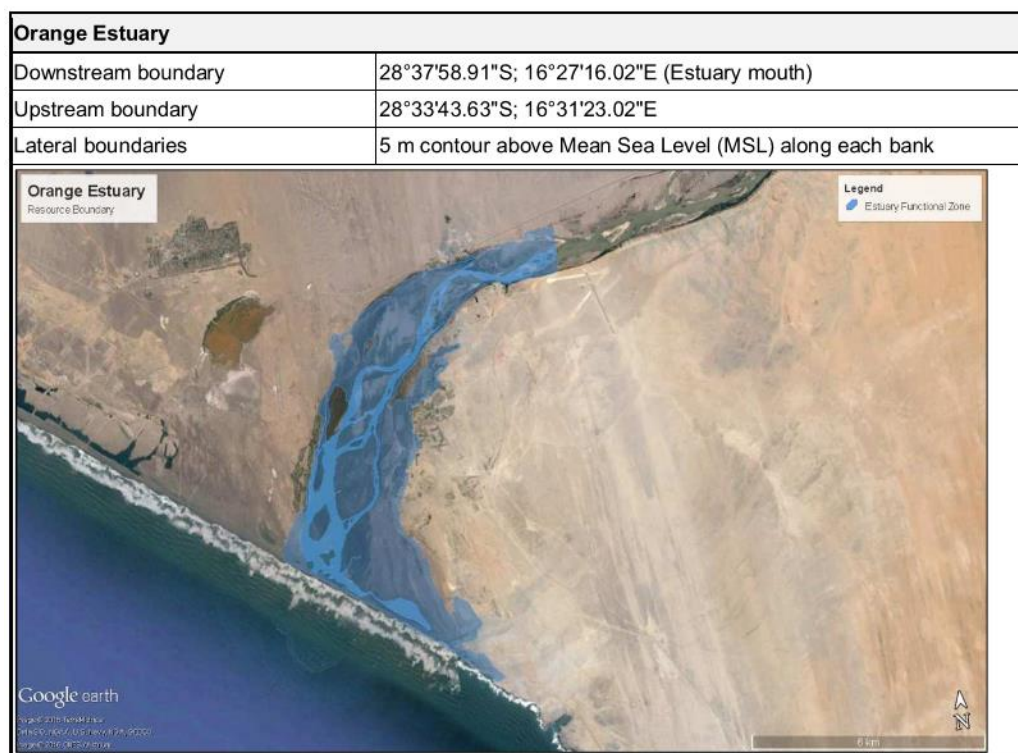
## **Estuaries**

The Lower Orange catchment include six estuaries of national importance which are the Orange, Buffels, Sout, Swartlintjies, Spoeg and Groen estuaries. The Orange River Estuary is classified as a Large Fluvially Dominated estuary (Van Niekerk, *et. al.*, 2019) and is the largest of these estuaries. The smaller Buffels, Sout, Swartlintjies, Spoeg and Groen estuaries are all classified as Arid Predominantly Closed estuaries.

### *Orange River estuary*

The Orange River estuary (Figure 8) can be described as a delta type river mouth which comprises a distributor channel system between sand banks covered with pioneer vegetation, a tidal basin, the river mouth and the saltmarsh on the south bank of the river mouth. The Orange River Mouth forms part of the Orange-Senqu River Basin.

The Orange River Mouth is a Ramsar wetland, however, it was placed on the Montreux Record in 1995 because 300ha of salt marsh had become desertified. This loss was attributed to leakage of diamond mine water, the effect of windblown dried slimes dam sediment on the marsh vegetation, construction of flood protection works and a beach access road, and the elimination of tidal exchange into the wetland due to a causeway constructed at the river mouth (Shaw *et al.* 2008). Due to the low rainfall on the West Coast and highly salinized nature of the desertified marsh area there has been little change of the salt marsh status over the last 10 years (Van Niekerk, *et. al.*, 2019).



**Figure 8: Orange River estuary and associated geographical boundaries (DWS, 2017b)**

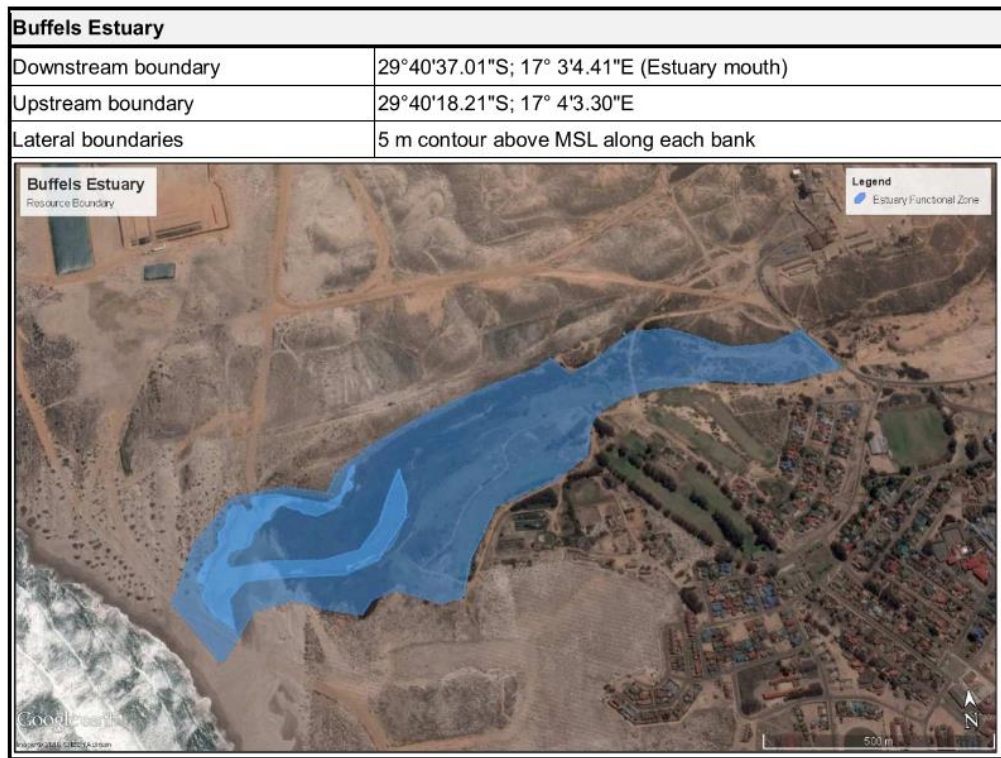
River inflows to the Orange River Estuary have been markedly reduced from reference, with only an estimated 44% of natural flows still reaching the system. Abstraction and regulation have also resulted in a marked reduction in the variability in river inflows from a pronounced seasonal flow to a nearly even flow distribution throughout the year. Surplus water releases for the generation of hydropower has resulted in the elimination of water deficits in the lower reaches of the river and the mouth now remains open almost permanently. The lack of mouth closure and associated back-flooding is regarded as particularly problematic as it is during such occurrences that flows into the saltmarsh area typically occur (CSIR, 2011a).

The Orange River estuary was further rated as of high Biodiversity Importance in the 2018, although the estuary is subject to a number of pressures, including flow modification, pollution, habitat loss, alien invasive fish and plant species and mining (Van Niekerk, *et. al.*, 2019).

#### *Buffels estuary*

The Buffels estuary (Figure 9) is located approximately 130km south of the Orange River estuary and is located in quaternary catchment F30G. The estuary covers approximately 40.8ha in size. The catchment area of the Buffels River is 9 375 km<sup>2</sup>. The Buffels River is about 150 km long from the mouth to where it divides into the Brak and the Riembreek rivers. The catchment falls predominantly within the winter rainfall area and episodic floods occur occasionally (Heinecken, 1981a). Annual precipitation varies from 200 - 250mm/a in the headlands to 75 - 100 mm/a at the sea. The river and its tributaries are ephemeral with surface flow only occurring after substantial

rainfall. Groundwater is estimated to be significantly modified with ground water use far exceeding the recharge of the aquifer (DWS, 2017a).



**Figure 9: Buffels estuary and associated geographical boundaries (DWS, 2017b)**

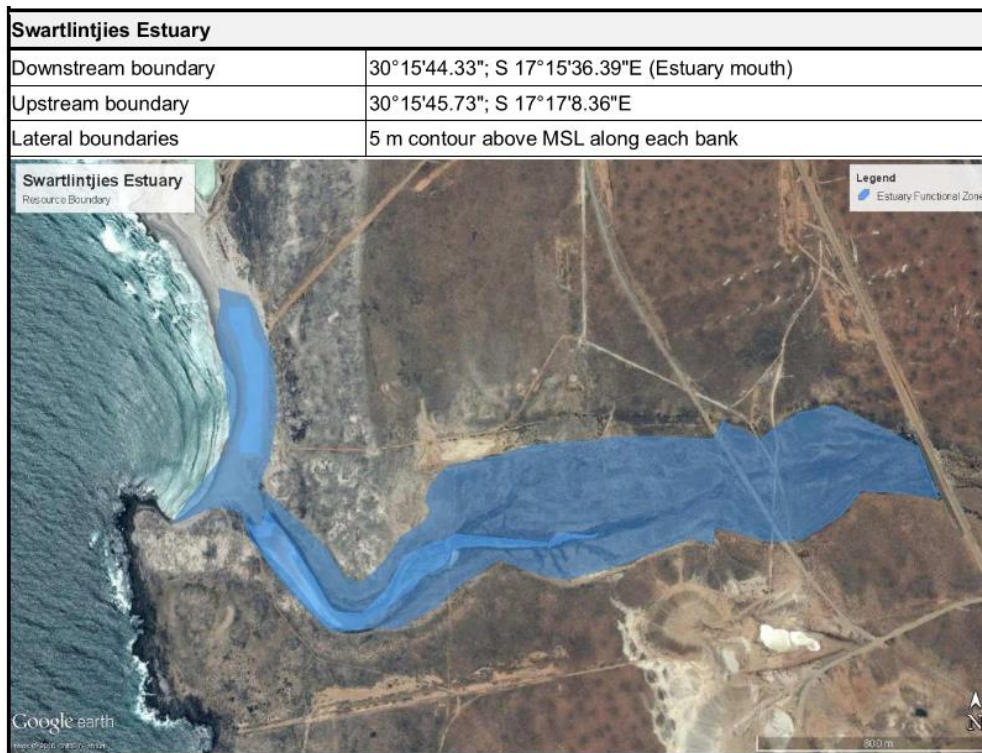
The Buffels Estuary is classified as an Arid Predominantly Closed estuary (Van Niekerk, *et. al.*, 2019), however the estuary is very seldom connected to the sea. Natural breaching by flood waters is estimated to have occurred every 3 to 7 years during flooding. Open mouth conditions would only prevail for short periods (days to a week or two) as flood peaks in arid catchments generally are a matter of hours with little follow up flow. However, under the reference condition overtopping of the sand bar at the mouth would have occurred regularly at high spring tides even after mouth closure (DWS, 2017a).

The major pressures on the Buffels Estuary include loss of freshwater input as a result of groundwater abstraction, mining activities in the surrounding environs and catchment resulting in destruction of habitat and change in sediment structure. Approximately five roads cross the system obstructing floods and freshwater underflow. Other pressures include grazing in the catchment changing sediment structure, development in the floodplain such as the golf course, fish kills due to eutrophication and disconnection with lower reaches (limit wind mixing), run-off from the golf course has encouraged reed growth. Extensive stands of *Acacia cyclops* (rooikrans) also occur in the water course of the upper reaches.

### Swartlintjies estuary

The Swartlintjies estuary is located approximately 70km south of the Buffels estuary in quaternary catchment F40D. The Swartlintjies estuary is situated approximately 6.5 km south of Hondeklip Bay within a strict security area of the Koignaas mining concession. The estuary covers approximately 93ha in size.

The estuary is fed by the Swartlintjies River, which is approximately 65 km long with a catchment size of 1748.48 km<sup>2</sup> (DWA, 2009b). The ephemeral Swartlintjies River only flows for short periods of time after rainfall events which occurring mostly between April and August. The Swartlintjies River and its tributaries have zero flow for more than 75% of the time and hence the catchment receives a low MAR of 1.2 Mm<sup>3</sup>.



**Figure 10: Swartlintjies estuary and associated geographical boundaries (DWS, 2017b)**

Flow in the lower catchment and into the estuary has been severely reduced as a result of the construction of roads through the riverbed. These structures have significant influence floods and baseflows to the Swartlintjies estuary and therefore the opportunity for breaching. It is anticipated that a 30% reduction in the magnitudes of floods reaching the estuary is likely as a result of local structures (DWS, 2017a).

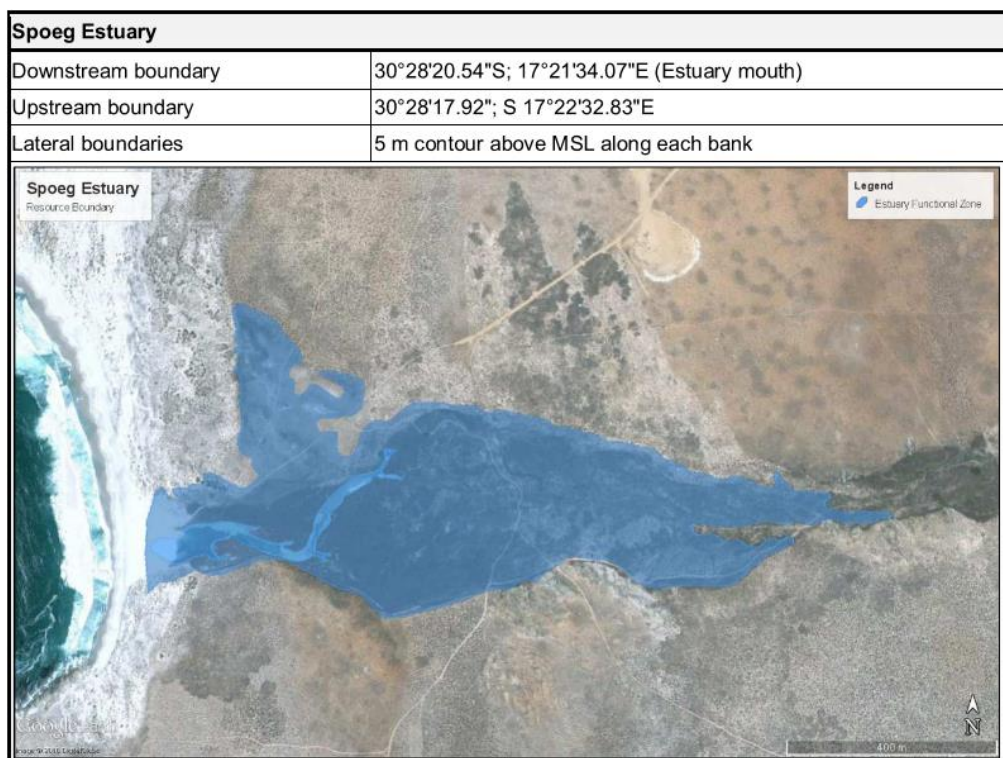
The Swartlintjies estuarine functional zone (EFZ) covers 1.4 km<sup>2</sup>. The lower reaches of the Swartlintjies estuary characterised by two extended meanders that widen out into the floodplain that was created by an extensive network of braided flood channels. The floodplain is approximately 400 m wide and 1.8 km long. The estuary is very seldom connected to the sea through an open mouth. Natural breaching by flood waters is estimated to have occurred every 3

to 10 years during floods. Open mouth conditions would only prevail for short periods (days to weeks) as flood peaks in arid catchments generally is a matter of hours with little follow up flow.

The major pressures on the Swartlintjies estuary include obstruction of freshwater flow, destruction of habitat through as road infrastructure and sumps, proliferation of alien vegetation. Nearby slime dams potentially introduce saline water and dust from the mine dumps.

### *Spoeg estuary*

The Spoeg estuary is located approximately 25km south of the Swartlintjies estuary and falls within quaternary catchment F40F. The estuary covers approximately 45.5ha in size. The catchment area of the Spoeg River is 1 375 km<sup>2</sup>. The river is ephemeral with surface flow only occurring after substantial rainfall.



**Figure 11: Spoeg estuary and associated geographical boundaries (DWS, 2017b)**

The mouth of the Spoeg Estuary is predominantly closed. The berm at the mouth of the Spoeg is high and does not allow for regular overwash. Very little information is available on the salinity of the Spoeg Estuary. Historical information suggests that the Spoeg Estuary has always been a brackish system.

The major pressures on the Spoeg Estuary include grazing in the catchment and limited loss of freshwater input from groundwater abstraction. Future pressures include an escalation of mining activities in the national park any disruption of subsurface flow.

### *Groen estuary*

The Groen estuary is located approximately 46km south of the Spoeg estuary and falls within quaternary catchment F50G. The estuary covers approximately 60ha in size. The Groen Estuary catchment area is estimated at about 4 500 km<sup>2</sup> (Bickerton, 1981) to 4 670 (van Niekerk *et al.*, 2015). Mean annual rainfall in the catchment varies from 100 - 200 mm.

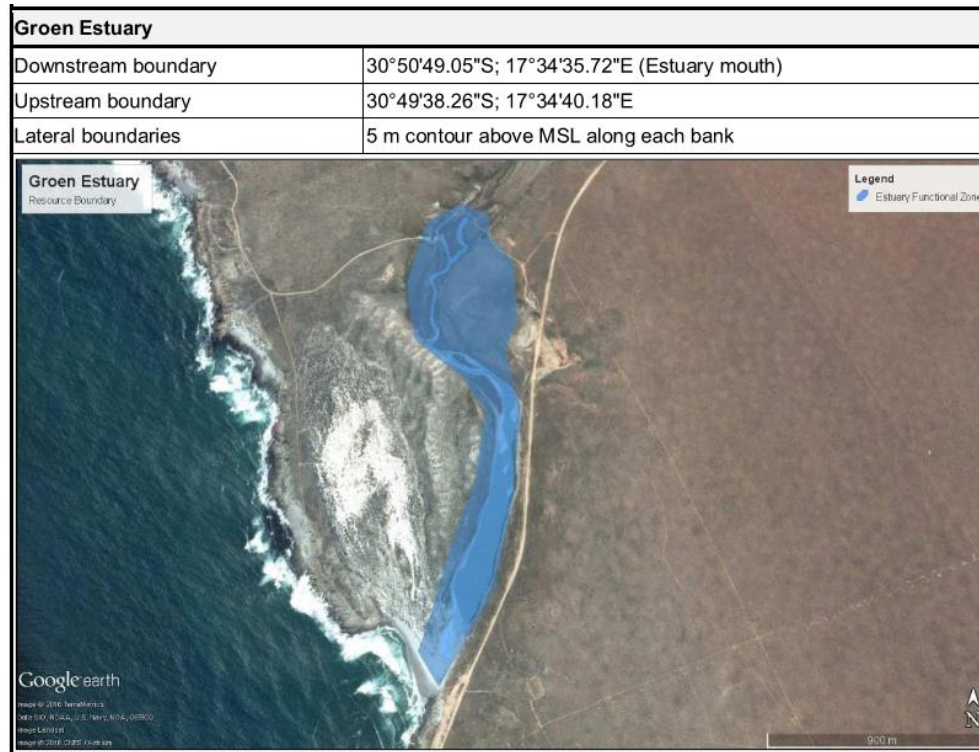


Figure 12: Groen estuary and associated geographical boundaries (DWS, 2017b)

Very little change has occurred in the surface water from a utilisation perspective. Minor change however is expected, especially in the higher flows and flood component, due to the presence of roads and embankments in the catchment acting as small farm dams and trapping surface water upstream of road infrastructure. The EFZ of the Groen Estuary is largely untransformed. With the most significant impact, a causeway running through the upper reaches to the local Namaqualand National Parks office. As the road is at a low level, the impact of it on floods is judged to be limited.

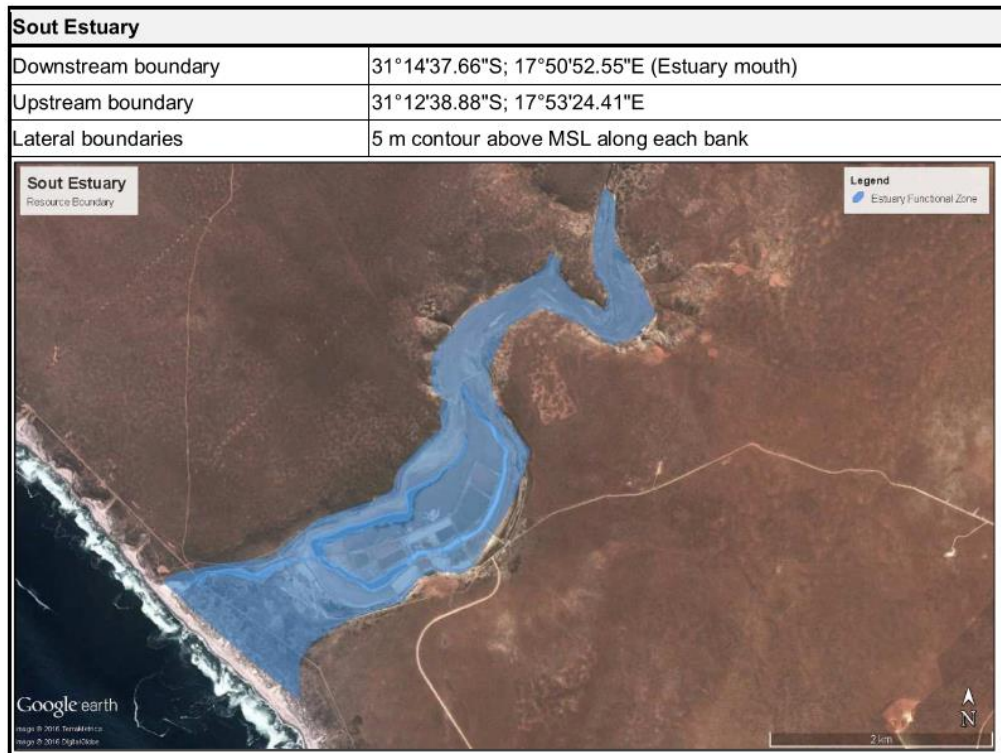
The major pressures on the Groen Estuary include habitat loss due to access road, grazing in the catchment, loss of freshwater input from groundwater abstraction, mining activities in catchment. Future pressures include an escalation of mining activities in the national park and any disruption of subsurface flow.

### Sout estuary

The Sout estuary is located approximately 52km south of the Groen estuary, 60 km north of the Olifants Estuary and falls within quaternary catchment F60D. The estuary covers approximately 433ha in size. The catchment area of the Sout River is estimated at 1 442 km<sup>2</sup>. The catchment falls predominantly within the winter rainfall area and episodic floods occur occasionally. The

annual precipitation of the area is very low. The river is ephemeral with surface flow only occurring after substantial rainfall.

Very little information is available on the hydrology and desktop estimates indicate that there is very little surface flow reduction. However, a weir above the estuary and local road infrastructure is estimated to impact on the magnitude of floods to the system, with similarity in floods to reference condition estimated at 80%.



**Figure 13: Sout Estuary and associated geographical boundaries (DWS, 2017b)**

Connectivity and circulation in the Sout Estuary have been severely modified and at present the system is characterized by three water bodies separated by causeways in the lower and middle reaches. Three roads bisect the estuary, the closest being at about 300 m and the other about 1 km from the mouth, with most of the EFZ disturbed around the mouth area. An extensive salt works is situated in the upper reaches of the system. Very limited connectivity exists between the different water bodies. What little there is, seems to be mostly through a series of channels and pumping schemes. The weir in the upper reaches also prevents connectivity with the catchment of the Sout River.

The major pressures on the Sout Estuary include significant habitat modification for salt works, numerous artificial channels and diversion of the water course, access roads bisecting the estuary, some loss of freshwater input from groundwater abstraction, and active mining activities.

### 3 AVAILABLE INFORMATION

### 3.1. Current Studies

Current studies underway include:

- Joint Baseline Survey-3: Baseline Water Resources Quality State of the Orange-Senqu River System (ORASECOM) (final reports awaited)
- Establishment of Basin-Wide Transboundary Resource Quality Objectives – Development of Transboundary RQOs (ORASECOM). (due to be completed by end-2023) (ORASECOM, 2023b).
- Transboundary e-Flows Study (ORASECOM) (final reports awaited)
- Updating the 2011 Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) Database on a Sub-Quaternary scale for rivers, and riverine wetlands and estuaries within Sub-Quaternary Reach in the Orange-Vaal WMA (Water Research Commission).
- Development, Updating and Review of the Reconciliation Strategy for the Central Planning Area comprising the Orange and Integrated Vall River Water Supply Systems Orange WMAs (DWS).

The update of the Reconciliation Strategy study has been delayed and the availability of study information and reporting is still to be confirmed.

### 3.2. Previous Studies

Previous studies undertaken in the Lower Orange catchment area that will support the water resource classification and RQOs project are listed in Table 3. These will be assessed and reviewed during the information and gap analysis task to determine applicability and availability of information.

**Table 3: Previous Studies undertaken within the Orange River Catchment**

Study/Report Name	Brief description	Date
ORASECOM Joint Baseline Survey-3: Baseline Water Resources Quality State of the Orange-Senqu River System	The JBS is conducted every five years in the Orange-Senqu River Basin, focusing on the monitoring of Aquatic Ecosystem Health (AEH). This study for the Lower Orange catchment will utilise the latest available data on surface water (physical- chemical and diatoms) and AEH (fish, macroinvertebrates and riparian vegetation) that will be relevant for this study. (ORASECOM, 2023a).	2021/2022
ORASECOM Integrated Water Resources Management Plan for the Orange-Senqu River Basin (Phase 3)	The 10-year basin-wide Integrated Water Resources Management (IWRM) Plan covering the period 2015-2024. It has focused on defining and prioritizing ORASECOM's actions and activities over the next ten years. It builds on Phase I and II of the IWRM	2014

Study/Report Name	Brief description	Date
	Plan. The IWRM Plan identified strategic objectives and action areas set out in Table 4.	
ORASECOM 2020-2021 Hydrological Season Synoptic Report on Surface Water Hydrology in the Orange Senqu Basin	The study addressed the compilation of a synoptic report of the 2020-2021 Seasonal (Annual) Surface Water Hydrology of the Orange-Senqu River Basin. This report focuses on surface water quantity information.	2022
DWS Determination of Ecological Water Requirements for Surface Water (Rivers, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA	The study addressed the determination of ecological water requirements and the basic human needs Reserve for the water resources (surface and groundwater) in the Lower Orange River catchment.	2017
ORASECOM Environmental Flow Requirements of the Orange–Senqu River and major tributaries	ORASECOM, 2011 and DWS, 2016. The ORASECOM study included three sites on the lower Orange River at Boegoeberg, Augrabies and Vioolsdrift and the EWRs were determined on an intermediate level. The same sites were included for the DWS 2016 study with an additional site selected at Sendelingsdrift.	2011 and 2016
Support to Phase 3 of the ORASECOM Basin-wide integrated Water Resources Management Plan: Work Package 4C – Water resource modelling	Water resources modelling, baseline scenario, yield analysis, stochastic verification, and validation of the Lower Orange Main stem, Molopo, Lower Orange tributaries (Brak and Hartbees), Fish River (Namibia)	2014
UNDP-GEF Orange-Senqu Strategic Action Programme EFR Study: Orange-Senqu River Basin Research project on Environmental Flow Requirements of the Fish River and the Orange-Senqu River Mouth	The study covered the Fish River in Namibia, Orange River downstream of the Fish River confluence and the Orange River Mouth. The study determined the PES and set the EWR at various sites selected in the study area.	2013
DWS Integrated Water Quality Management Strategy	Department of Water Affairs (DWA), 2009. Development of an Integrated Water Quality Management Strategy for the Upper and Lower Orange River Water Management Areas, Desktop Catchment Assessment Study: Upper Orange Water Management Area (WMA 13 and 14)	2009
DWS Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River – Final Reconciliation Strategy	The Reconciliation Strategy presents a reconciliation of water availability and requirements in the Orange River catchment and based on the water balance, intervention options are presented. The study included amongst others, the following specialist reports:	2015

Study/Report Name	Brief description	Date
	<ul style="list-style-type: none"> <li>• International obligations</li> <li>• Current and future Water Requirements</li> <li>• Urban Water Conservation and Water Demand Management</li> <li>• Irrigation Demands and Water Conservation/Water Demand Management</li> <li>• Surface Water Hydrology and System Analysis</li> <li>• Water Quality, and</li> <li>• Reserve Requirement Scenarios and Scheme Yield.</li> </ul>	
ORASECOM Transboundary Preliminary Diagnostic Assessment (TDA)	Orange Senqu-River Basin. Preliminary Transboundary Diagnostic Analysis. Adopted by ORASECOM in April 2008. Report details the key transboundary issues of the Orange-Senqu basins, provides an analysis of these issues, documents the findings in terms of the causal chain analysis and looks at knowledge gaps.	2008
ORASECOM Orange Senqu-River Basin Transboundary Diagnostic Analysis (TDA)	<p>Orange Senqu-River Basin Transboundary Diagnostic Analysis: Final Draft Adopted by ORASECOM in April 2013.</p> <p>The report provides a scientific and technical basis for the identification and prioritisation of key issues concerning the degradation of aquatic ecosystems in the Orange–Senqu River basin.</p>	2013
ORASECOM National Action Plan for the Orange-Senqu Basin in South Africa	National Action Plans (NAP) are strategic implementation plans to address priority environmental concerns in specific parts of the Orange–Senqu River Basin. The NAPs are closely related to the basin-wide Orange–Senqu Integrated Water Resources Management (IWRM) plan.	2014
DWS Water Quality Total Dissolved Salts (WQT) Modelling and Water Resource Planning Model (WRPM) setup requirements for the Orange River	The study included a calibrated WQT Model for the Orange River and the configuration and testing of the WRPM for the Orange River System	2012
DWS Orange River: Assessment of water quality data requirements for planning purposes: Upper and Lower Orange Water Management Areas (WMAs 13 and 14).	Reports detailing the water quality status quo of the Upper and Lower Orange WMAs based on historical data and a snapshot survey and proposed resource water quality objectives for the Orange River. The study also proposed monitoring sites and a programme for water quality.	2011
DWS, River Eco-status Monitoring Programme (REMP)	The DWS has a routine REMP that takes place on a quarterly basis and whereby macroinvertebrates are monitored. This data will be requested from DWS and included in the Macroinvertebrate Response	Quarterly / on-going

Study/Report Name	Brief description	Date
	Assessment Index (MIRAI), as additional data for the hydrological year.	
Freshwater Biodiversity Information System (FBIS)	On-line platform with biotic data available (fish and macroinvertebrates) that will be used where relevant for the purpose of this study, to supplement the baseline data.	On-going

**Table 4: IWRM Plan Priority Action Areas (ORASECOM, 2014)**

	Strategic Objective	Main Action Areas
1	Ensure the optimised sustainable management of the basin water resources	<ul style="list-style-type: none"> <li>• Surface and groundwater assessments</li> <li>• Optimising efficient utilisation, development, adaptive management of water resources</li> <li>• Inter/Intrasectoral planning and coordination (Horizontal and vertical alignment)</li> </ul>
2	Support socio-economic upliftment and eradication of poverty in the basin	<ul style="list-style-type: none"> <li>• Equitable utilisation of (the basin's) water resources</li> <li>• Water resources development</li> </ul>
3	Ensure that the adverse effects of catchment degradation are reduced, and the sustainability of resource use is improved	<ul style="list-style-type: none"> <li>• Improving water resources quality</li> <li>• Catchment degradation, watershed management, settlement and land-use planning</li> <li>• Environmental water requirements</li> </ul>
4	Maximise security from water-related disasters	<ul style="list-style-type: none"> <li>• Flood and drought mitigation, extreme events, climate proofing</li> </ul>
5	Put an adequate knowledge base in place	<ul style="list-style-type: none"> <li>• Water resources and associated environmental data and information.</li> <li>• Water use and demand data and information</li> </ul>
6	Build sufficient capacity and institutional strength	<ul style="list-style-type: none"> <li>• Promotion/ maximising mainstreaming of key crosscutting and enabling action</li> </ul>
7	Promote high level of stakeholder engagement	
8	Ensure appropriate financing mechanisms are in place	
9	Promote adaptive management and effective monitoring and evaluation systems	

	Strategic Objective	Main Action Areas
10	Promote the mainstreaming of adaptation to potential impacts of climate change into planned actions	
11	Ensure the mainstreaming of gender considerations into planned actions	

### 3.3. Reserve Studies

The Reserve (quantity and quality) is defined in terms of the Ecological Water Requirements (EWR), ensuring the water required to protect aquatic systems (flow, water quality, habitat and biota) of the water resource are provided for; and Basic Human Needs (BHN), ensuring that the essential needs of individuals served by the water resource in question are provided for. The Reserve forms a basis to the water resource classification process by ensuring that the ecological requirements and basic human needs of the significant water resources are accounted for in the analysis. In addition, they define the quantity component of the resource quality objectives. The studies undertaken in the Lower Orange catchment include:

- An intermediate Environmental Flow Requirements (EFR) study was undertaken for ORASECOM in 2010 and included three sites on the lower Orange River at Boegoeberg (EFR O2), Augrabies (EFR O3) and Vioolsdrift (EFR O4).
- The Reserve study undertaken for DWS for the Lower Orange River catchment in 2016 used the same sites and included an additional site on the Lower Orange at Sendelingsdrift (EFR O5). No sites were selected on the main tributaries (Sak, Hartbees, Ongers) presumably due to the arid nature of these rivers. The study addressed rivers, wetlands/pans, groundwater and estuaries in accordance with established DWS procedures and processes.

The outputs from the EFR and Reserve study for rivers (EWR sites), wetlands/pans (as applicable), groundwater (resource unit/catchment) and the estuaries (as identified) will be used in the classification of the water resources and the determination of resources quality objectives. Where priority Resource Units (RU) are identified for the tributaries due to flow requirements, additional information will be selected during the field visit. These might be biological (fish and/or macroinvertebrates) or just diatoms and a habitat integrity assessment depending on the specific requirements for the priority RU.

EWRs were only determined for the main Orange River within the study area. The river EWR/EFR sites in the Reserve study are set out in Table 5 and shown in

Figure 14. Although EWR site 01 was selected, the setting of flow requirements were not undertaken due to the present operation of Vanderkloof Dam and the strategic use (ESKOM) that results in this operation (DWS, 2015). No additional release can currently be made in this upper reach.

**Table 5: Ecological Water Requirements (EWR) sites (intermediate)**

RU	EWR site code	River	Quaternary catchment	Co-ordinates	
<b>COMPREHENSIVE EWR SITES</b>					
EWR01	HopeTown	Orange	D33		
EWR02	Boegoeberg	Orange	D73	-29.0055	22.16225
EWR03	Augrabies	Orange	D81	-28.4287	19.9983
EWR04	Violsdrif	Orange	D82F	-28.7553	17.71696
EWR05	Sendelingsdrif	Orange	D82L	-28.0718	16.95951

### *Scenarios from the Reserve study*

As part of the Reserve study (DWS, 2017), management scenarios were identified to model the impact of implementation of the EWRs on the yield of the lower Orange River. These included present day scenarios with and without EWR, future scenarios (2035 demands and developments) with and without EWR and combinations of various release scenarios from Upper Orange as well as from proposed Violsdrift Dam. Any additional scenarios specifically relevant to the ecological function or well-being of the water resources of the entire basin, e.g., the operation of releases from the larger dams and scenarios assessed for the Upper Orange in relation to the Lower Orange will be discussed with DWS before finalisation of the scenarios for this study.

### *Biophysical Nodes*

The resource units defined as part of the Reserve Study for the arid sections in the Lower Orange River tributaries, are represented by quaternary catchments, and consists of a number of Sub Quaternary (SQ) reaches. This has also been linked to the groundwater units and the previous assessments undertaken at a quaternary basis. The biophysical nodes represent the outflow point at each of these quaternary catchments in most cases, with some exceptions particularly in the case of endoreic areas. Ninety-nine (99) biophysical nodes were defined within the Lower Orange tributaries including the small coastal rivers along the west coast and are presented in Figure 15. The outputs will support the classification process and RQO determination.

### *ORASECOM Environmental Flow Requirements*

As part of the Phase III ORASECOM basin wide integrated resources management plan study (ORASECOM, 2014), the environmental flow requirements were determined at 8 different sites along the Orange and major tributaries. A second study (UNDP – GEF Orange-Senqu Strategic Action Programme: Research Project on Environmental Flow Requirements in the Namibian Fish River and the Orange-Senqu River Mouth, 2013 study) that focused on the environmental flow requirements in the Namibian Fish River as well as the Orange River mouth environmental

requirement was also undertaken. The results of these studies will be used in addition to the DWS Reserve study in determining the water resource classes and setting RQOs.

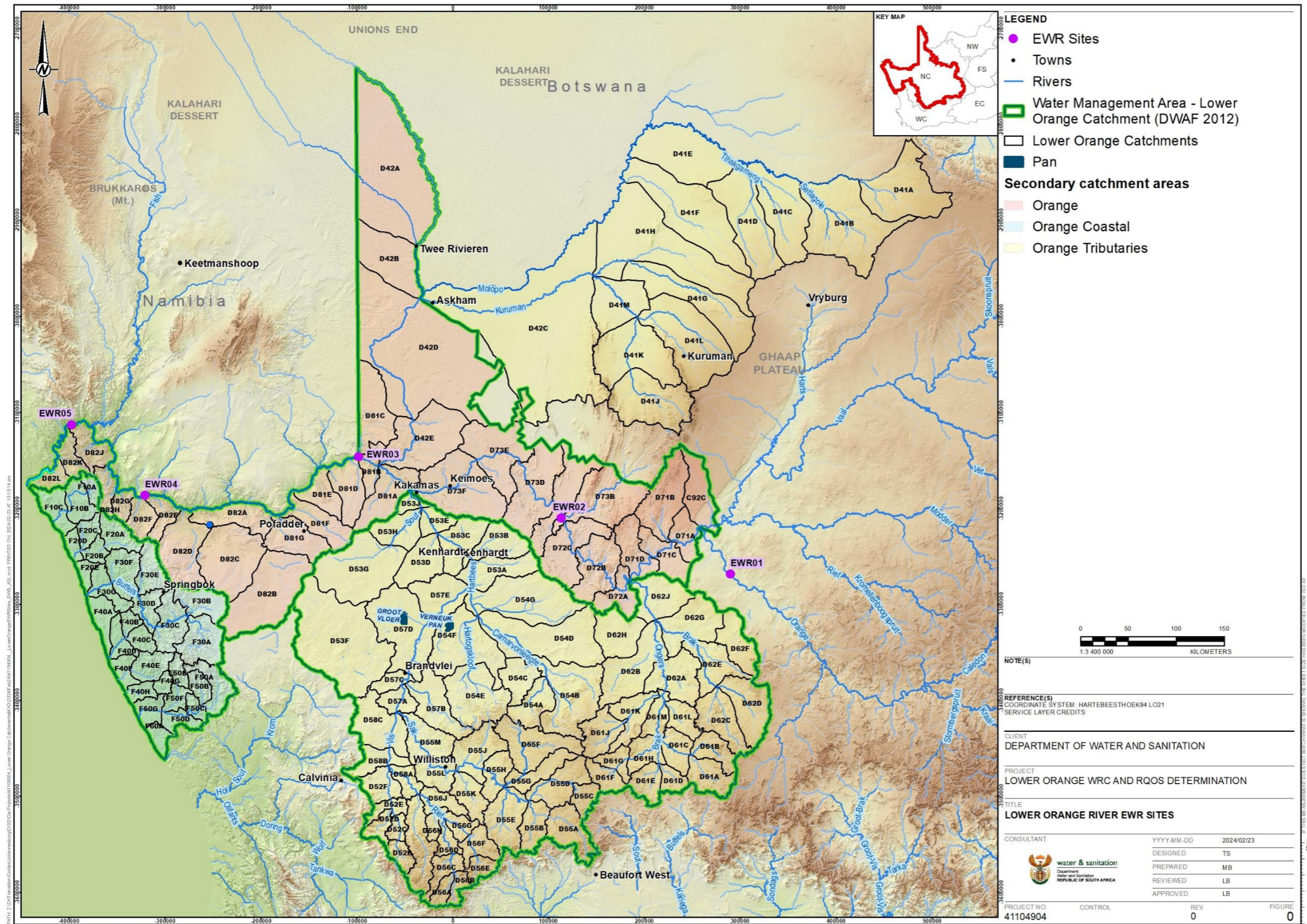


Figure 14: Lower Orange River EWR sites



Figure 15: Lower Orange River Biophysical Nodes (Source: DWS, 2017)

### 3.4. ORASECOM Studies

ORASECOM has initiated numerous studies across the basin. In particular, they commissioned a study in 2009 to assess existing relevant environmental flow studies for the entire Orange River Basin (Dickens, 2009). Since then, ORASECOM undertakes the Joint Basin Survey (JBS) every five (5) years, which commenced in 2010 (first of its iterations – JBS1) (ORASECOM, 2009). The JBS focusses on the aquatic ecosystem health (AEH) from source to sea through the Basin. The second survey was conducted in 2015 (JBS2) (ORASECOM, 2016), followed by the third iteration (JBS3) conducted recently from October 2021 and completed in 2023 (ORASECOM, 2023). The objective of the JBS is to primarily generate an understanding of the ecological trends of the Orange-Senqu River Basin, and to contribute to the establishment of standardised forms of collecting, processing and disseminating data or information regarding water quality, pollution and health of the River System.

The JBS includes the Lower Orange catchment, within the wider basin, relevant for this study. Thus, information, data and knowledge gathered from these programmes will further contribute depth to this study within the Lower Orange catchment particularly with regards to water quality (including diatoms), fish, macroinvertebrates and riparian vegetation.

The JBS3 sites are listed in Table 6 within the Lower Orange catchment area.

**Table 6: JBS3 monitoring sites (ORASECOM, 2023)**

Code	River	Co-ordinates	
<b>Lower Orange Catchment Area</b>			
OSAEH_26_7	Brak	-29.622990	23.016668
OSAEH_26_16	Orange	-29.655185	22.744638
OSAEH_26_17	Orange	-28.437353	21.401059
OSAEH_26_4	Hartbees	-28.857377	20.642833
OSAEH_28_2	Orange	-28.510598	20.171900
Molopo River (Riemvasmaak) (only water quality data including diatoms)	Molopo	-28.464097	20.285076
OSAEH_28_1	Orange	-28.958260	19.172805
OSAEH_28_3	Orange	-28.897728	18.391482
OSAEH_28_4	Orange	-28.762038	17.725099
OSAEH_28_5	Orange	-28.077724	16.944311
OSSWQ_28_4	Orange	-28.565938	16.504421

### 3.5. Modelling and System Analysis

The system analysis supports the scenario evaluation step of the water resource classification process. The scenario evaluation requires that the system demands and the EWR requirements be assessed in confirming if all user requirements are met and the risks presented to the system

based on the varying ecological and socio-economic configurations for each integrated unit of analysis (IUA). In terms of the Lower Orange, the models and supporting hydrology is available and can be adopted for this study. The related operating rules and system management procedures for the Orange River catchment have also been updated and provide further confidence to the process as part of this study. The Lower Orange main stem is a very arid area with nearly no local runoff and only contributes 1% of the total natural runoff at the Orange River Estuary (DWS, 2013). The average mean annual evaporation for this area is 2600 mm/a. The main stem of the Orange River is highly regulated through the upstream Gariep, Vanderkloof and Bloemhof Dams.

Tributaries such as the Ongers, Sak and Fish (Namibia) Rivers are draining arid and semi-arid regions. The flows in these rivers are very infrequent and will only contribute to the Orange River's flow during periods of relative high rainfall. The contribution from these rivers to the firm yield of the Orange River is small. Similarly, Molopo and Nossob Rivers from Namibia, Botswana and the Northern Cape Province north of the Orange do not contribute to the Orange River as these riverbeds are impeded with sand dunes. These rivers consequently are seldom included in the WRYM and eventual WRPM model.

The hydrological data, has been updated and extended as part of the ORASECOM Integrated Water Resources Management Plan (IWRMP) Phase 2 study and Phase 3 (ORASECOM, 2014), applied for all the areas upstream of the Orange-Vaal confluence and the main stem Orange and covers an 85-year period from 1920 to 2004 hydrological years. The hydrology information in the upstream catchments is generally of high to very high confidence. The hydrology prepared as part of the ORASECOM study included the assessment of 16 hydrological zones, 4 of which are located within the Lower Orange. These 16 hydrological zones included 207 hydrology time series files which have been assessed. The hydrological zones have been given a general confidence rating based on data availability in preparation of the hydrology. The hydrology is generally considered to have a good confidence rating. These hydrological zones are shown in Figure 16 as taken from DWS (DWA, 2013).

The system models applied to the analysis include the Water Resources Planning Model (WRPM) and Water Resources Yield Model (WRYM). These models are used for determining dam yields, system balances and assessing the impacts of development scenarios, and have also been used for a variety of water resource analyses throughout the country for many years.

The Orange River system is a highly complex and largely integrated system. It also includes several transfers into and out of the basin, including international obligations, and therefore requires the inclusion of parts of other neighbouring river basins into the water resources modelling setup. Most of the WRYM and WRPM model setups for the Lower Orange are rated to be at medium, medium high to high confidence.



Figure 16: 16 Hydrological modelling zones of the Orange River Catchment (source DWA, 2013)

The models were updated for the ORASECOM studies and then further improved as part of the Orange Reconciliation Study undertaken in 2015. The WRYM will be used to confirm the yield of the systems identified for further investigations, as part of the water resource classification task.

The Molopo River catchment does include a low confidence in the hydrological data WRYM and WRPM networks. The area along the west coast has only the WRSM2000 model setup available, representing a low confidence level (DWS, 2015). Update of the hydrology of the Molopo and Lower Vaal catchments is being undertaken and further information on this will be sourced.

The area of the Vaal River contributes 27% of the total natural runoff at the Orange River estuary. However due to the river being highly regulated and developed it currently only contributes significant flows to the total flow in the lower Orange River in above normal, high flow periods. The Vaal does however contribute towards demands at Douglas via spills and return flows, which has downstream benefits. The Upper Orange catchment has high runoff areas in the upper reaches (Kraai River) and very low runoff in the lower reaches. The natural unit runoff varies between 1 and 70 mm/a and contributes approximately 10 % of the natural runoff at the Orange River Mouth. (DWS, 2013).

A summary of the hydrology for the Lower Orange is presented in Table 7 (DWS, 2013).

**Table 7: Summary of the hydrology per sub catchment in the Lower Orange (incremental runoff)**

Sub catchment		Natural runoff (million m <sup>3</sup> )	Percentage of total natural runoff (%)
Lower Orange Mainstem	D72, D73, D81, D82	135	1
Fish	D46	739	6
Molopo	D41, D42, D43, D44, D45	135	1
Lower Orange Tributaries	D61, D62, D51-D58	162	1
Lower Vaal	C31, C32, C33, D91, D92	191	2
Upper Orange	D13, D14, D31, D32, D33, D34, D35, D21-D24	1191	10

### 3.6. DWS REMP Monitoring Sites

The DWS conducts a quarterly routine monitoring program known as River Ecostatus Monitoring Programme (REMP), during which macroinvertebrates are recorded to assess the health and integrity of selected river systems in the Lower Orange catchment area. These REMP sites are detailed in Table 8. Most REMP sites are monitored, unless affected by factors such as flooding, high flows, dry conditions, or access constraints. When the time comes, the most recent data from the last hydrological year will be extracted from the REMP site MIRAs, which will be requested

from DWS regional offices, to supplement the data for this study. Additionally, in Table 8, JBS3 sites that correspond with DWS REMP sites are indicated in green and enclosed in brackets.

**Table 8: DWS REMP sites within the Lower Orange catchment**

Site	River	Latitude	Longitude	Ecoregion	Geozone
<b>Primary Catchment C9</b>					
C9VAAL-DELPO	Vaal	-28.41847	24.29047	29.02	F
C9VAAL-GONGG	Vaal	-28.48797	24.40919	29.02	E
C9VAAL-SCHMI	Vaal	-28.71169	24.07258	29.02	F
C9VAAL-STCLA	Vaal	-29.0549	23.8213	26.01	F
C9VAAL-VAALB	Vaal	-28.45019	24.32617	29.02	E
C9VAAL-WARRE	Vaal	-28.10756	24.84256	29.02	F
C9VAAL-WVALE	Vaal	-28.09578	24.86975	29.02	F
<b>No REMP sites in primary catchment D4, D5 and D6</b>					
<b>Primary catchment D7</b>					
D7ORAN-GIFKL (JBS3: OSAEH_26_17)	Orange	-28.43722	21.400969	26.05	F
D7ORAN-GROBL	Orange	-28.86658	22.04244	26.05	F
D7ORAN-KANON	Orange	-28.63594	21.09061	26.05	F
D7ORAN-KEIMO	Orange	-28.72806	20.98547	26.05	E
D7ORAN-NEUSB/KAKAM	Orange	-28.77686	20.73969	26.05	E
D7ORAN-PRIES (JBS3: OSAEH_26_16)	Orange	-29.66117	22.75564	26.05	F
D7ORAN-UPING	Orange	-28.45256	21.25992	26.05	F
<b>Primary catchment D8</b>					
D8ORAN-BLOUP	Orange	-28.51061	20.172	28.01	F
D8ORAN-GOOD (JBS3: OSAEH_28_03)	Orange	-28.90742	18.20825	28.01	F
D8ORAN-ONSEE	Orange	-28.74072	19.3305	28.01	E
D8ORAN-PELLA (JBS3: OSAEH_28_01)	Orange	-28.96411	19.14531	28.01	F
D8ORAN-RICHT (JBS3: OSAEH_28_05)	Orange	-28.0777	16.9442	28.01	F
D8ORAN-VIOOL (JBS3: OSAEH_28_04)	Orange	-28.76211	17.72633	28.01	F
<b>No REMP sites in primary catchment F</b>					

### 3.7. Groundwater Studies

Groundwater information to assess/specify the classification and RQOs for the Lower Orange catchment, requires at least the following (updated) attributes:

- Water level depths (depth to the water table from land surface);
- Groundwater abstraction volumes from borehole schemes and single users;
- Vulnerability of the resource with respect to sustainable yield(s) and/or water quality status/trends, thus time series monitoring data;
- Status and/or variation of effective rainfall (rainfall pattern(s) and rate(s)); and
- Effective aquifer recharge values – could use methodology such as Chloride Mass Balance to update recharge values, and recent rainfall time series data to verify effective recharge events.

Groundwater data/information used for the “Groundwater EWR Report (DWS, 2016) for the Lower Orange will be available as baseline information for this classification study and RQOs assessment. It is foreseen that this study will follow the same methodology that was used in previous assessments (e.g. the Thukela classification), which allow assessments down to quaternary catchment level.

Several local high-level groundwater exploration investigations in the Lower Orange catchment have been conducted in the last two decades and data/information should be available from the Department of Water and Sanitation. Information from large basin studies such as the ORASECOM (2014) integrated Water Resources Management Plan will be used as reference as well. The Kalahari Group Aquifers in the D42A and D42B quaternary catchments is regarded as a Transboundary Aquifer System and regarded as a highly vulnerable aquifer systems in terms of sustainable replenishment in a semi-desert environment.

Several small groundwater systems supplying towns/villages in the Boesmanland Region are currently augmented (tested) for long-term artificial recharge during periods of good surface runoff events.

Specific attributes such as groundwater level trends and water quality status/trends will be acquired from the Department’s groundwater assessment/monitoring programs and used to produce a modern review for the classification and RQOs. There are several special groundwater monitoring sites in the Lower Orange catchment where monitoring sites are frequently visited for water level measurements and water sampling.

### 3.8. Wetlands

Detailed information on the inland wetlands of the Lower Orange catchment is largely limited to specific priority systems, such as the Orange River Mouth Ramsar Site. There are however resources that are available for assisting with identifying other important wetland resources in the catchment. These include but are not limited to, the National Wetland Map 5 (Van Deventer *et al.*, 2018), the NFEPA wetland layer (Nel *et al.*, 2011), and the wetland Ecological Water Requirements (EWR) study done as part of the Lower Orange catchment Reserve (DWS, 2016)

– this study focusses only on wetlands within the South African extent of the catchment. Priority systems will be focused on, as identified through the Reserve study and additional systems identified in this study.

Relatively detailed information is available for the Orange River Mouth Ramsar Site (refer [www.Ramsar.org](http://www.Ramsar.org) – Annotated List of Wetlands of International Importance), a transborder site between South Africa and Namibia.

The site provides habitat for a variety of endemic plants and during the summer is the sixth richest wetland in southern Africa, in terms of bird numbers supported; however activities including diamond mining, irrigation, and large-scale water abstraction have resulted in degradation of the saltmarsh on the south bank resulting in the wetland being placed on the Montreaux Record (a register of Ramsar wetlands where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference, maintained as part of the Ramsar List) ([www.Ramsar.org](http://www.Ramsar.org)).

### 3.9. Estuaries

Much information is available related to the Orange River estuary and the smaller arid predominantly closed estuaries. The main studies supporting this study have summarised the relevant and available information related to the estuaries well and include:

- Ecological Water Requirements (EWR) determination undertaken by the DWS for surface water, groundwater, wetlands and the estuary in the Lower Orange Catchment (2017). Key reports include:
  - Department of Water and Sanitation, South Africa, December 2015. Determination of Ecological Water Requirements for Surface water (River, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA. Inception report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. DWS Report No: RDM/WMA06/00/CON/COMP/0115.
  - Department of Water and Sanitation, South Africa, February 2017a. Determination of Ecological Water Requirements for Surface water (River, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA. Buffels, Swartlintjies, Spoeg, Groen and Sout Estuaries Ecological Water Requirement. Authored by CSIR: L van Niekerk, J Adams, SJ Lamberth, S Taljaard for Rivers for Africa. DWS Report No: RDM/WMA06/00/CON/COMP/0316.
  - Department of Water and Sanitation, South Africa, July 2017b. Determination of Ecological Water Requirements for Surface water (river, estuaries and wetlands) and Groundwater in the Lower Orange WMA. Main Summary Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. DWS Report No: RDM/WMA06/00/CON/COMP/0317
- ORASECOM Basin-wide Integrated Water Resources Management Plan (2014)
- Aquatic Ecosystem Health Joint Basin Survey (2011, 2015, 2021),
- Orange River Reconciliation Strategy Study undertaken in 2014/ 2015 and the current update underway,

- Assessment of Estuarine Realm in the 2018 National Biodiversity Assessment.

The 2017 EWR study undertaken for surface water, including estuaries, and groundwater in the Lower Orange WMA considered all the relevant studies, assessments and data available on these resources at the time. This study also draws significantly on the EFR study focussing on the Orange River (2010) and EFR Study covering the Fish River in Namibia, Orange River downstream of the Fish River confluence and the Orange River Mouth (2013). Both the 2010 and 2013 studies were undertaken at Comprehensive Ecological Reserve level, therefore the 2017 EWR study of the Orange River estuary was done at a comprehensive level. The overall level of data is therefore sufficient to support this study.

Data on the five smaller estuaries in the Lower Orange catchment was, however, limited at the time of the 2017 EWR study. An Estuarine Health Assessment, which included field assessments and sampling, of the 5 estuaries were therefore accommodated to support the determination of EWRs for these 5 estuaries. The Lower Orange Estuarine Health Assessment was conducted as a desktop procedure during which a regional team of specialists evaluated estuary health based on the general characteristics of the estuaries. This data together with the specialist information provided during the course of the study therefore represents the most comprehensive recent data on these systems and will largely suffice to support this current study.

During the 2017 EWR study for the Lower Orange catchment, each of the 6 estuaries in the Lower Orange catchment have been delineated as separate Estuarine Resource Units. Data available for the estuaries in question include:

- Detailed EcoClassification for the Orange Estuary.
- Simulated monthly flows under reference conditions into the estuary for the 6 estuaries.
- Long term proposed EWR requirements
- Understanding of major pressures and impacts on the estuaries.
- Data on abiotic and biotic components of the estuaries available and considered in the determination of the ecological categories and ecological importance of all the estuaries.
- Functional and estuarine importance of the estuaries determined.
- EcoClassification, EcoSpecs and Thresholds of Potential Concern (TPC) proposed for the estuaries.
- Detailed recommendations on interventions/actions required to maintain or achieve the REC and PERC.
- Preliminary Reserve determined and recommendations proposed.
- Simulated and workshopped flow scenarios for pre- and post-dam scenarios.

### **Present Ecological State:**

#### *Orange Estuary*

The present ecological state (PES) of the estuary was more formally assessed in 2003 using the Estuarine Health Index as part of a rapid determination of the preliminary ecological reserve for the estuary (DWAF 2003). This assessment concluded that the Orange River Estuary was in a

largely modified state (Ecological Category of D+). Since then, a number of detailed assessments have been undertaken. Amongst these is a detailed EcoClassification undertaken for the Orange Estuary during the 2013 EWR study. All past assessments have resulted in the 2013 assessment of the Orange Estuary EWR being at comprehensive level.

The most recent re-assessment undertaken as part of the 2018 National Biodiversity Assessment (NBA) concluded that the Orange River estuary continue to be severely impacted and was assigned a PES of category D (DWS, 2017b; Van Niekerk, et. al., 2019) and a Recommended Ecological Category of C (DWS, 2017b).

#### *Buffels Estuary*

A desktop assessment was undertaken for the Buffels estuary during the 2017 EWR determination for the Lower Orange catchment. The PES and REC for the Buffels estuary was set as D (Table 9). The Preliminary Ecological Reserve Category (PERC) was also set at the category D (DWS, 2017b). The PES category was confirmed to be a D in the 2018 NBA.

#### *Swartlintjies Estuary*

The desktop assessment undertaken for the Swartlintjies estuary during the 2017 EWR determination for the Lower Orange catchment confirmed that the PES and REC, as well as the PERC, for the Swartlintjies estuary was set as B (Table 9) (DWS, 2017b). The PES category was confirmed to be a D in the 2018 NBA.

#### *Spoeg Estuary*

The desktop assessment undertaken for the Spoeg estuary during the 2017 EWR determination for the Lower Orange catchment confirmed that the PES and REC for the Spoeg estuary was set as A/B (Table 9) (DWS, 2017b). The PES category was confirmed to be A/B in the 2018 NBA.

#### *Groen Estuary*

The desktop assessment undertaken for the Groen estuary during the 2017 EWR determination for the Lower Orange catchment confirmed that the PES for the Groen estuary was set as category B, while the REC and PERC was set as category A/B (DWS, 2017b). The PES category was confirmed to be B in the 2018 NBA.

#### *Sout Estuary*

The desktop assessment undertaken for the Sout estuary during the 2017 EWR determination for the Lower Orange catchment confirmed that the PES for the Sout estuary was set as category E (Table 9), while the REC and PERC was set as categories D and D/E to D, respectively (DWS, 2017b). The PES category was confirmed to be E in the 2018 NBA.

**Table 9: EWR variables for the Buffels, Swartlintjies, Spoeg, Groen and Sout estuaries (DWS, 2017b)**

Component	Estuary				
	Buffels	Swartlintjies	Spoeg	Groen	Sout
Reference MAR (Mm <sup>3</sup> /a)	11.2	1.2	1.3	5.5	0.7
Reference groundwater discharge (Mm <sup>3</sup> /a)	0.23	0.63	0.36	0.13	1.24
Present groundwater discharge (Mm <sup>3</sup> /a)	-0.84	0.59	0.22	0.08	1.13
Present Ecological Status	↓ D	B	A/B	B	E
Estuarine Importance	Average Importance	Average Importance	Average Importance	Average Importance	Average Importance
Conservation Importance (in Namaqualand National Park)			High	High	
Recommended Ecological Category	D	B	A/B	A/B	D
Surface water flow mitigations	↑ floods (road culverts)	↑ floods (road culverts)			↑ floods (weir)
Groundwater mitigations				↑	
Water Quality Mitigations	x			x	
Non-Flow related Mitigations	x			x	x
Potential for further water resource development without impacting on ecology	No	No	No	No	No

### 3.10. Socio-Economics

The purpose of the socio-economic component of the WRCS is to assess the economic prosperity and social well-being implications of different catchment configuration scenarios while utilising the 7-step WRCS procedure. The component assesses and demonstrates the value of ecosystem services (ES) and the economic consequences of water planning scenarios and, how they relate to social well-being.

Previous Studies that will be reviewed includes but not limited to:

- ORASECOM: Water accounts for the Orange River catchment (2014).
- DWS, Lower Orange Water Management Area: 2004
- DWS, Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River (2014)
- Development of ISPS for central region: Lower Orange WMA (2004)

### 3.11. International Institutional Structures

The Orange River is part of an international river basin and shared watercourse by the four Orange Basin states *viz.* South Africa, Namibia, Lesotho and Botswana. The key institutional structures of relevance to the Orange River Basin (Upper and Lower catchments include:

- The Permanent Water Commission (PWC) which evolved from the Joint Technical Committee formed between South Africa and Namibia in 1987. The commission advises the governments of the two basin states on the use and development of the lower Orange River. The commission

focuses on the Vioolsdrift and Noordoewer Irrigation Schemes (the PWC evolved from the Vioolsdrift / Noordoewer Joint Irrigation Scheme).

- The Lesotho Highlands Water Commission (LHWC) is a bi-national body that evolved from the Joint Permanent Technical Commission established under the terms of the Lesotho Highlands Water Treaty. This organisation is responsible for matters of joint concern to Lesotho and South Africa with regard to the implementation of the Lesotho Highlands Water Project (LHWP). Activities include the appointment of auditors and consultants, operating and maintenance plans, tendering procedures, the allocation of costs between the parties and the quantities of water to be delivered.

There are two national institutions linked with the LHWC. The Trans-Caledon Tunnel Authority (TCTA) manages and maintains the delivery tunnel which transfers water across the border (*i.e.* under the Caledon River) to the Ash River in the Vaal catchment as well as all other aspects of the infrastructure in South Africa.

The Lesotho Highlands Development Authority (LHDA) is responsible for the management of all aspects of the project that fall within Lesotho, including infrastructure and social aspects, such as the resettlement and compensation of displaced communities, water supply to resettled communities, irrigation and tourism.

- The Orange-Senqu River Commission (ORASECOM) established in November 2000 is the institution responsible managing the water resources of the Orange-Senqu River basin. The mandate of ORASECOM is to promote the equitable and sustainable development of the resources of the Orange-Senqu River. ORASECOM is the first commission to be established following the regional ratification of the Southern African Development Community (SADC) Protocol on Shared Water Course Systems. ORASECOM provides a forum for consultation and coordination between the riparian states to promote integrated water resources management and development within the basin.

ORASECOM is expected to strengthen regional solidarity and enhance socio-economic cooperation within the region. In this respect, the broad range of studies undertaken by ORASECOM will support the classification of the water resources and setting of RQOs. ORASECOM will also be a key stakeholder to this study, and it is important that the processes and outputs of this study are aligned as far as possible to the IWRMP (Phase 3) and the strategic objectives and plans.

ORASECOM does not, however, have any direct links (through formal mechanisms) with the bilateral organisations (the LHWC or the PWC), although the basin states are required to inform ORASECOM of any issues pertaining to the basin, changes to agreements or impacts on the waters of the basin.

Furthermore, the Commission does not set out criteria for equitable allocation, which is subject to negotiation at political level, and if there is no agreement within the Commission about a proposed project, it is also subject to negotiation at political level (DWS, 2015).

## 4 STUDY INFORMATION REQUIREMENTS

### 4.1. Reconciliation Strategy

The Reconciliation Strategy for Large Bulk Water Systems: Orange 2015, is available and will be used for the evaluation of scenarios task of the classification process. The proposed planning scenarios and intervention options recommended will be assessed to confirm which are still applicable and need to be considered for this study. Of specific relevance to the Lower Orange River will the development of Vioolsdrift Dam.

Little information is available on the current DWS study: 'Development, Updating and Review of the Reconciliation Strategy for the Central Planning Area comprising the Orange and Integrated Vaal River Water Supply Systems Orange WMAs' initiated in 2021. The DWS Water Resource Classification (WRC) will be engaged to source any available information and outputs from this study.

### 4.2. Water Resource System Models

In support of the scenario analysis task of the Classification process, DWS Directorate: WRC would have to facilitate the following in terms of the system models required from within the Department:

- A copy of the latest updated WRYM and WRPM for the Orange River catchment (data and hydrology text files).
- The latest version of the Integrated Vaal WRPM model and ORP (data and hydrology text files).
- The latest version (2023) system models applied in the system operation annual operating analysis updated with the present day demands and network configuration are required.

### 4.3. ORASECOM Studies

A number of ORASECOM studies are available and the information and data will be sourced. Of specific relevance will be the recently completed JBS 3 Survey study data and Transboundary RQOs study. The stakeholder databases related to the studies will be useful to this study and the DWS: Directorate WRC has been in contact with ORASECOM to facilitate this request. The linkages of the transboundary RQOs and the catchment RQOs developed for the Lower Orange River through this study will require alignment and engagement on the co-ordination of the implementation thereof.

### 4.4. Reserve

The results of the 2017 study are considered adequate for the information requirements of this study. It will need to be confirmed if the gaps exist for the tributary sub-catchment areas. The study was based on sites selected on the mainstem and no sites on the drier tributaries. Thus, information as to the state of these tributaries might be lacking as it is based on desktop

assessments only. However, many of these are endorheic systems and have been likely addressed through the biophysical nodes that have been specified.

The availability of the hydraulics from the cross-sections at the existing EWR sites are required for the assessment and interpretation of the ecological consequences for various water resource development scenarios. In addition, the rule and tab tables of the EWRs determined for the Lower Orange River sites will be required. The various models prescribed by the Department, including MIRAI, FRAI, IHI and EcoStatus, will be used during the assessment of the existing EWR sites. At this point it is envisaged that there will not be a need for new EWR sites.

A copy of all rule and tab tables, associated biological models and all relevant Reserve data will be required to be provided by DWS.

#### **4.5. Lower Orange catchment/WMA Boundary Delineation**

It is the team's understanding that the D42C and D41B-M catchments (Kuruman and Setlagole Rivers) is included in the Vaal catchment, although the river is a tributary of the Molopo which is in the Lower Orange catchment. While these catchments were not included as part of the study area for this study, it was agreed at the inception meeting of 6 February 2024, that the drainage region boundaries would be adopted and that these catchments will be included.

#### **4.6. Groundwater**

A wide range of aquifer systems are present in the study area – it is foreseen that existing datasets will be upgraded with the latest groundwater information, *i.e.*, from recent projects and monitoring programme datasets. Upgrading of the groundwater use as per Water Use Authorisation Registration and Management System (WARMS) will have to be considered as it is the only direct source of larger water use figures. Groundwater use by local municipalities and irrigation systems are regarded as bulk water supply schemes and their present usage (abstraction figures), quality/quantity status and impact(s) need to be assessed.

One of the important aspects of this study guiding the proposed resource quality objectives, will be the groundwater quality and quantity trends – this will require long-term groundwater monitoring data. It is assumed that regional monitoring programs by DWS, water services providers, and authorized water users (*viz.*, as per water use license audits) should provide this information.

Specific datasets have been developed for the Lower Orange Reserve (DWS, 2016) determination Study that is already in the format that components thereof can be used as baseline information for this study.

Although basic assessment(s) of the groundwater characteristics has been conducted in the past, this study should focus on the “modern” status and trend of the groundwater resources – *i.e.*, whether they will be sufficient for future sustainable development. Information from local groundwater development studies, exploratory surveys for the catchments groundwater

monitoring programme and resulting time series datasets from these monitoring programmes would provide valuable “modern” data to support realistic water resource classification and RQOs numerical and narrative(s) settings.

Long-term groundwater monitoring data, from both regional and national monitoring program will have to be assessed and interpreted. There might be areas where more detailed groundwater exploration/development information from recent investigations are available – academic, public and private institutions will be contacted.

It should be noted that a significant concern that has disseminated during the last 15 to 20-years of groundwater resources assessment is “the long-term average rainfall depths” used for groundwater recharge estimations (in general). Annual groundwater recharge is one of the “ruling factors” when RQOs as specified. Generally, quantification of groundwater availability is based on normally “average” rainfall since 50-years ago which does not represents the current effective rainfall depths values anymore.

Climate variation in southern Africa has a direct impact on the long-term sustainability of the aquifer systems in the study area. It has been documented that effective aquifer storage recharge is not an annual phenomenon currently and is probably a one-in-five-to seven-year event. Groundwater resource can therefore not be managed according to an annual rainfall recharge figure – or at least reduce the general annual recharge values by a factor <1.0. This aspect should be considered with great care in this study.

#### **4.7. Wetlands**

The wetland EWR study done as part of the Lower Orange catchment Reserve (DWS, 2016) includes mapped representations of wetland integrated ecological importance, and priority wetlands, suggesting that an integrated spatial dataset for priority wetlands in the catchment is available. Together with the data available from the National Wetland Map 5 (Van Deventer *et al.*, 2018) and the NFEPA wetland layer (Nel *et al.*, 2011), this data should be consolidated so that any gaps (e.g. wetland typing, ecological categorisation) can be identified, and addressed as part of this study.

#### **4.8. Estuaries**

The majority of data, models and information required to support the classification and determination of RQOs for the estuaries in the Lower Orange catchment is available through the studies, programmes and reports available to the study team. However, data and information are limited in some areas:

- Recent data and information relating to the system changes driven by mouth closure of the Orange River estuary is limited. In this case, specialist input from especially the specialist team that undertook the 2017 EWR study could assist to define a realistic scenario in light of data limitations.

- Associated with the point above, data on hydrology and hydrodynamics of the estuarine systems are limited. Continuous river flow gauging at the head of the Orange River estuary is not available, while continuous water level recordings is only available at the bridge. In this case, specialist input from especially the specialist team that undertook the 2017 EWR study could assist to define a realistic scenario in light of data limitations.
- Although snapshot data is available for the estuarine components: microalgae, invertebrates and fish, no seasonal data is available.
- Confirmation of the magnitude and presence of existing pressures, as well as identification of new pressures (if any) related to each of the estuarine systems need to be confirmed. This could be addressed through site visits and input from specialist, especially the specialist team that undertook the 2017 EWR study.

#### 4.9. Socio-Economic Analysis

The ecosystem services and economic analysis to be developed during the scenarios will be supported by inputs from: surface and ground water; hydrological; and wetland specialist reports to be conducted in this study.

Table 10 lists the data sources will also be used to analyse socio-economic status of the study area.

**Table 10: Data required to conduct Socio-Economic Analysis**

Data required	Possible Source	Scale
Latest Population densities, social status	National Census data (Stats Sa), Department of Health	Ward Level, Provincial, Municipal
Latest Land Use/Cover	DFFE (egis.environment.gov.za)	National
Economic contributors	Stats Sa, IDPs	Provincial, Municipal
Catchment boundary	DWS	National
Water resource	South African National Biodiversity Institute (SANBI)	National
Infrastructure		National
Satellite Imagery		National

#### 4.10. Potential Data Gaps

Based on the preliminary analysis undertaken potential information and data gaps that may exist relate to the following aspects:

- Water quality data for the catchment (surface and groundwater);
- Socio-economic information:
  - At municipal or catchment level;
  - Physical water account for the sub-catchment (Water use data *i.e.* Volume of water used by sectors, municipal water use, transfers data, groundwater extractions, waste-water volumes); and
  - Ward level population data, as the meta data for 2022 census data is not yet available
  - Health Data by municipality for the catchment;
  - Recent Macro-Economic Classification Data for the catchment.
- EWR sites for the Orange River tributary catchment.

These aspects will be addressed in more detail in the next study task on the information and gap analysis.

#### 4.11. Risk Assessment

The potential identified risks that could have an influence of the execution and completion of the tasks in respect of the classification of water resources in the Lower Orange River catchment are listed in Table 11. As the process will be undertaken with the best available current information, the project team will attempt as far as possible to mitigate the risks within the current scope, time and budget of the project. Should a key constraint be encountered the project team will inform the DWS Directorate Water Resource Classification timeously.

**Table 11: Possible identified risks and uncertainties**

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
Evaluation of scenarios within IWRM	Medium	The Orange Vaal system is managed as an integrated system. It may not be practical to assess the scenarios for the Lower Orange River catchment in isolation.	Possibly assess the scenarios at an integrated level (through the integrated WRPM)	The results may not directly reflect the implications to the Lower Orange River users.	DWS and Study Team
Socio-economic assessment	Medium	Lack of socio-economic data at a catchment/IUA scale. Unavailability of Census 2022 data.	Disaggregate macro-data to the appropriate catchment scale where available.	Lower confidence in results obtained. 2011 Census data may be outdated	Study Team

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
			Adopt 2011 Census data.		
EWR Quantification	EWR sites only on the mainstem Orange River, none on tributaries	State of these tributaries based on desktop information (DWS, 2014) only	Undertake biological or field verification surveys (diatoms and IHI).  Linkages with updating of desktop PES/EI/ES of lower Orange study to obtain additional information	Might use present state for tributaries that are not a true reflection of the rivers	
Surface water quality assessment	Inadequate water quality monitoring	Limited water quality data for sites in the catchment	Additional samples may be taken for water quality assessment and an attempt will be made to source further water quality data from other sources available such as ORASECOM and local studies.	An inaccurate description of the water quality in some of the catchments may lead to incorrect classification and RQOs determined.	Study Team
Groundwater Assessment	Not sufficient groundwater quantity data coverage ( <i>viz.</i> , aquifer saturation levels)	Spatial coverage is a function of exploration exercises – merely hotspot information is available	Obtain information from public and (where possible) private sources. Remote sensing sources and assessments will be applied.	Under estimation of excessive groundwater uses not measurable	Study Team.  Limited to 3-months to search for monitoring datasets
	Not sufficient groundwater quality data coverage	Poor water quality protection is a concern which could increase the salinity status of aquifer systems, e.g.,	All groundwater monitoring networks to be searched to	Underestimate the water quality status and trends of productive aquifer systems.	

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
		untreated wastewater discharges into drainages recharging aquifer systems.	enhance time series datasets. Search for institutional reports on water quality (mining and industries).		
Estuaries assessment	Limited data on mouth dynamics, hydrology and hydrodynamics	Limited data on mouth dynamics, hydrology and hydrodynamics for the 6 estuaries in the Lower Orange catchment is available.	Addressing mouth dynamics is dependent on assessment of the estuarine systems sometime after actual mouth closure. Sampling is therefore not the likely solution. Long term data regarding hydrology and hydrodynamics is the limitation concerning these components. The best solution is therefore obtaining specialist input from the team that undertook the 2017 EWR study.	Mouth closure, hydrology and hydrodynamics is the drivers of the biotic response from the other components assessed in the estuarine systems. Without a realistic model of the hydrology and hydrodynamics in these systems, classification and determination of RQOs and EcoSpecs for the biotic components may be skewed.	Study team
	Possible changes in the pressures on the estuarine systems	Possible changes in the known pressures on the estuarine systems in the Lower Orange WMA may have resulted from the last assessment of pressures on these systems. This includes potential new or additional future pressures that must be taken into account.	Mitigation of this risk can be done through detailed assessment of current pressure data and information, a focussed site visit to confirm the status of pressures on the estuarine systems, as well as specialist input	Accurate quantification of pressures on these estuarine systems is critical to inform the classification and RQOs of these systems and must be considered in the models that will be compiled for the WMA.	Study team

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
			from specialists that has undertaken assessments on these systems in the past.		
RQO Determination	Transboundary RQOs developed by ORASECOM.	Potential misalignment of the transboundary RQOs with this process. Implementation challenges regarding applicability of the two sets of RQOs.	Obtain agreement between DWS and ORASECOM on alignment of the two processes and the application of the RQOs developed.	Confusion with stakeholders/users of the Orange River. Inconsistency in implementation. Regulatory challenges in respect of water use authorisations.	DWS

## 5 SCOPE OF WORK

### 5.1. Overview

The main objective of the study is to coordinate the implementation of the water resources classification system (WRCS), by undertaking the classification of all significant water resources in the Lower Orange Catchment and determining the associated Resource Quality Objectives (RQOs).

This study is primarily of a technical nature and will be supported by stakeholder engagement and consultation at key milestones with different target audiences. The approach and methodology that will be applied is in accordance with the 7-step process of the WRCS outlined in Regulation 810, the DWS manual *Procedures to Develop and Implement RQOs* (DWA, 2011), and the integrated process as outlined in the study, *Development of Procedures to operationalise Resource Directed Measures* (Feb 2017) as set out in Figure 17, which includes the integration of the outputs of the ORASECOM EFR and Transboundary e-Flows/DWS Reserve determination studies for surface water, groundwater and wetlands for the water resources. The procedure to develop and monitor wetland resource quality objectives (Bredin *et al*, 2019) will also be applied in this study.

The Lower Orange Reserve Study outputs will be adopted. The standard methodologies for Reserve determinations (Desktop/field verification and Rapid III) will be applied should any gaps be identified in the 2017 study. Previous water resource management studies that have been undertaken or are currently being undertaken in the catchment that will be used to support this study are described in Section 3 of this report. The key tasks that will be addressed through the study are listed below and detailed in Figure 18, and further in the chapters to follow:

- Confirmation and filling in of information gaps related to the Reserve determination study and EWRs and socioeconomics related to the water resources in the Lower Orange catchment.
- Status quo assessment of the catchment including aspects related to water quantity and quality, water resource impacts, existing monitoring programmes, water resource infrastructure, institutional environment, socioeconomics, and sectoral water uses and users.
- Delineation of Integrated Units of Analysis (IUAs) and Resource Units (RUs).
- The application of the WRCS, i.e., integrated units of analysis delineation and establishing the water resource class by integration of the economic, social, and ecological goals through a suitable analytical decision-making system (trade-offs), specifically modelling identified scenarios to determine feasibility.
- The application of the RQO procedure to determine the RQOs (resource unit delineation; sub-component and indicator prioritisation; and narrative and numerical limits determination).
- Stakeholder engagement, co-operative governance, and consultation and communication processes to be followed.
- Population of the gazette templates, and
- Study management.

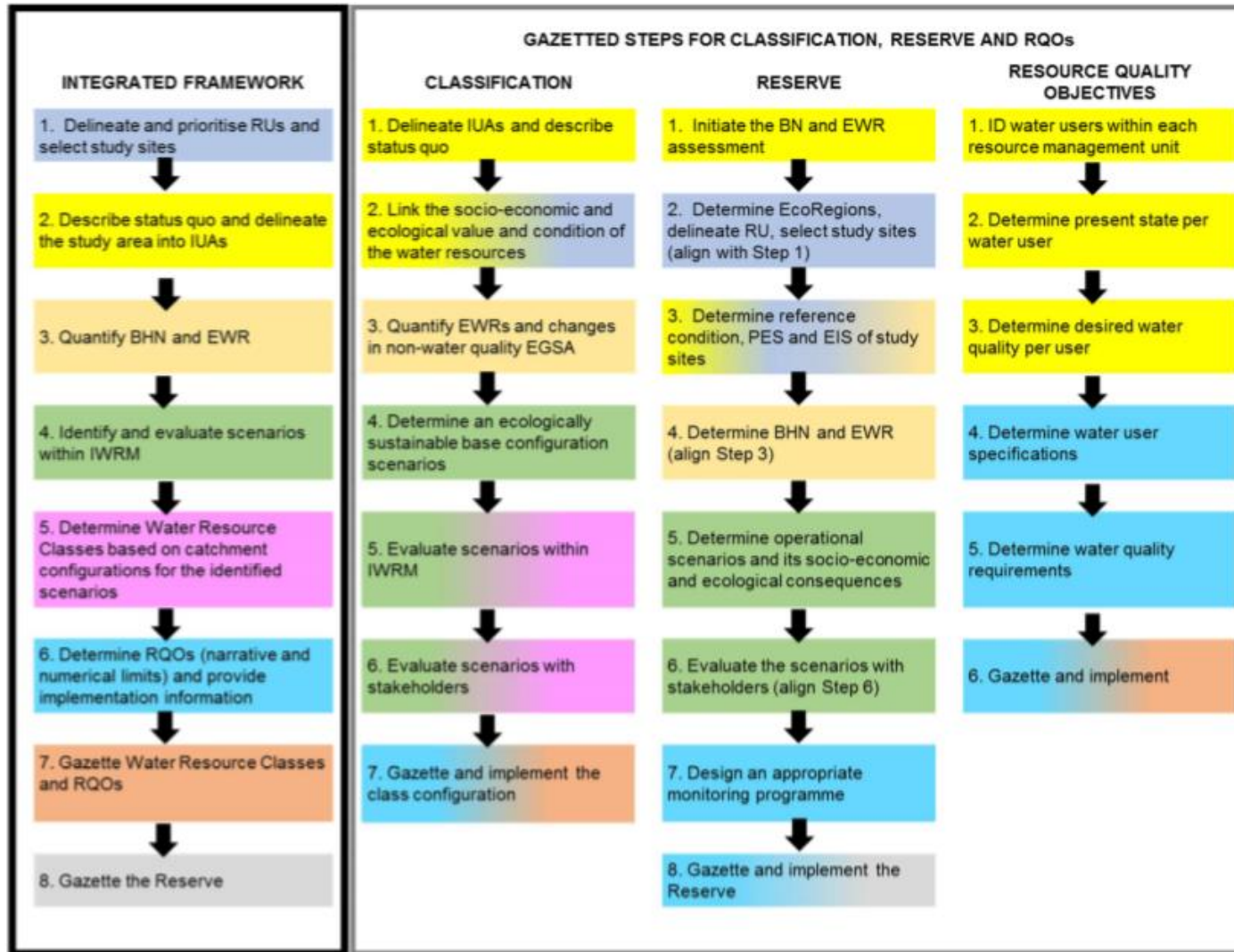


Figure 17: Integrated Framework of the Gazetted steps for Classification, Reserve and RQO Determination (DWS, 2017)

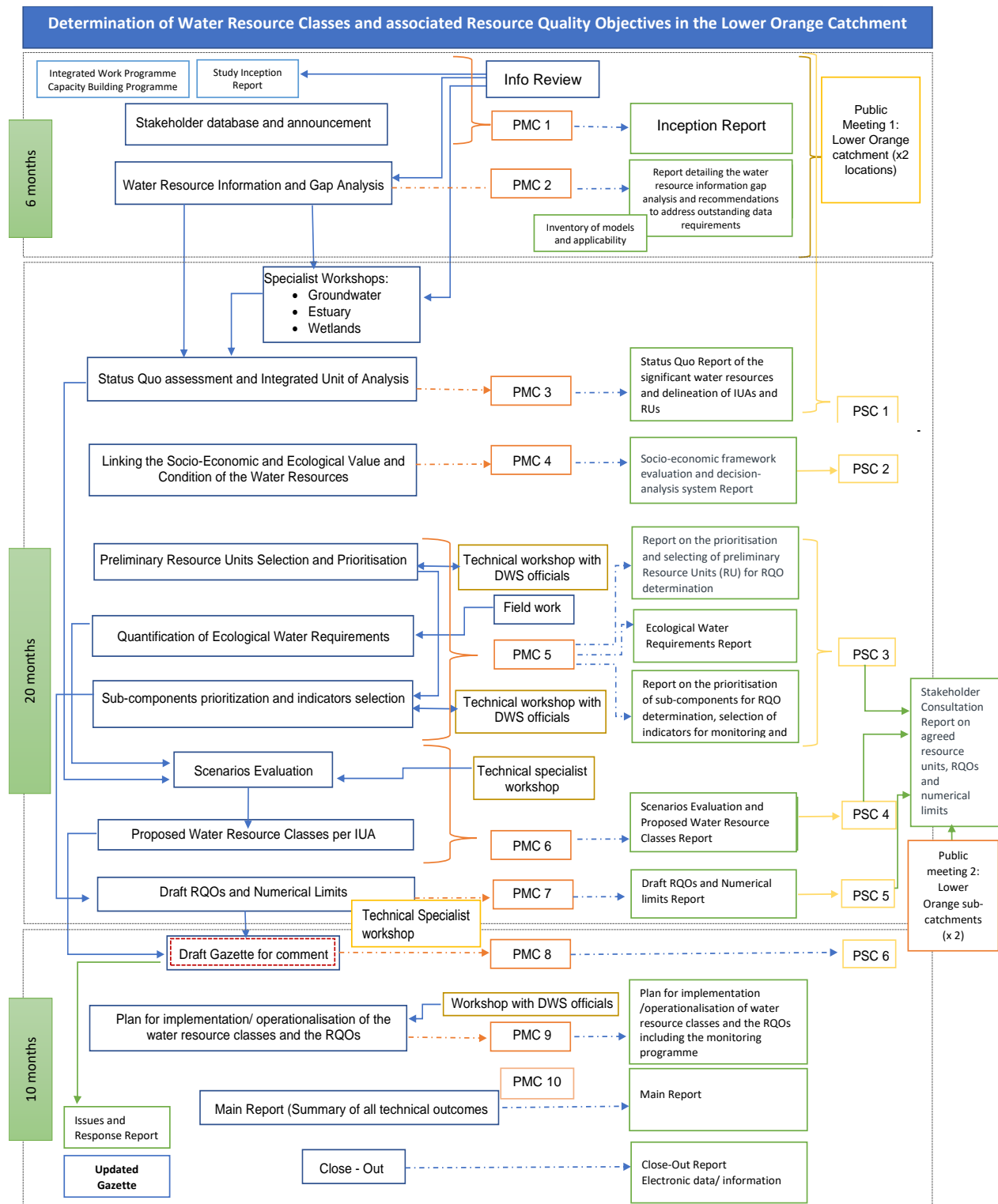


Figure 18: Study Tasks and Deliverables

## 5.2. Water Resource Components

This study focuses on the classification of significant water resources in the Lower Orange River catchment. This will include an identified network of significant resources comprising the rivers, dams, wetlands and pans, estuaries and groundwater resources within the catchment. The available information will be used to prioritise their significance in the catchment and importance to associated water resource systems. For the purpose of this study significant is defined as per the WRCS definition (Volume 2: February 2007, Appendix A).

- **Rivers:** The significant rivers to be classified within defined integrated unit of analysis (IUA) will be identified and confirmed during the status quo phase. This will, as a first step, comprise the main stem river and tributary catchments of the Lower Orange River catchment (the South African portion) including:
  - Lower Orange mainstem
  - Ongers River,
  - Sak River,
  - Hartebeest, and the
  - the Molopo/(*Kuruman\**, *although mainly ephemeral to episodic systems*),
  - Possibly smaller tributaries in upper catchments (if more seasonal hydrological characteristics).

\*The D41G, D41H, D41J-M catchment (Kuruman River) is excluded from the Orange River catchment area, although the river is a tributary of the Molopo. In addition, portions of the C92B and C92C are included as part of the Lower Orange. It was agreed at the inception meeting of 6 February 2024 that the drainage region boundaries will be adopted for this study.

The approach to the endhoreic river systems will be confirmed as many of the tributaries of the Lower Orange are dry with almost no contribution to the main stem.

Additional considerations, e.g., new dams (proposed Vooldsdrift) or priority river reaches for future development or protection purposes will refine these IUAs. Large wetland and pan systems, the priority estuaries and groundwater areas contributing significantly to the base flows of the rivers will be included as part of the consideration of IUA delineation.

- **Wetlands/Pans:**

Priority systems as identified through the National Wetland Map and NFEPA wetland layer, Lower Orange Reserve Study and ORASECOM transboundary RQO study will be identified. Wetlands in the study area will be assessed and a priority list of the most important wetlands/ wetland systems/pans will be compiled which will be taken through to RQO development.

- **Groundwater:**

An assessment of the groundwater RQO attributes required for this study will be conducted – based on the methodology required (GRDM guidelines). A compilation of available groundwater studies related to this study will follow. Time related datasets are required from official monitoring programs and WUL audits.

Establish the extent of data and information gaps and define ways to address this shortfall. The status and trends of groundwater quantity and quality from national and regional monitoring programs and water use license audits should be assessed as well. In general, timely audits of all groundwater related water use licenses should contain crucial time series data that will enhance the credibility of this study.

A process to calculate numerical attributes for each quaternary catchment will follow based on the available methodologies applied in similar previous studies, this approach is to standardize the process.

Five (5) main hydrogeological (time dependant) attributes will be addressed for this assessment:

- Groundwater recharge (impacted over time by climate variations/trends)
- Groundwater interaction with surface water resources to support EWR requirements, *i.e.*, baseflow contribution (but considered limited in this catchment)
- Long-term water level trends providing a measure of aquifer saturation levels – impacted by climate variation(s)
- Groundwater quality time series status and trends will be studied to establish long-term trends and short-term, and
- Status of groundwater use and Basic Humans Needs (BHN) Reserve.

An assessment of the groundwater attributes required for this study will be conducted to establish the level of data and information gaps that need to be addressed.

- **Estuaries**

Six estuaries of national importance in the Lower Orange catchment include the:

- Orange,
- Buffels,
- Sout,
- Swartlintjies,
- Spoeg, and
- Groen Estuaries.

## **6 PROJECT INCEPTION (TASK 1)**

### **6.1. Inception Report**

Task 1 comprises the inception phase of the study. The inception phase is an important component as it provides a platform for assessing and understanding the scope of the project to ensure alignment between DWS's expectations for the study and the final outputs delivered by the study team.

The purpose of this component is to clearly define the project tasks and ensure agreement on the process and activities and the final study deliverables. It includes the definition of the role-players,

project scope and the study programme related to the various tasks. The study tasks are largely guided by the 7-step WRCS process and 6-step RQO Determination process.

Relevant key information that is required to support the water resource classification and associated RQO determination has been reviewed and presented. Specific emphasis has been placed on the recent Reserve Determination studies, previous ORASECOM studies/ Joint Basin Surveys 2 and 3 (JBS) and water resource planning studies (reconciliation strategy) and other relevant studies (e.g. update of 2014 desktop PES/EI/ES database) that have been undertaken. The specific linkages and alignment with the outputs of these studies have been identified during this phase. This report serves as a roadmap for study roll out.

A capacity building programme containing the required activities has been developed and is included in this inception report. In addition, this report highlights the key stakeholder engagement that will take place throughout the project and communication and implementation actions have been defined and collated into a plan during the inception phase.

Project inception has included:

- Initiation meeting with the client to confirm the study terms of reference and client's specification in terms of study management, communication and liaison, stakeholder engagement and contractual aspects (October 2023).
- Team liaison and co-ordination to mobilise team members and initiate the study.
- Preliminary review of available information and data availability in respect of the tasks on which the study will be based.
- Identification of some of the key challenges that are envisaged;
- An outline of the approaches that will be used for the key components to be undertaken through the study process,
- Confirmation of the study work programme, and
- A proposed capacity building programme.

Deliverables forming part of the inception phase include:

**Task 1 Deliverables:**

- Study Inception Report
- Inception Meeting
- Capacity Building programme, and
- Stakeholder database and Project Announcement (in progress, to follow)

**6.2. Information and Data Collation (TASK 2)**

The purpose of this task will be to review previous studies; existing literature and reports, maps and any other relevant information relating to the study area and the collation of data and models

that is supportive and required for the determination of water resource classes and associated RQOs in the Lower Orange catchment. The review will specifically put emphasis on the following:

- High confidence EFR/Reserve determination studies for the Lower Orange Catchment completed in 2017 for rivers, groundwater, wetlands and estuaries.
- The ORASECOM Transboundary Resource Quality Objectives Study recently completed.
- The ORASECOM Joint Basin Survey 3 (JBS3)
- Integrated Water Resources Management Plan (Phase 3) developed by ORASECOM, which focused on economic analysis, water demand projections, water resources modelling, water quality, environmental flow requirements and economic approaches. The Phase 2 plan will also be reviewed.
- PES and EIS Study (2013), and the current update to the PES/EIS Database Study (2023) – however a draft updated databases will only be available end 2025.
- Reconciliation Strategy for the Lower Orange (2015)
- Water Resource System Models (setup and data files)
- Water resources infrastructure setup and water supply systems and developments.
- Any other Reserve work done within sub-catchments,
- Obligations in terms of the PWC agreement (with Namibia) (present and future use from the Orange River),
- Economic data;
- Information from REMP and other biological monitoring programmes, and
- Water quality and ecological information from the DWS Water Management System as well as any additional water quality data from external sources, such as ORASECOM, including potential diatom data from the North-west University which holds the countries diatom library.

A key component of the information gathering will be the understanding and incorporation of the outputs of the above as well as the identification of the data required to be collected, where data gaps exist and where data and information is outdated. The gap analysis will determine any other additional work required, and specifically where additional rapid or desktop Reserves will be required. The preliminary analysis does indicate that no significant gaps exist. The approach to addressing endhoreic rivers once confirmed, may identify specific gaps to process. The Orange River system is well-studied due to it being an internationally shared water course and the central basin to major inter-basin transfers within South Africa.

Field assessments are catered for should there be a need to address identified gaps and collate additional data specifically related to EWRs, wetlands and the estuaries.

This task will also include the sourcing of the system water resources models (WRYM and WRPM) that have been developed for the study area. The models will be used to support the scenario evaluation step of the WRCS process and to assess the achievability of the RQOs. The 2015 study Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River is anticipated to provide the key inputs, as well as any recent updates undertaken through the system management and operating analysis studies of DWS.

The WRYM and WRPM have been updated with hydrology up to 2004 and the most up to date system demands have been incorporated. Preliminary assessment indicates that the models will require minimal refinement to support the analysis in the classification study.

Preliminary information analysis and review has been initiated during this inception phase as the outcome of the information gap analysis will guide the rest of the project programme.

**Task 2 Deliverables:**

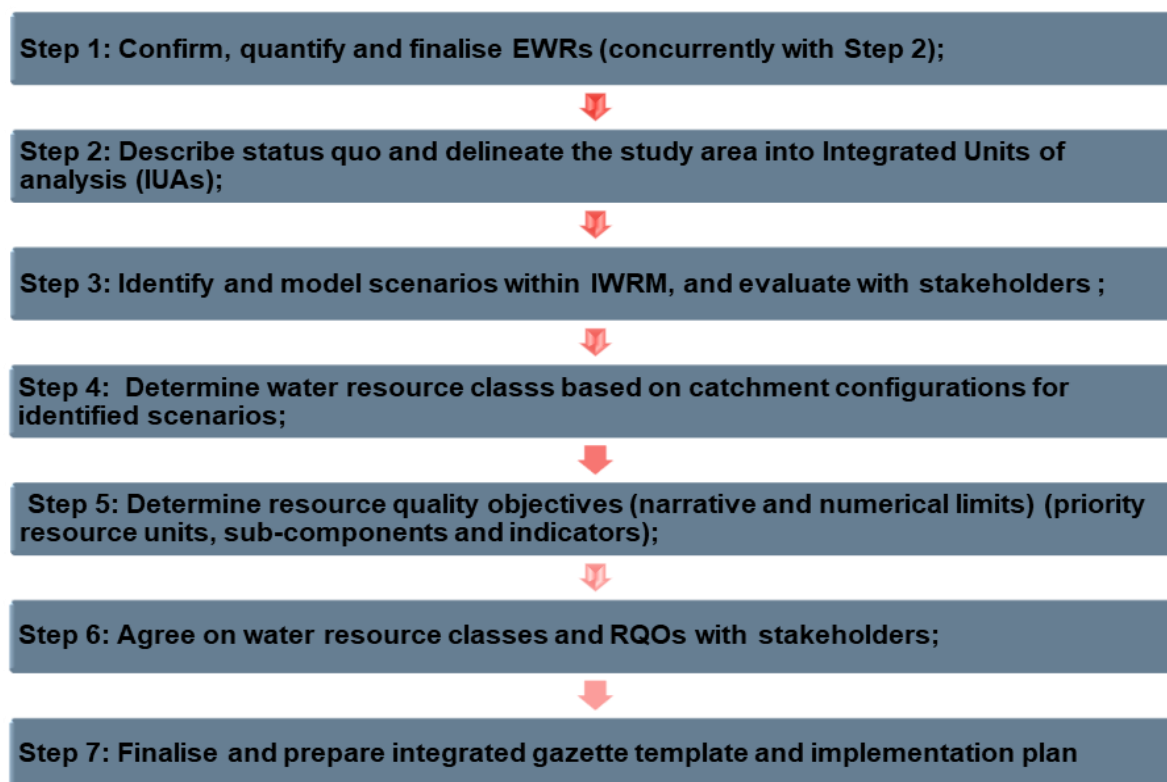
- Report on water resources information gap analysis and recommendations to address outstanding data requirements, as well as the water resource models and their applicability to this study.

## **7 DETERMINATION OF THE WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES (TASKS 3 and 4)**

It is understood that the purpose of establishing water resource classes and determining the associated RQOs is to facilitate a balance between protection and use of water resources. It is important to recognise that different water resources will require different levels of protection. The focus is on protecting the water resource to ensure a healthy functional aquatic ecosystem, while also meeting the requirements of the other water users in the catchment (e.g., domestic, agricultural, industrial and recreation as well as international requirements from both Namibia and Botswana).

The team will strive to ensure that as much of the existing information is used and the steps kept as simple as possible. As the process unfolds, the complexities of the study area, local conditions and stakeholder drivers may also influence the outcomes.

The project approach and methodology that will be applied is in accordance with the 7-step process of the WRCS outlined in Regulation 810, the DWS manual, *Procedures to Develop and Implement RQOs* (DWA, 2011), that has been integrated into the process outlined in the study report, *Development of Procedures to operationalise Resource Directed Measures* (Feb 2017). Activities common to the Water Resource Classification process and RQO determination will be synchronized, and outcomes aligned, meaning that certain tasks for the two components will be undertaken in parallel. The steps to be undertaken as required in terms of the scope of work are indicated in Figure 19, and described below.



**Figure 19: Water resource classes and RQOs determination Process for the Lower Orange River catchment (integrated process in adherence to Regulation 810 of Government Gazette 33541)**

Respective approaches/tools will apply for the respective water resource components in terms of the steps outlined above.

### 7.1. Rivers

#### *Step 1: Confirm, quantify and finalise EWRs*

The results from the existing EWR sites, from previous studies will be evaluated in terms of data availability (e.g., hydraulics, biological data relevance and present state confirmation). A review of the biophysical nodes will also be undertaken to confirm adequacy. The EWR results will be used for extrapolation to identified hydronodes.

Ecological water requirements will be confirmed at each of the selected EWR sites per IUA, priority hydronodes and at the outlet of the IUAs (if EWR site is not in the vicinity of the outlet) for the PES, REC and TEC. The EWR determination will be based on a combination of results from (i) previous studies, (ii) update of the EWR (PES, REC) based on surveys to be undertaken as part of this study and (iii) extrapolate to other sites using the exiting EWR sites characteristics.

The approaches and tools as prescribed by DWS will be used, including MIRAI, FRAI, IHI EcoStatus model and the DRM will be applied if required.

The output will be a set of EWRs per EWR site, hydronode and outlet of IUA for the PES, REC and TEC. Drought, maintenance flows and freshets/ floods will be specified separately to provide flexibility of ecological consequences determination during the evaluation of scenarios. EWR summary and rule tables, monthly time series and flow duration curves provided at each site.

*Step 2: Describe status quo and delineate the study area into Integrated Units of Analysis (IUAs)*

The catchments and IUAs will be described in terms of present state considering the water use developments. The IUA delineation will consider the broader catchment boundaries (key tributary catchments), water resource developments, including storage dams, water supply schemes and developments and land use activities (protected areas, irrigation), ecological information (ecoregion level II, present status, Environmental Importance and Sensitivity (EIS)), groundwater use and interaction and estuarine zones. This will be integrated with the socio-economic zones and stakeholder inputs to determine the final IUAs.

Priority resource units (RUs) and associated hydronodes will be identified within the delineated IUAs. These priority RUs will be based mainly on ecological considerations (A, A/B and B category reaches with very high EI and ES). Reaches with significant water use impacts (quantity and quality) will also be included as priority reaches. Reaches with major wetland systems, pans and ground water areas contributing to the base flows in the rivers will be included as part of the priority RUs.

A specialist workshop is proposed to confirm an approach to address the many endhoreic rivers in the Lower Orange.

Once the status quo assessment is complete, the system models (WRYM and WRPM) as available will be configured and setup based on the confirmed water use allocations and system requirements. This is to ensure that the models will be configured to include the most up to date information.

*Step 3: Identify and model scenarios considering integrated water resources management (IWRM), and evaluate with stakeholders*

Operational scenarios will be defined, including water use developments as well as scenarios for the protection of the water resources. These scenarios will also be informed by the Reconciliation Strategy for the Orange River System, the Lower Orange Reserve study as well as aspects from the Integrated Vaal River System (IVRS), the ORASECOM IWRM Phase 3 study, Transboundary RQO study and any additional developments and planning interventions identified by the DWS:NWRP.

Based on the ecological configurations, proposed developments and socio-economic considerations scenarios will be confirmed, and run to assess consequences of the evaluation of the scenarios to determine the classes. The implementation of the EWRs and proposed new dam developments (Violsdrift Dam) in the Lower Orange will be considered. The scenarios will be modelled with WRYM/ WRPM for the Orange River catchment. Each scenario will be evaluated

to determine the ecological state and ecological consequences at each of the selected EWR sites and priority hydronodes.

*Step 4: Determine water resource class based on catchment configurations for identified scenarios*

The ecological consequences as determined in the previous step will be integrated to provide the resulting classes for each scenario per IUA and at the hydronodes. Thus, a balance between protection and water use for each IUA is established, i.e., the Target Ecological Category (TEC). The implications of meeting the TEC will be described and will ultimately inform the RQOs determined and the Implementation Plan.

*Step 5: Determine resource quality objectives (narrative and numerical limits) (priority resource units, sub-components, and indicators).*

The various tools developed to prioritise RUs (Step 2), and identify sub-components and numerical indicators and limits, will be used to determine the RQOs. The EWR results for the TEC (quantity, habitat, and biota requirements) will be used for those RUs that are selected for the setting of RQOs.

These draft resource quality objectives will be presented and workshopped with stakeholders, and the proposed final results will be prepared for inclusion in the gazette template. These will include the final EWRs for the TECs and the RQOs for quantity, quality, habitat, and biota requirements.

The ORASECOM Transboundary RQO Study will have to be assessed and the outputs aligned where possible with this Lower Orange Study.

## **7.2. Groundwater**

Groundwater Resource Units (GRUs) will be based on the quaternary catchment demarcations. There is no need to go for a finer demarcation of resource units (RUs) as the data is not available. However, where specific hotspot/stressed areas are present, these will be high-lighted in terms of the specific stress/hotspot condition(s), or a specific water quality aspect (Steps 1 and 2 of Integrated Framework for RDM – see Figure 17).

Resource units were adopted for the catchment in the 2016 Groundwater EWR study (DWS, 2017), and it is proposed that classification stay within these demarcations – unless monitoring data shows difference from 2016 to 2023. Specific characteristics (as per Step 2.1 of the Integrated Framework) and additional information requirements will be based on the availability of geohydrological data as in the National Groundwater Archive, but the basic attributes should remain the same due to the aquifer's hydraulic characteristics (Table 4.2 as in Step 2.2 of the Integrated Framework for groundwater resources).

An update of the BHN Reserve, in terms of the most recent population (census) information and a 2018 BHN evaluation will be conducted (based on a 25ℓ/p/d allocation). The groundwater Classification and associated RQOs will be addressed specifically at the EWR sites to address

surface water – groundwater interaction. If possible (*i.e.*, depending on actual hydraulic information), stream (flow) depletion impacts (or factors) will be quantified/qualified (Step 3 - 3.1/3.4 of Integrated Framework for groundwater resources).

Classification of the mapped aquifers in the Lower Orange catchment as assessed through a “national” groundwater classification system, based on the geohydrological mapping exercise was done historically. The attributes demarcating this classification on the groundwater potential side do obviously not change over time due to the aquifer matrix uniformity, however, the groundwater quality and quantity can change and therefore impact on the groundwater classification due to climate change, *i.e.*, average rainfall depths – Step 4 of Integrated Framework for groundwater resources). Information based on the different aquifer configurations and characteristics will be applied as per geohydrological mapping and groundwater resources assessments, and wherever updated information is available, this will be used to augment the original baseline characteristics.

Groundwater quality tends to change over relatively long periods due to extraordinary conditions such as direct pollution, over-usage and/or drastic climate variations. Therefore, groundwater (quality) classification will be addressed using all water quality datasets available and only those units (*viz.* quaternary catchments) where significant changes have been spotted will be re-assessed in terms of the water quality classification. Associated resource quality objectives per IUAs will be addressed and formulated (as per narratives and numerical limits), and to account for such cases where deterioration of the water quality is noted, priority resource units/subcomponents/indicators will be proposed (towards Step 6 of Integrated Framework for groundwater resources). Special attention will be given to sole aquifer systems providing water to rural town/villages and the mapped high salinity “hot spots” in the catchment.

Groundwater quantity (as per the borehole yield classes, BYC) has been mapped in terms of borehole yields, *i.e.*, as indicated on the 2001-2002 national geohydrological maps. This is actually a serious backlog in terms of the aquifer sustainability as significant changes in terms of rainfall recharge and water use have probably developed since 2002. Based on the information generated in the 2016 Groundwater EWR assessment, certain quaternary catchments have high stress factor (SI) values which puts them into a stressed classification status (Step 5 of Integrated Framework for groundwater resources) – these catchments will be addressed to verify the current status and what measures (narratives) should be proposed to improve the sustainability of these systems.

Classification in terms of the current aquifer saturation status (*viz.*, time series water level trends) is expected to be problematic, however, where possible recent water level data will be sourced from the Bloemfontein and Upington Regional Office groundwater monitoring programmes. Based on this information, and the water level status generated in the 2016 Groundwater EWR study, some indication of water level recession/replenishment could be drafted. RQOs for aquifer saturation levels would be possible to generate. As a support, long-term rainfall trends, using cumulative rainfall departure analysis could be applied to support classification and associated resource quality objectives for groundwater quantity – this attribute is however, highly impacted

by climate variability and long-term objectives might be difficult to specify. Protection of the resource rather than over-utilization should be proposed/practiced (Step 6 of Integrated Framework for groundwater resources).

Based on the available groundwater datasets/information, assessment of quaternary catchments where over-utilisation/hotspots areas of groundwater resources in terms of water quality and quantity will be undertaken. Furthermore, where there is significant contribution of groundwater to base flows, these quaternary catchments will be highlighted, and base flow rates defined where flow data is available. Depending on the availability of local groundwater data/information, “hotspots” in terms of water level and water quality trends will be evaluated and used to specify the resource classification and quality objectives.

The most important scope of work will be to ensure that the historic groundwater information platform/datasets are updated to recent information. Several attributes additional to the above-mentioned attributes, *i.e.*, baseflow estimations (where applicable) and the effect of climate variation somehow “disqualifies” the application of groundwater datasets older than the 1990’s.

An assessment of areas where there may exist a possibility of interaction between groundwater and surface water sources (based on the surface water quality characteristics, *i.e.*, levels of dissolved silicon in surface water) is required. The success of this assessment is, however, based on the availability of streamflow information to quantify the groundwater contribution to baseflow – that requires a thorough assessment supported by desktop assessment of satellite imagery.

It is expected that areas where significant groundwater volumes are abstracted for use, *i.e.*, irrigation schemes, municipal bulk water supplies and shallow mine dewatering, river baseflow will be impacted. These areas will be identified as per Steps 1 and 2 of the EWR assessment criteria. Depending on sufficient long-term groundwater monitoring data, Steps 3 of the EWR assessment may be possible. Groundwater information, based on the national geohydrological mapping (done >20-year ago) should be sufficient to (at least) determine the water resource classes and quality objectives. Areas where recent groundwater use-developments have taken place should be assessed.

The interaction between groundwater and specific wetlands needs to be qualified as the water requirement for these wetlands are merely driven by shallow groundwater conditions – lowering local groundwater level elevations by a few decimetres (10x cm) will have significant impacts on wetland biomes and water balance.

Once the groundwater resource classes and quality objectives have been established, GRUs/IUAs will be prioritized in terms of resource residual allocations and water quality “hotspots” – specific indicators will be identified, and implementation measures.

### **7.3. Wetlands**

#### *Preliminary identification of significant wetland resources*

Existing GIS resources such as the National Wetland Map 5 (Van Deventer *et al.*, 2018), the NFEPA wetland layer (Nel *et al.*, 2011), the wetland EWR study for the Lower Orange Reserve (DWS, 2016), Ramsar site spatial data (Orange River Mouth) and other literature on wetlands of the area will be used to identify significant wetland resources in the Lower Orange River catchment. Depending on the resolution of available imagery, this will be complimented with desktop mapping where appropriate in areas where the wetland coverage is poor. Information from available reports related to key wetlands in the catchment will also be used to support this. The expected outcome is the development of a Priority Wetland layer for the catchment, building on that already developed as part of the wetland EWR study for the Lower Orange Reserve (DWS, 2016).

*Workshop to determine which wetlands are likely to be providing key ecosystem services (ecosystem services assessment)*

A specialist wetland workshop will be held by the team to understand the catchment stresses and to provide input into the determination of the IUA's. This will assist in identifying those wetland resources likely to be providing key ecosystem services within the catchment.

*Refinement of Priority Wetland layer and desktop delineation of Priority Wetlands*

Based on the workshop outcome, the Priority Wetland layer will be refined and a desktop delineation of selected Priority Wetlands will be undertaken. The refinement will include consideration of the following criteria:

- Whether or not the system is, or occurs within, a Ramsar Site;
- Whether or not the system occurs within a conservation area;
- Whether or not the system is recognised as having cultural significance;
- Whether or not the system occurs in a database, regional, local or other, that indicates it as being an important wetland;
- Whether or not based on expert opinion, the system can be considered an important wetland;
- Whether or not the system is known to support rare or endangered species;
- Whether or not the system can be considered representative of a specific type or representative of an eco-region;
- Systems known to contain peat (peatlands);
- Systems known or thought to be important in terms of supporting livelihoods or providing key ecosystem services;
- Systems thought to be important in terms of the hydrology, geohydrology and/or the biogeochemistry of a particular area or sub-catchment;
- Systems thought to be unique or representative of a type unique to a particular area or region;
- Whether or not the system forms part of a particular complex of wetlands that may be linked by certain attributes or a key driver; and
- Whether or not the system forms part of a river, biodiversity or landscape corridor that is considered important for a particular area or region or a particular species.

- Whether or not the system can be considered as depending on a groundwater resource for its long-term existence, *i.e.*, a groundwater driven wetland system (so-called fens).

The above will further be considered in the context of the health or state of the wetland systems selected and the likely trajectory of change given the current land-uses in the area or whether or not it is considered to be at risk from proposed new water uses in the area. The intention is to produce a refined Priority Wetland layer for the catchment, also taking into account aspects related to land and water use issues in the catchment.

#### *Desktop typing and categorisation of Priority Wetlands (PES and IS)*

Where possible, the selected Priority Wetlands will be typed in accordance with the HydroGeoMorphic (HGM) classification system first described by Brinson (1993) and modified for application in South Africa by Kotze *et al.* (2007), and SANBI (2009). Key drivers, which are essentially automatically derived as part of the HGM classification, will also be determined for the Priority Wetlands. This is the strength of the HGM system as each HGM wetland type has conceptually distinct hydrological drivers based on the input, throughput and output of flows or water (see Kotze *et al.*, 2007). This process will further be strengthened by considering aspects related to the catchments of the wetlands and considering possible groundwater links.

An integrated ecological importance rating was ascribed to wetlands within the Lower Orange catchment in the 2016 wetland EWR assessment, based on data obtained from the national PESEIS study (DWS, 2014). It is expected that Present Ecological State (PES) and Importance and Sensitivity (IS) information may need to be updated, given the elapsed time period since the last assessment.

Other databases and information sources will also be used where appropriate to contextualise the current general state and importance and sensitivity indicators where possible and identify any significant changes since the 2016 wetland EWR assessment that was done for the Lower Orange reserve. It is envisaged that regional and national land cover databases as well as provincial conservation plans, river health programme and NFEPA information will be used as the baseline data for this purpose. If appropriate, an updated desktop PES assessment may be undertaken using a combination of the desktop PES model (Kotze, 2016) or WET-Health Version 2 (Level 1A) (Macfarlane, Ollis and Kotze, 2020) and image-based rapid assessment technique.

#### *Verification of the Priority Wetland layer*

It is proposed that this involves a field visit to selected Priority Wetlands. Rapid field assessments of the systems visited will be undertaken where possible and access allows, and the land categorisation used in the desktop PES assessment will be checked and verified as applicable. The objective of the field visit will be to verify, where possible, the desktop categorisations and typing of the wetlands visited.

#### *Update the categorisation (PES and IS) and determine the REC and TEC of the Priority Wetlands*

Based on the findings of the field visit, the categorisation of the Priority Wetlands will be updated as necessary. It is envisaged that additional workshops may be held with the study team during this phase of the study in order to align and integrate the findings of the wetland study with the overall Classification. During this task, the Recommended Ecological Category (REC) will be derived for the Priority Wetlands based on a modification of the standard rules indicated in Rountree *et al.* (2013). Based on known threats or pressures for development within the related catchment areas, the relationship between the threats/pressures and the expected change in condition of the Priority Wetlands identified will be determined. Wetland baseline condition or current PES will serve as the starting point. Expert judgement will be used to derive how the priority systems are likely to either stay the same or change depending on the pressures they are currently experiencing or based on additional threats or pressures going forward.

*Determine wetland sub-components and indicators as applicable*

It is envisaged that this will involve a wetland team workshop to determine sub-components and indicators for each Priority Wetlands RQO's as applicable.

*Set preliminary Wetland RQOs*

Generic and specific preliminary RQO's for each of the Priority Wetlands/Pans will be developed as applicable.

#### **7.4. Estuaries**

It is important to assess whether there have been any changes to the pressures exerted onto the estuaries within the period since the 2017 EWR study of the Lower Orange catchment. To maintain the Orange Estuary in a high ecological category recommendation made in terms of REC in the 2017 EWR study and reflected in the 2018 NBA must be achieved.

Where necessary, a site visit to the estuaries by the team will be conducted to survey for changes in abiotic drivers and biotic responses where data are limited or changes in anthropogenic pressures are perceived. Given that the only snapshot assessment of the 5 smaller estuaries were done in 2016, the need for another sampling trip would be assessed to determine whether the answers it will provide is worth the time and cost. The additional information gained from this and from more recent available information will be used to:

- Identify flow and non-flow pressures;
- Confirm ecological baseline and health;
- Reassess the Present Ecological Status (PES) of the estuary during a specialist workshop;
- Re-evaluate ecological water requirements; and
- Prepare the RQOs for the PES and Recommended Ecological Category (REC) for all estuary components as follows:
  - flow

- hydrodynamics,
- water quality,
- sediment processes,
- microalgae,
- macrophytes, invertebrates, and
- fish and birds.

The approaches and tools as prescribed by DWS will be used in conjunction with the 'Estuary Health Index Manual' by Turpie, 2013.

## 7.5. Socio-Economic Assessment

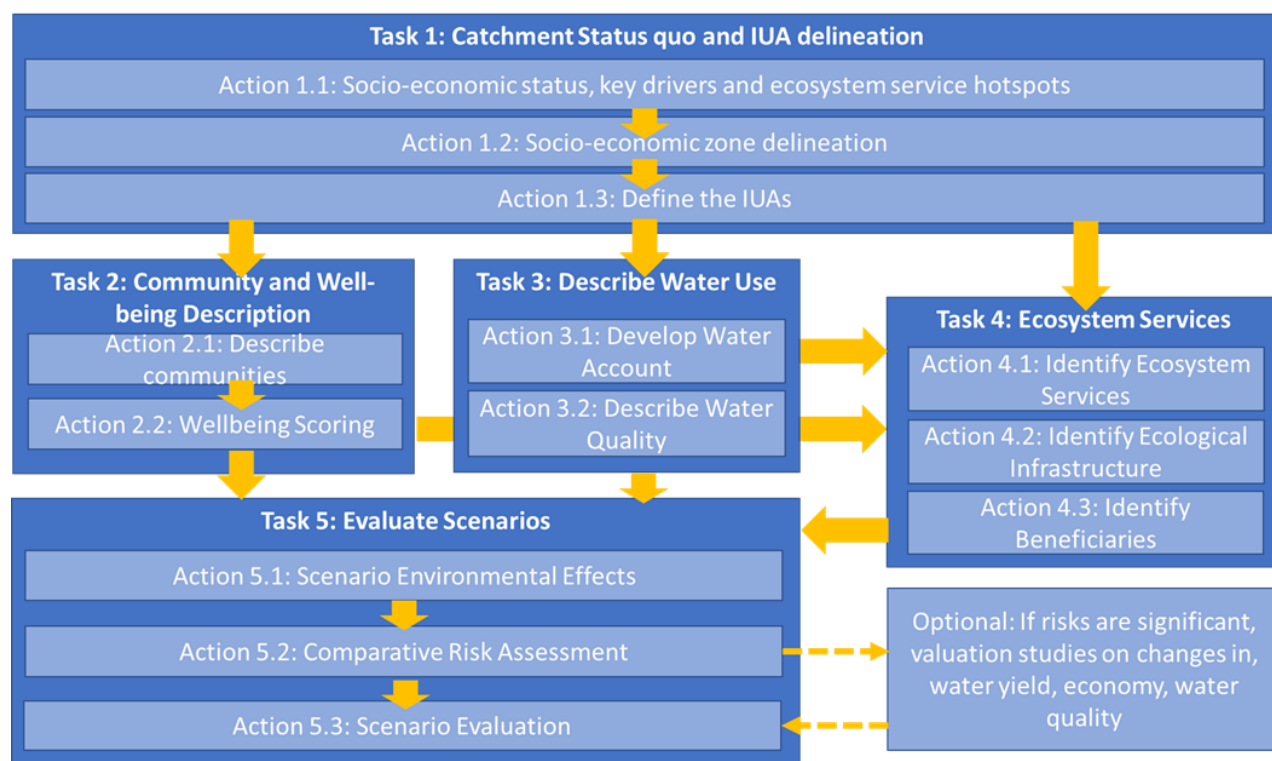
The socio-economic assessment (SEA) for Lower Orange River catchment water resource classification requires the definition, understanding and classification of social, economic, and ecological components. The approach classifies the primary characteristics of each component towards assessing impacts against various scenarios. The classification will be conducted in line with DWA 2007c: Socio-economic guidelines for the 7-step classification procedure and will draw directly from the updated guidelines as presented in WRC, 2018 project entitled: Review of Socio-Economic Guidelines for Water Resource Classification and Development of an Improved Decision Support Tool. A schematic representation of approach and tasks to be followed as per WRC, 2018 are presented in Figure 20.

It is noted that the proposed approach corresponds to the gazetted Department of Water and Sanitation gazette on the: Socio-economic guidelines for the 7-step classification procedure as per Figure 21 (DWA, 2007c).

### 7.5.1. Task 1: Determination of Catchment Status-quo and Determination of IUAs

The three actions required for determining the IUA's are as follows:

- **Action 1.1:** Describing the present socio-economic status and key drivers and ecosystem service hotspots within Lower Orange catchment through identifying of ecosystem services across the catchment guided by Millenium Ecosystem Assessment (MEA) 2005 and The Economics of Ecosystems and Biodiversity (TEEB) 2013. This action requires an understanding of spatial patterns in population densities, land use and the economic drivers across the catchment.
- **Action 1.2:** Delineating the socio-economic zones through having homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems.
- **Action 1.3:** Defining the IUAs in workshop environment with all relevant specialists contributing their findings and agreeing on the proposed IUA delineations.



**Figure 20: Socio-economic assessment approach with stepwise tasks and intermediate actions to be followed in the Lower Orange River catchment socio-economic analysis**

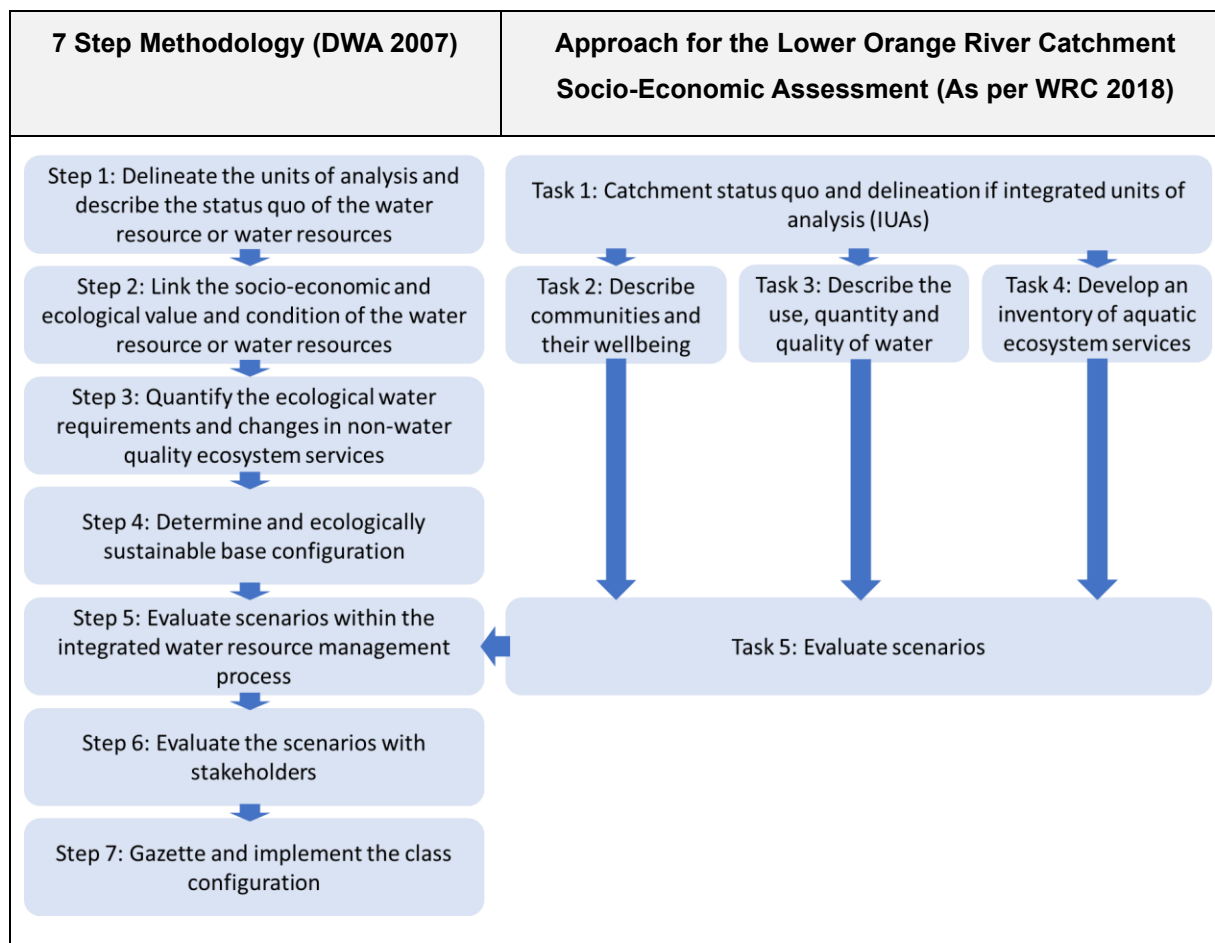
### 7.5.2. Task 2: Describe Communities and Their Wellbeing

The aim of this task will be to describe the wellbeing of communities within each IUA identified in the previous step.

The well-being of the communities in the Lower Orange catchment will be described using various indicators of financial, physical, human, social and natural capital assets available to those communities. The process includes the construct of an index of wellbeing which are used together to determine a Social Wellbeing Score (SWS).

Three actions required to complete this task:

- **Action 2.1:** Describe the social context. This will largely be based on the latest census data.
- **Action 2.2:** Wellbeing Index Scoring which will be approached through multiple indicators of well-being being integrated, resulting in an overall Social Wellbeing Score (SWS).
- **Action 2.3:** Describing the relationship with water sources which will illustrates the reliance of households and individuals on specific water sources for daily use.



**Figure 21: Alignment of the Socio-economic guidelines with the 7-Step process for determining water resource classes**

### 7.5.3. Task 3: Describe the Use and Value of Water

The objective of this task will be to describe the way in which water is used on an IUA level, and to estimate the value generated by that use.

- **Action 3.1:** Water accounts will be developed and that includes physical and monetary flow accounts. Water flow accounts are useful for analysis on how economic changes impact the environment and how changes in water availability impact the economy.
- **Action 3.2:** A high level water quality account will be defined that will assist in reporting consequences of economic development that result in ecological degradation. This action will rely heavily on inputs from the other classification components.

Integration of water quality account and water flow account will assist in quantifying available water that is suitable for use.

### 7.5.4. Task 4: Develop an Inventory of Aquatic Ecosystem Services

Following on from task 1, the purpose of this step will be to identify the ecosystem services (ES) within the catchment at an IUA level and determine a broad idea of the demand of these services by communities and the economic sectors that utilize them.

Three actions required to complete this task:

- **Action 4.1:** The TEEB (2013) classification system provides a typology of ecosystem services. This typology will be used as a guideline to identify the relevant ecosystem services within each IUA.
- **Action 4.2:** Identifying the ecological infrastructure, which in turn supplies the flow of ecosystem services identified in Task 1.
- **Action 4.3:** Determining beneficiaries and demand for ecosystem services on a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography.

#### 7.5.5. Task 5: Evaluate Scenarios

The objective of this task will be to evaluate the selected scenarios within the socio-economic framework. The scenarios, in the context of water resource management and planning, are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Three actions required to complete this task:

- **Action 5.1:** Develop environmental effect statements which will provide context on the broad effects that scenario changes have at the IUA level. This allows participants of the analysis to form a causality chain of the effects of changes in the environment to beneficiaries.
- **Action 5.2:** Conduct a Comparative Risk Assessment (CRA) process.

The aim of the CRA is to determine the risk the selected scenarios pose to ecosystem services. This process will be informed by outputs of Tasks 2, 3 and 4.

CRA methodology takes a rigorous approach to determining the risk posed to ecosystem services resulting from various management scenarios. The CRA is typically conducted by a team of multi-disciplinary experts in a workshop setting whereby the list of ecosystem services are prioritised based on risk. The prioritised list will contain a descriptive chain of causality for each ecosystem service/scenario interaction. Prioritised ecosystem services would then move on to the valuation step.

- **Action 5.3:** Ecosystem Services Economic Valuation

If ecosystem services are at risk, economic valuation techniques will be utilised to assist in the evaluation of the trade-offs between the various scenarios. It is important to note that the valuation step can be resource intensive, especially where no previous valuation has been

done for the region. As a result of this the methodology used in the valuation step will be driven by available resources. As a point of departure however, the framework to support decisions when choosing valuation techniques as developed by Blignaut and Lumby (2004) will be utilised. Techniques to be explored are included below:

- If market values are available, then changes in productivity techniques will be employed,
- If non-distorted (efficient) market prices are not available, then surrogate market approaches such as the travel cost and hedonic pricing methods can be used;
- If market prices are not available, but direct (efficient) proxies are, a variety of assumed preference techniques such as damage cost, replacement cost, cost of illness or other benefit transfer methods (BTM) can be used;
- When indirect proxies are available, observed behaviour techniques such as the travel cost and hedonic pricing methods can be used; and
- If no market prices or proxies exist, hypothetical behaviour methods such as contingent valuation methods or conjoint analysis methods can be used.

It is often necessary to use a combination of valuation techniques rather than a single technique to value ecosystem services. The team will explore techniques which will be practical and relevant for Lower Orange River catchment.

The approach described above relies heavily on data inputs from the bigger classification process and transdisciplinary collaboration. As a tool to standardise and simplify the process the Socio-Economic Classification Tool (SeCT) as developed in WRC, 2018 will be used.

#### **7.5.6. The Socio-economic Classification Tool (SeCT)**

The Socio-economic Classification Tool (SeCT) is a method for assessing, comparing, ranking and describing formally, the risks to ecosystem services and therefore the benefits they provide based on changing scenarios.

The SeCT is a Microsoft Excel based tool that incorporates all the tasks from the socio-economic assessment, by ensuring standardised inputs and outputs. This tool aims to simplify the process and ensure that classifications are transparent and comparable. The tool also provides a platform from where realistic socio-economic information is presented when determining trade-offs resulting from various water use scenarios.

#### **7.5.7. Additional Considerations: Shared Water Course**

The classification of a catchment in terms of contribution of available water and ecosystem services to socio-economic wellbeing is a valuable method to inform appropriate resource management approaches. In the case of the Lower Orange River the quantification of these components will require assessment of the benefits at a larger international basin scale. The catchment is significant meaning the value of water availability is not limited to South Africa but to

Namibia as well.

The specific approach will be explored further in subsequent deliverables as management scenarios become clearer.

#### **Tasks 3, 4 and 5 Deliverables**

- Status Quo and delineation of Integrated Units of Analysis and Resource Units Report
- Report linking the value and condition of water resources
- Resource Units Prioritization Report
- Ecological Water Requirements Report
- Scenarios and Consequences Report
- Draft Water Resource Classes Report
- Sub-component prioritisation and indicators selection Report
- Draft RQOs and Numerical limits Report
- RQOs and numerical limits workshop and stakeholder consultation Report
- Final RQOs and numerical limits Report
- Classes and RQOs Gazette template
- Plan for implementation/operationalisation of water resource classes and RQOs

## 8 STAKEHOLDER ENGAGEMENT (TASK 6)

It is recognised that the process of determining water resources classes and associated RQOs requires a strongly driven stakeholder engagement and communication component supported and guided by the necessary technical and institutional components. While stakeholder engagement is a key consideration in this study, the overall study outcome is technically driven, and supported by the appropriate engagement structures.

Stakeholders are defined as persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and / or the ability to influence its outcome, either positively or negatively.

Given the context of the classification and RQO determination processes, stakeholder engagement for this study aims to:

- Inform the broader public of the project and assist in awareness creation and the understanding of what water protection measures mean to them as water users within the catchment,
- Engage key stakeholders (directly affected parties, influencers, decision-makers and thought leaders representing various sectors of society) involved in concurrent activities to intelligently apply the collective wisdom to the successful determination of water resource classes and RQOs; and
- Through sound relationships with key stakeholders and satisfactory communication, build trust, create understanding, and collaborate to ensure that all role players work towards sustainable water resource protection and use.

Previous stakeholder databases generated through the Reserve Determination Study, Reconciliation Strategy, the ORASECOM studies such as the recent Joint Basin 3 study and the Transboundary RQO study, will be used as a basis to identify stakeholders and develop a working database that will be regularly updated over the course of the study.

The stakeholder communication and liaison process are briefly described below.

### 8.1. Development of a stakeholder database

A stakeholder database will be compiled and maintained throughout the study. The identification of stakeholders is important and will be done in collaboration with the DWS, ORASECOM and stakeholders in the study area.

Stakeholders may include locally affected communities or individuals and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organisations and groups with special interests, the academic community, or other businesses.

A copy of the stakeholder database, complete with stakeholder names, organisations and contact details has been initiated and will be submitted to the DWS by mid-January 2024.

The stakeholder database will be dynamic and will be updated as the project progresses. The study team will keep track of interactions with stakeholders, such as e-mail correspondence and meeting attendance. The study team will provide DWS with a copy of the stakeholder database at various points during the project.

### 8.2. Announcement of the study

Following finalisation of version 1 of the stakeholder database at the end of this inception phase, the study will be officially announced in a short letter on a DWS letterhead and signed by the Chief Director: Water Ecosystems Management. A Background Information Document (BID) explaining the whole study in detail will be included in the announcement email. There will also be a registration and comment sheet that will need to be completed and returned to the Study Team.

### 8.3. Project Management Committee meetings

There will be 10 project management committee meetings (PMC) over the course of the Study at dates proposed in Table 14 in Section 10. The study team will provide secretariat services.

The main aim of the committee will focus on assessing and monitoring progress of the study, providing guidance and support on review of deliverables.

### 8.4. Project Steering Committee meetings

Six (6) Project Steering Committee (PSC) meetings will be held over the course of the project and will take place after specific milestones have been reached. Proposed dates are included in Table 12. The exact format of the PSCs will be agreed at the first PMC meeting, however it is suggested that the PSC meetings be held in the catchment with the possibility of including a TEAMS on-line link for those too far to travel.

**Table 12: Proposed PSC dates and deliverables to be discussed at the meeting**

Date	PSC	Will include feedback on the following deliverables
July-24	1	<ul style="list-style-type: none"> <li>Water Resources Information and gap analysis report</li> <li>Status quo and IUAs</li> <li>Linking the value and condition of water resources</li> </ul>
Nov-24	2	<ul style="list-style-type: none"> <li>Resource Units prioritization and sites selection</li> <li>Ecological Water Requirements Report</li> </ul>
Apr-25	3	<ul style="list-style-type: none"> <li>Scenarios and consequences</li> <li>Water Resource Classes</li> </ul>
Oct-25	4	<ul style="list-style-type: none"> <li>Sub-components prioritization and indicators</li> <li>Draft RQOs and numerical limits</li> </ul>
Mar-26	5	<ul style="list-style-type: none"> <li>Classes and gazette template</li> </ul>
Jul-26	6	<ul style="list-style-type: none"> <li>Implementation / operationalisation plan</li> <li>Gazette comments</li> </ul>

Tasks will include booking of the venues, preparation of the invitations, agendas, attendance registers, presentations and a BID for each meeting. Take minutes in the form of questions / comments / issues and responses.

## 8.5. Specialist Workshops

Specialist workshops will be arranged when the need arises for in-depth discussion with scientists / specialists / non-governmental organisations. Three proposed workshops are catered for, and the following tasks will be undertaken:

- Specialists will receive a notification of the meeting date and the proposed meeting objectives at least three weeks in advance,
- Clear objectives for the meeting/workshop will be defined and communicated in the invitation,
- Attendees will receive documentation for the meeting at least five working days before the meeting, with a formal information letter of their attendance, and
- Minutes in the form of questions / comments / issues and responses will be taken and distributed after the meeting. These will be incorporated into the Issues and Response Register as necessary.

## 8.6. Technical Task Group meetings

Technical Task Group meetings will be arranged as needed and allowance has been made for four (4) such meetings.

- Identified stakeholders, from the PSC, will receive a notification of the meeting date and the proposed meeting objectives at least three weeks in advance,
- Clear objectives for the meeting/workshop will be defined and communicated in the invitation,
- Attendees will receive documentation for the meeting at least five working days before the meeting, with a formal information letter of their attendance, and
- Minutes in the form of questions / comments / issues and responses will be taken and distributed after the meeting. These will be incorporated into the Issues and Response Register as necessary.

## 8.7. Public Meetings

Two rounds of public meetings (4 meetings) will be arranged at suitable centres in the catchment area. It is proposed that meetings are held as follows:

1. June 2024 - On study initiation at the time of the status quo assessment and IUA delineation to inform the meeting of the project, get comments on the main areas of concern as perceived by the stakeholders, and present and get comments on the proposed IUAs. In addition, PSC nominations will be made at this meeting, and
2. November 2025 - towards the conclusion of the technical processes to inform stakeholders of the recommended water resource classes and RQOs.

PSP tasks will include:

- Booking of the venue,
- Formal advance registration process based on the database developed during January 2024,
- A Background Invitation Document,
- Notification of the meeting date and its objectives at least five weeks in advance,
- Engaging on various means to communicate the meeting,
- BID for the meeting and any other relevant documents at least five working days before the meeting, with a formal information letter of their attendance; and
- Taking of minutes in the form of questions / comments / issues and responses. These will be incorporated into the Issues and Response Register as necessary.

### **8.8. Consolidated Issues and Responses Report**

An Issues and Responses Register will be compiled and updated throughout the project. This report will list all the comments from stakeholders (to be received from comment sheets, at meetings, via emails and telephone calls) and responses from the project team. This report will be used as a monitoring tool and will also be attached to the gazette going to the Minister.

### **8.9. Feedback to Stakeholders**

Feedback to stakeholders will be done by means of:

- Direct answers to any questions or requests for additional information by emails,
- Meetings (PSC and public) throughout the project,
- Issues and Response Register available on the website (<http://www.dwa.gov.za/rdm/WRCS/default.aspx>), and
- Regular BIDs during the project.

#### **Task 6 Deliverables:**

- Stakeholder database,
- Meeting documentation; and
- Record of stakeholder comment/issues and responses.

## 9 CAPACITY BUILDING (TASK 7)

A key requirement of the Terms of References for the study is capacity building of relevant departmental officials, both at the Regional and National Offices. This is coupled with the capacity building of stakeholders through the various tasks that will occur through the study. Capacity building will be realised through the following mechanisms in this study, namely:

- **Mentorship:** *Mentoring of the Lower Orange River study DWS study manager and identified DWS colleagues* - which will involve dedicated, one-on-one guided sessions with the identified specialists on the team.
- **Stakeholder Engagement** - *Stakeholder involvement over the course of the project, through their participation.* Stakeholder groups will develop an understanding of water resource protection through the Classification/RQO Process and its relevance to their own water use and land-use activities. This will also assist in the enhancement of the public's understanding of the concepts of integrated water resource management and sustainable development.
- **Training Workshops** - *Participation of identified DWS officials* - in dedicated workshops on water resource components and classification aspects to build their capacity and broaden their skills base with respect to the WRCS and RQO process as well in terms of specific technical content.

These three sub-components are outlined in the sections below.

### 9.1. Mentorship

Mentorship focus areas for the Lower Orange Classification Study as identified by the DWS study management team include:

- Wetlands
- Estuaries
- Rivers: Hydrology and Hydraulics
- GRU Delineation and prioritization, Quantification of groundwater component of EWR

The following mentorships activities will be undertaken in respect of the above technical areas:

- Dedicated sessions with the mentees and relevant specialists at the start of each identified activity. This will give the mentee an idea of the process and steps to be undertaken as well as an understanding of the expectations.
- Workshops and/or meetings will be held with the mentees to complete specific tasks or technical assessments to support the activity outcome.
- Mentoring on the specific models and assessment tools that support the component (this will include practical application for a selected site)
- Completion of a short report or specific outcome product to support the study process.
- Field visit related to component as required.

The details of the mentorship activities and identified mentees as part of the capacity building plan are indicated in Table 13:. Some of the activities may integrate with the Upper Orange WRC Study.

**Table 13: Details of the mentorship component of the capacity building plan for the Lower Orange Study**

Activity	Topic/ Approach	Time Requirement for Mentee	Proposed scheduling	Outcome
<b>Lower Orange Classification and RQO Study Mentorship on Wetlands</b> <b>MENTEE:</b> Ms. Mohlapa Sekoele, Mr Samkele Mnyango and Ms. Tinyiko Neswiswi				
Preliminary identification of significant wetland resources.	Using existing datasets (electronic and available literature) identify significant wetland resources in the Lower Orange catchment.	5 days (1 week) in the office with the specialists	April 2024	<ul style="list-style-type: none"> <li>Understanding of process and involvement to prioritise wetland resources. Ability to undertake wetland prioritisation process using the approach.</li> </ul>
Workshop to determine which wetlands are likely to be providing key ecosystem services (ecosystem services assessment).	Team workshop with Wetland Specialists and WSP team to understand the catchment stresses and to provide input into the determination of the IUA's.			<ul style="list-style-type: none"> <li>Familiarity and training in the approach to identification of the wetland ecosystem service hotspots and priority catchments. Mentees capacitated in inclusion of wetlands into delineation of IUAs.</li> </ul>
Refinement of Priority Wetland layer and desktop delineation of Priority Wetlands.	Based on the workshop outcome refine the Priority Wetland layer and undertake desktop delineation of the systems.			<ul style="list-style-type: none"> <li>Mentees able to update/refine the priority wetland layer identified based on the outputs of the team workshop and IUA delineation.</li> </ul>
Desktop categorisation of Priority Wetlands (PES and IS).	Undertake a desktop PES and IS assessment of the Priority Wetlands		<ul style="list-style-type: none"> <li>Experience in the PES and EIS assessment of wetlands. Training the approach.</li> </ul>	
Verification of Priority Wetland layer and desktop categorisation.	Field visit to selected Priority Wetlands. Apply rapid field assessments of the systems visited and check/verify the land categorisation categories used in the desktop PES assessment.		June/July 2024	<ul style="list-style-type: none"> <li>Mentees able to groundtruth the prioritised wetland systems through the field visit. Experience in the process of the field verification will be gained.</li> </ul>
Set preliminary RQOs.	Develop generic and specific preliminary RQO's for each of the Priority Wetlands as applicable.	2 days	August 2025	<ul style="list-style-type: none"> <li>Mentees will gain experience and ability to draft wetland RQOs.</li> </ul>

Activity	Topic/ Approach	Time Requirement for Mentee	Proposed scheduling	Outcome
<b>Lower Orange Classification and RQO Study Mentorship on Estuaries</b> <b>MENTEE:</b> Ms. Mohlapa Sekoele, Ms. Nolusindiso Jafta, and Ms. Tinyiko Neswiswi				
Estuaries Overview	Introduction and overview to Estuaries – focus on the estuaries in the Lower Orange	0.5 day	March 2024	Mentees will acquire an understanding of the estuaries and how they are assessed. Knowledge on characteristics of estuaries and how to define them will be gained.
Estuary assessment and data collection (if gaps are identified)	Field visit to selected estuaries (abiotic components).	Accompany the estuarine specialists on field visit to selected estuaries	To be confirmed	Training in the analysis of collated data will be gained. Experience in the input into EH (this can be a desktop exercise should the field visit not be required) and how to apply the data
EcoClassification	Review of the Determination of the PES, EIS, and REC	3 days	September/October 2024	Experience in the ecological categorization process and how apply the various components to assess the ecological status.
Assessment of the ecological consequences of the scenarios	Use of EHI and scoring in assessing the predicted condition of estuaries			Experience with the assessment of the predicted future condition of the estuary under each scenario. An understanding on the application on the EHI tool
EFR quantification	Quantifying EWR for REC			Knowledge and baseline understanding on how the flow scenario that will maintain the resource in the REC or TEC is determined.
<b>Lower Orange Classification and RQO Study Mentorship on River Hydrology and Hydraulics</b> <b>MENTEE:</b> Ms. Mohlapa Sekoele, Mr Samkele Mnyango and Ms. Tinyiko Neswiswi				
Water Resource Modelling	Introduction to the WRYM, WRPM and WRSM2000 using an example	3 days	To be confirmed	Understanding of what the 3 models encompass (data and model requirements) and how to interpret the outputs
Hydraulic assessment and modelling	Field visit to selected river (this may be a site closer to Pretoria if no additional Rapid Reserves are needed)	Accompany the hydraulician on field visit to selected rivers	To be confirmed	Understanding and experience in how to determine and apply the cross-sectional profile and slope survey, discharge and flow depth measurements and stage discharge relationships. Knowledge of how to apply them.

Activity	Topic/ Approach	Time Requirement for Mentee	Proposed scheduling	Outcome
EWR quantification	Introduction to the running of RDRM (Spatsim) using an example from the Upper Olifants Reserve	1 day	To be confirmed	Understanding of how to quantify Ecological Water Requirements and basic understanding to the RDRM
<b>Lower Orange Classification and RQO Study Mentorship on Groundwater</b> <b>MENTEE: TBC from SD: GWRD</b>				
Groundwater Resource Units delineation	Running an example of Groundwater Resource Units delineation	5 days (1 week) in the office with the specialists	To be confirmed	Understanding and knowledge of approach on how to delineate groundwater resource units
Quantifying groundwater use/abstraction, stress index	Calculating stress index using the data for the Upper Orange River		To be confirmed	Capacity built in how to calculate the Stress index
Modelling groundwater recharge and aquifer recharge and EWR	Modelling groundwater recharge and aquifer recharge and EWR		To be confirmed	Understanding of the approach on how the Recharge and Reserve are calculated. Ability to apply the results.
Determining groundwater quantity RQOs		2 days	July/ August 2025	Mentees will gain experience and ability to draft groundwater RQOs.

## 9.2. Training Workshops

The Study Team will hold capacity building workshops at certain points in the study, specifically during tasks 3 and 4 of the process directed towards the identified DWS officials. Workshops will relate to the following and will coincide with a study milestone. In person sessions are proposed with interactive sessions of presentations and where possible practical exercises.

- Overview of the Water Resource Classification and RQOs determination process (2 days)
- Socio-economic Analysis (1 day)
- Surface Water hydrology and Water Resource Modelling (1 day)
- Water Quality (1 day)
- Groundwater (GRU delineation, Prioritization of GRUs, Quantification of groundwater component of EWR)
- Estuaries (1 day)
- Evaluation of scenarios and determination of classes (will address determination of ecologically sustainable base configuration scenario) (1 day)
- RQO RU and sub-component prioritisation (1 day)

### ■ Overview of the Water Resource Classification and RQOs determination process

A two-day workshop will be held for trainees to (i) provide an overview of the Classification, RQO determination processes including any relevant tools available, and (ii) provide an overview of the process used to delineate integrated units of analysis and resource units.

The workshop will be in the form of presentations and practical sessions led by the Study Team. The aim of training workshop will be to adequately equip the DWS officials with the relevant study information on the classification process, RQO process, the outcomes, how to apply the information, requirements, and implications of implementation.

### ■ Socio-economic Analysis

The purpose of the workshop will be to provide DWS officials with an understanding of the socio-economic analyses and how trade-offs are analysed when comparing the different catchment configurations. Officials will be taken through the underlying data sources and general analyses that determine the Socio-economic Comparison Tool (SeCT) and how this tool can be practically used. The workshop is expected to take no longer than one day, but if necessary further time can be added.

### ■ Water Quality assessment

An introduction to water quality will be provided to trainees. Training on the use and application of water quality component in terms of the process will be conducted using the Lower Orange River dataset as far as possible. It is expected that DWS officials will use their own computers to work on the data. Regional monitoring data can be applied to the practical exercises.

## ■ Groundwater Resources Assessment

A flow sheet explanation of how the groundwater component of the study developed will be compiled for capacity building applications. Specific evaluations/calculations as per the Seven Step Guideline will form the framework of the approach and specific variables required in the assessment process will be high-lighted. These specific variables required for the GRDM evaluation, for example, are:

- Groundwater Resource Units (GRUs) and Integrated Units of Analyses (IUAs):
- Procedure how to prioritise GRUs
- Application of Groundwater contribution to river/stream baseflow:
- Principles of groundwater resource classes based on aquifer and land use conditions in specified GRU/IUA (Groundwater quantity and quality expressed in terms of PES, REC and TEC).
- Specification of RQOs and implementation:
  - Setting of protocols with respect to (i) Groundwater stress indexing, (ii) Groundwater utilization (use), (iii) Groundwater quantity/quality status and trends in GRU/IUAs ; and
  - Typical narratives and numerical limits based on hydrogeological status/characteristics in the GRU/IUAs;
  - Measures (plus indicators) to consider for resource unit(s) prioritizing (Table 8.1 as in Step 6.2 of the Integrated Framework for groundwater resources); and
  - Protocols to implement RQOs in priority resource units.

It should be noted that there are a few complex estimations required in the groundwater component of the quality classification and resource quality objectives assessments – mainly because of the lack of time series datasets. It is therefore foreseen that capacity building activity will aim to highlight the processes and programs that are required to address these shortages – specifically at catchment level where monitoring networks and programs are required to generate specific datasets. An overview of different monitoring processes will be highlighted.

## ■ Estuaries

A training working will cover the following aspects providing an overview and introduction to attendees:

- Introduction to estuaries
- Estuarine Functional Zone
- Benefits of estuarine biodiversity
- Pressures on estuarine ecosystems

- Classification and Resource Quality Objectives

#### ■ Evaluation of scenarios and determination of classes

A training workshop will be held on the following:

- How to evaluate scenarios
- Determination of the ecologically sustainable base configuration scenario
- Socio-economic implications of the different scenarios
- The determination of the proposed water resource classes.

Various aspects will be covered which include amongst others, ecological condition; ecological water requirement; scenario development, analysis and evaluation; interpretation of results; economic modelling and evaluation; discussion of implications and process from recommended scenarios to water resource classes.

#### ■ Surface Water hydrology and Water Resource Modelling

This will comprise an introductory training course on hydrology and water resource modelling. Components that will be addressed include:

- Introduction to Water Resources Planning
- Introduction to the WRSM2000
- Introduction to the WRYM
- Overview of the WRPM

#### ■ RQO determination and Resource Unit and sub-component prioritisation

Training to create understanding and application of resource unit prioritisation and the tool will be given to trainees. The prioritisation of the resource units including the results and details of the application of the tool will be discussed. Participants will be given the opportunity to work through the tool.

Training on sub-component selection and prioritisation will involve a participatory process where trainees will be taken through the sub-component prioritization tool, its application, the criteria and scoring and the prioritisation process. Thereafter the process will facilitate the identification of the priority subcomponents. The process will be interactive and provide opportunity for discussion on how to apply the RQO procedure and undertake the task of sub-component selection and prioritisation.

### 9.3. Stakeholder Empowerment

Stakeholder empowerment sessions will be linked to existing catchment forums. The team will capacitate stakeholders through the identified forum meetings. Each presentation will run through the process, tool applied or applicable approach so that stakeholders become familiar with the

methodology applied. Where applicable supporting information will be made available to stakeholders.

**Task 7 Deliverables:**

- Mentorship activities, training workshops and stakeholder engagement activities
- Capacity Building Report.

**10 STUDY MANAGEMENT AND COORDINATION (TASK 8)**

Study management and coordination will run throughout the 36-month project duration. Ms Priya Moodley is the PSP study team manager and will oversee the daily management and coordination of the study, in collaboration with the DWS Study Manager and the specialists.

The Project Management Committee (PMC) will comprise the formal management structure of the study management process that will engage with various DWS representatives (National and Regional) for both guidance and review. Informal management processes will comprise liaison with the client, team co-ordination, study administration and reporting, financial management and general communication.

The PMC will be constituted during the inception phase of the project by DWS Study Manager. As per the contract, ten PMC meetings will be held over the course of the study and will comprise the relevant Departmental officials identified by the DWS project manager. The Departmental representatives of ORASECOM will sit on the PMC.

Proposed tentative dates for the PMC meetings are and deliverables/ aspects that will be discussed are set out in Table 14 which are linked to key milestones and/or deliverable due dates.

**Table 14: Proposed PMC dates and deliverables or study aspects addressed**

Date	PMC	Deliverable Feedback/Progress/Outcomes
Feb-24	0	Inception Report
Mar-24	1	Information status, stakeholder engagement and capacity building Water Resources Information and gap analysis report
May-24	2	Status quo and IUAs
July-24	3	Linking the value and condition of water resources
Sep-24	4	Resource Units prioritization Report
Dec-24	5	Ecological Water Requirements Report
Apr-25	6	Scenarios and consequences Water Resource Classes
July-25	7	Sub-components prioritization and indicators
Sep-25	8	Draft RQOs and numerical limits Report

Date	PMC	Deliverable Feedback/Progress/Outcomes
Jan-26	9	Classes and gazette template
Mar-26	10	Implementation / operationalisation Plan

### 10.1. Client Liaison

Liaison with the DWS Study Manager will include the following activities:

- Attendance at the PMC meetings over the course of the Study.
- Establishing interim communication to advise the Study Manager of, inter alia, important events or problem situations, information requests, task challenges/constraints, project progress, changes to the team, and
- Compiling and updating the “Record of Decisions” for the Study Manager and ensuring that all recorded actions are attended to within the specified budget and time limits of the Study.

### 10.2. Coordination of Study Team

The PSP Study Manager will be responsible for overall coordination of the Study Team and activities will include:

- Serving as link between DWS Study Manager and the Study Team.
- Ensuring that the task leaders and specialists are properly briefed prior to commencing with work.
- Monitoring and control of performance, programming and cost of the study (which it is understood will be deliverables based) including revision of the Study Programme, if and when necessary,
- Management of project deliverables and due dates, and
- Collation of specialist inputs.

### 10.3. Study Administration

Study administration duties to be performed will include:

- Compiling, verifying and submitting deliverables-based invoices and progress reports to the Client. The Client will be presented with an invoice with a supporting progress report from the Study Team. The Study Leader will arrange payment to the other members of the Study Team after receiving the same from the Client; and
- The Study Leader will provide a secretariat to perform the required duties for the Project Management Committee.

### 10.4. Progress Reporting

A reporting system will be instituted whereby progress reports, and other relevant information necessary to inform the client will be prepared. Bi-monthly progress reports will be prepared and when invoicing according to the deliverable, a supporting progress report will be included.

The first Progress Report will be submitted by the 14<sup>th</sup> of December 2023 that will encompass work undertaken for the first three months since project initiation, and then followed at the end of February 2023, and bi-monthly thereafter.

The format of the project progress reports will be confirmed by the DWS during the inception phase.

### **10.5. Peer Review**

It was noted in the proposal that four (4) Senior Technical Advisers have been included, to allow capacity building for younger professionals, however, should it be required, peer reviewers in the field will be approached to review the content and suitability of the deliverables, where identified.

These reviewers will be identified and confirmed through the project management team. It is important to note that specialists in the various fields are invited to sit on the PSC and will do reviews in that manner as well.

#### **Task 8 Deliverables:**

- Project management committee meeting and minutes.
- Bi-monthly Progress reports.
- Record of Decisions, and
- Invoices with supporting progress reports.

## 11 SUMMARY OF DELIVERABLES

The summary of deliverables for the study will include the following as listed in Table 15.

**Table 15: Summary of Study Deliverables**

Deliverables		Due dates
1	Inception meeting, Inception Report including Capacity Building Programme	November 2023
2	Stakeholder database and project announcement	December 2023
3	Water Resources Information Gap Analysis Report	February 2024
4	Status Quo and delineation of Integrated Units of Analysis and Resources Units Report	April 2024
5	Report on linking the value and condition of water resources	June 2024
6	Resource Units prioritization Report and selection of sites	August 2024
7	Ecological Water Requirements Report	November 2024
8	Scenarios and Consequences Report and draft Water Resources Classes Report	March 2025
9	Sub-components prioritisation and Indicators selection Report	June 2025
10	Draft RQOs and Numerical Limits Report	August 2025
11	RQOs and Numerical Limits Workshop and Stakeholder Consultation Report	September 2025
12	Classes and RQOs Gazette Template	December 2025
13	Plan for implementation/ operationalisation of the Water Resource Classes and the RQOs	March 2026
14	Support with addressing comments received during the gazetting period, including updating the comments register	June 2026
15	Main Report including Project close out	August 2026
16	Project Steering Committee Meeting Minutes and updated Issues and Response Register	6 times throughout the project
17	Technical Task Group Meeting Minute and updated Issues and Response Register	4 times throughout the project
18	Specialist Workshops (rivers, wetlands, and groundwater)	3 times throughout the project

Deliverables		Due dates
19	Public Meeting Minutes and updated Issues and Response Register	Two rounds (x2) throughout the project, (4 meetings in total)
20	Sectoral / one-on-one meetings and updated Issues and Response Register	4 times throughout the project
21	Capacity Building and Mentorship Progress and Outcome Reports	6 times throughout the project
22	Project Management Committee Meetings and updated Issues and Response Register	10 times throughout the project
23	Project Administration and Management Progress Reports	Bi-monthly/ 18 times throughout the project

## 12 WORK PROGRAMME

The work programme of the study tasks is provided in Appendix A. The study will be completed within the 36-month time frame as specified in the contract. In terms of the programme the study is expected to terminate in September 2026.

## 13 STUDY TEAM

The study team participating in the study are indicated in Table 16. Team members who will act as senior technical advisers, mentors, and reviewers for the PSP are also indicated. This has been done to broaden capacity in WSP and the sector.

**Table 16: Study Team Members**

Team Member	Company Name	Project Role
Priya Moodley	WSP	Project Lead, coordination, and report integration; process integration, capacity building and management, water quality, and stakeholder facilitation
Lee Boyd	WSP	Project management support, coordination and report integration; water quality, and stakeholder facilitation
Christiaan Schutte	WSP	Hydrology/ hydraulics; WRPM/ WRYM; Scenario's assessment. Support with report integration.
Oliver Maleté	WSP	
Sarah Skinner	WSP	Lead: Hydrogeology
Kylie Farrell	Specialist	Lead: Aquatic Ecology
Retha Stassen	Specialist	Lead: Ecological Water Requirements and Reserve assessment
Jackie Crafford	Prime Africa	Lead: Socioeconomics

<b>Team Member</b>	<b>Company Name</b>	<b>Project Role</b>
Aisling Dower	WSP	Lead: Wetlands, biodiversity and ecosystem services specialist
Dr Mathys Vosloo	Naturanova Environmental	Lead: Estuaries
Wynand Vlok	Specialist	Aquatic ecology; riparian vegetation
Qondile Monareng	WSP	Stakeholder Consultation, liaison, Communication, Logistics; Co-ordination
Nivirshee Juggath	WSP	WRPM/ WRYM; Scenario's assessment
Given Mothapo	WSP	Groundwater Assessment support
Khumo Mogapi	WSP	Mapping and GIS support
Martie Brink	WSP	Mapping and GIS support
Lufuno Nemakhavhani	WSP	Wetland Ecology
Dineo Makate	Prime Africa	Socio-economic evaluation data collation and analysis
Valmak Mathebula	Prime Africa	Socio-economic evaluation data collation and analysis
Karen Eatwell	Prime Africa	Socio-economic evaluation data collation and analysis
Tebogo Khoza	WSP	Aquatic ecology and will be trained in the ecological models
Khodani Khaku	WSP	Data collection and support, modelling, hydrology, GIS support
Boipelo Tshehla	WSP	Data collection and support, modelling, hydrology
Philemon Mahlangu	WSP	Data Collation and analysis; wetlands
Dr Benjamin van der Waal	Specialist	Geomorphology
<b>Senior Technical Advisers</b>		
Trevor Coleman	WSP	Overall technical adviser and review
Dr Eddie van Wyk	Specialist	Groundwater technical advice and review
Gary Marneweck	Specialist	Wetlands technical advice and review
Gerald de Jager	Specialist	WRPM/ WRYM technical advice and review

## 14 REFERENCES

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**APPENDIX A**

**WORK PROGRAMME**



