DETERMINATION OF WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES FOR THE LOWER ORANGE CATCHMENT

Project Steering Committee Meeting 4

,

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Designation: PSP
Directorate: for Chief Directorate Water Ecosystems Management

Date: 18 November 2025, Online Meeting

WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

STUDY OBJECTIVE

To determine Water Resource Classes and Resource Quality Objectives (RQOs) for all significant water resources in the Lower Orange Catchment Area *to facilitate* ***sustainable use of the water resources*** *while* ***maintaining ecological integrity.***

Protection of Water Resources

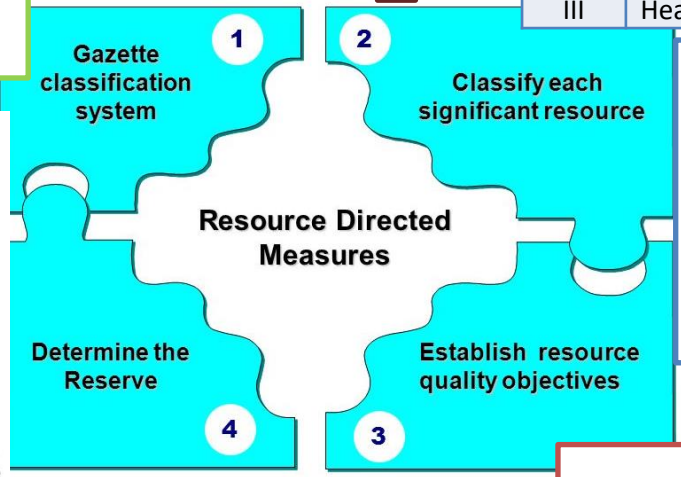
Rivers, groundwater, wetlands and estuaries.

National system for classifying resources

- *Gazetted on 17 September 2010, Gazette No. 33541, Regulation 810*

Class	*Description of use*	*Ecological Category*	*Description of resource*
I	Minimally used	A-B	Minimally altered
II	Moderately used	C	Moderately altered
III	Heavily used	D	Heavily altered

Defines and specifies the procedures for determining the classes of water resources (7 steps), the Reserve (8 steps) and resource quality objectives (6 steps).

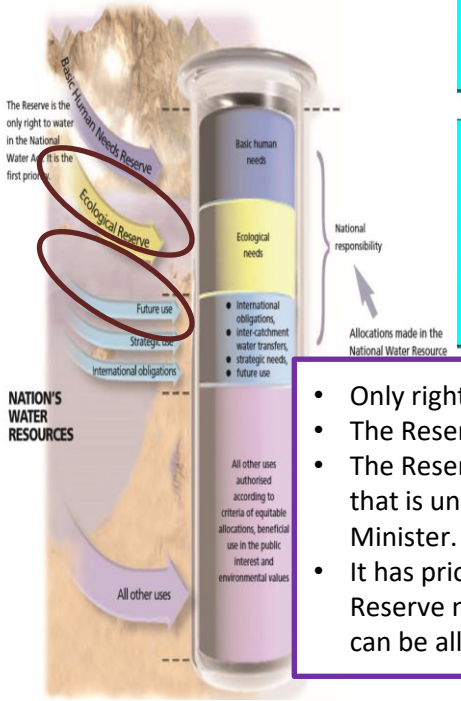


Each class represents:

- a different **level of protection** that is required for the water resource, and the extent to which the water can be used.

Classification is used in two ways:

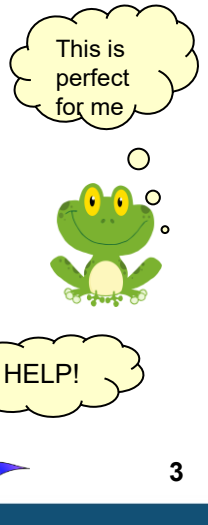
- To define the **present status** of the water resource
- To define the state towards which the water resource needs **to be managed** sustainably (**future state**).



- Only right in NWA
- The Reserve is an integral part of the RQO
- The Reserve is part of the water resource that is under the direct control of the Minister.
- It has priority over all other water use. Reserve must be met before water resources can be allocated to other water users

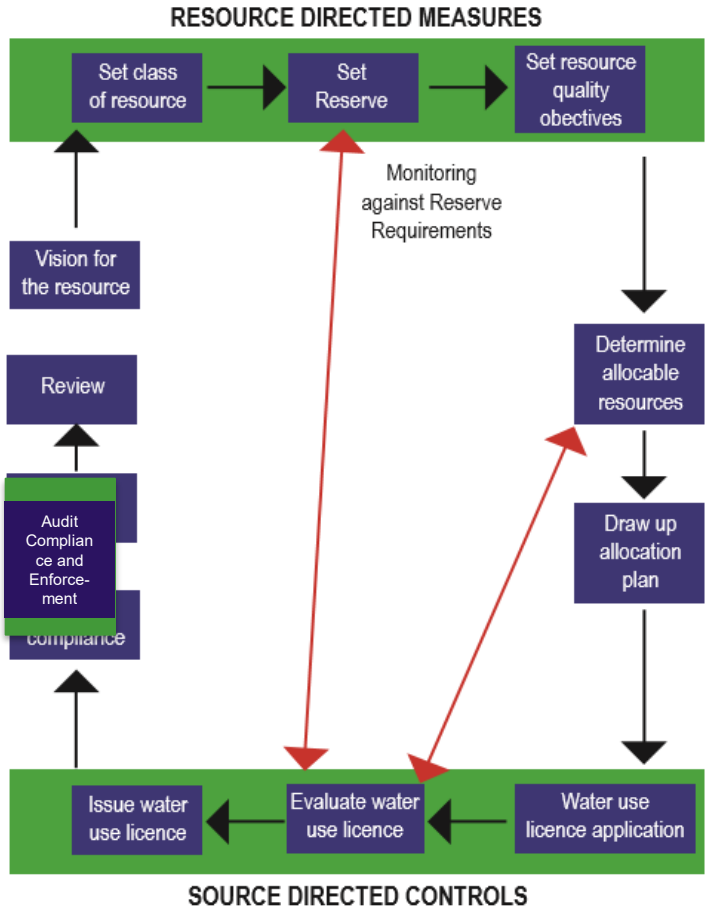
Targets or objectives/ management goals that provide statements about:

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



Balancing Use and Protection

Integrated Water Resources Management (IWRM)



Classification Process

- Step 1: Delineate the integrated units of analysis and describe the status quo of the water resource or water resources;
- Step 2: Link the Socio-Economic and Ecological Value and Condition of the water resource or water resources;
- Step 3: Quantify the ecological water requirements and changes in non-water quality ecosystem goods, services and attributes;
- Step 4: Determine an ecologically sustainable base configuration scenario;
- Step 5: Evaluate scenarios within the integrated water resource management process;
- Step 6: Evaluate the scenarios with stakeholders;
- Step 7: Gazette and implement the class configuration.

We are here

Resource Quality Objectives Process

- Step 1: Delineate the integrated units of analysis and define the resource units;
- Step 2: Establish a vision for the catchment and integrated units of analysis;
- Step 3: Prioritise and select preliminary resource units for RQO determination;
- Step 4: Prioritise sub-components for RQO determination and select indicators for monitoring;
- Step 5: Develop draft resource quality objectives and numerical limits;
- Step 6: Agree on resource units, RQOs and numerical limits with stakeholders;
- Step 7: Finalise and gazette RQOs.

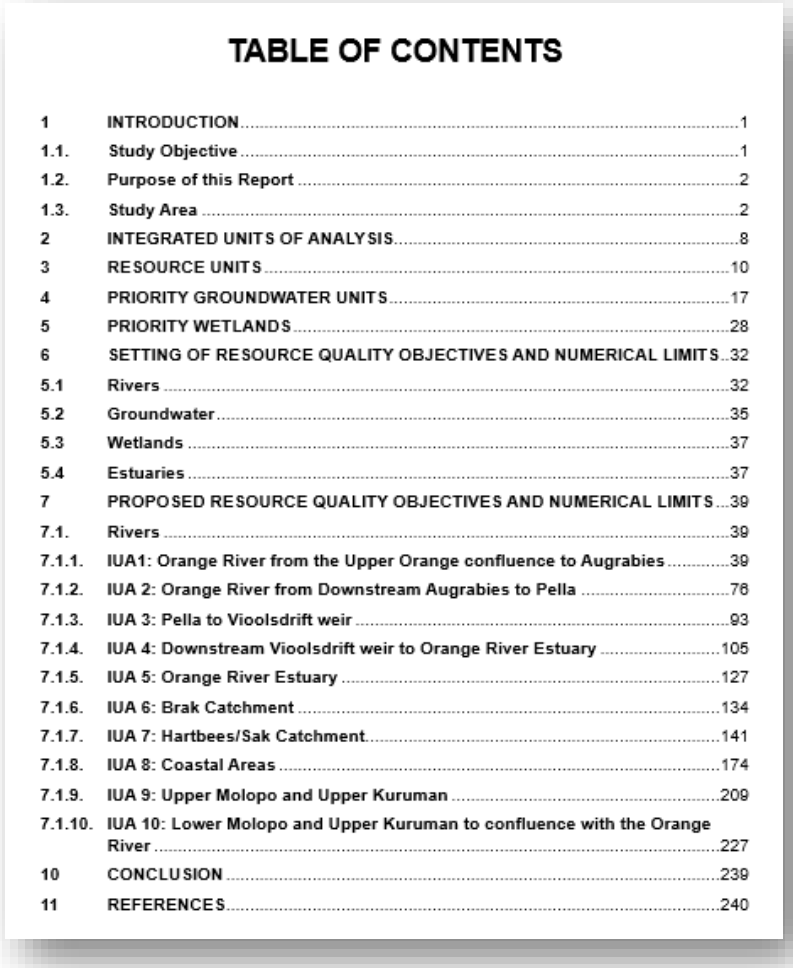
PURPOSE OF MEETING

To present the:

- Proposed draft RQOs that have been determined for the Lower Orange Catchment
- Rivers, groundwater, estuaries, wetland components
- Draft report was circulated for comment (August 2025)

Report Contents Summary

- Introduction and Background, Description of the study area
- Integrated Units of Analysis
- Resource Units and prioritisation – rivers, wetlands, estuaries and groundwater
- Approach to determining and setting the RQOs and numerical limits
- Proposed Resource Quality Objectives and Numerical Limits:
  - Rivers
  - Groundwater
  - Wetlands
  - Estuaries



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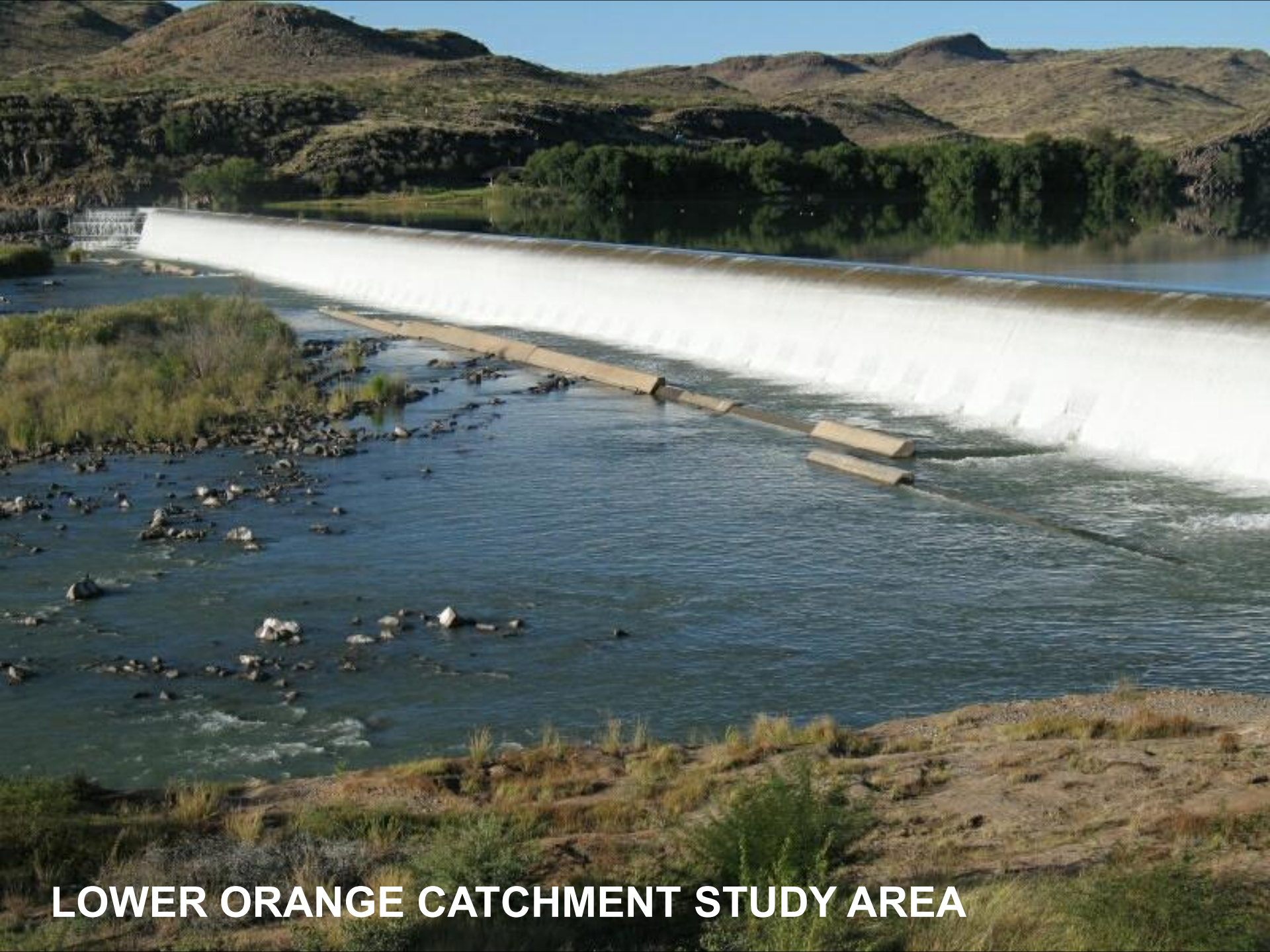

LOWER ORANGE CATCHMENT STUDY AREA

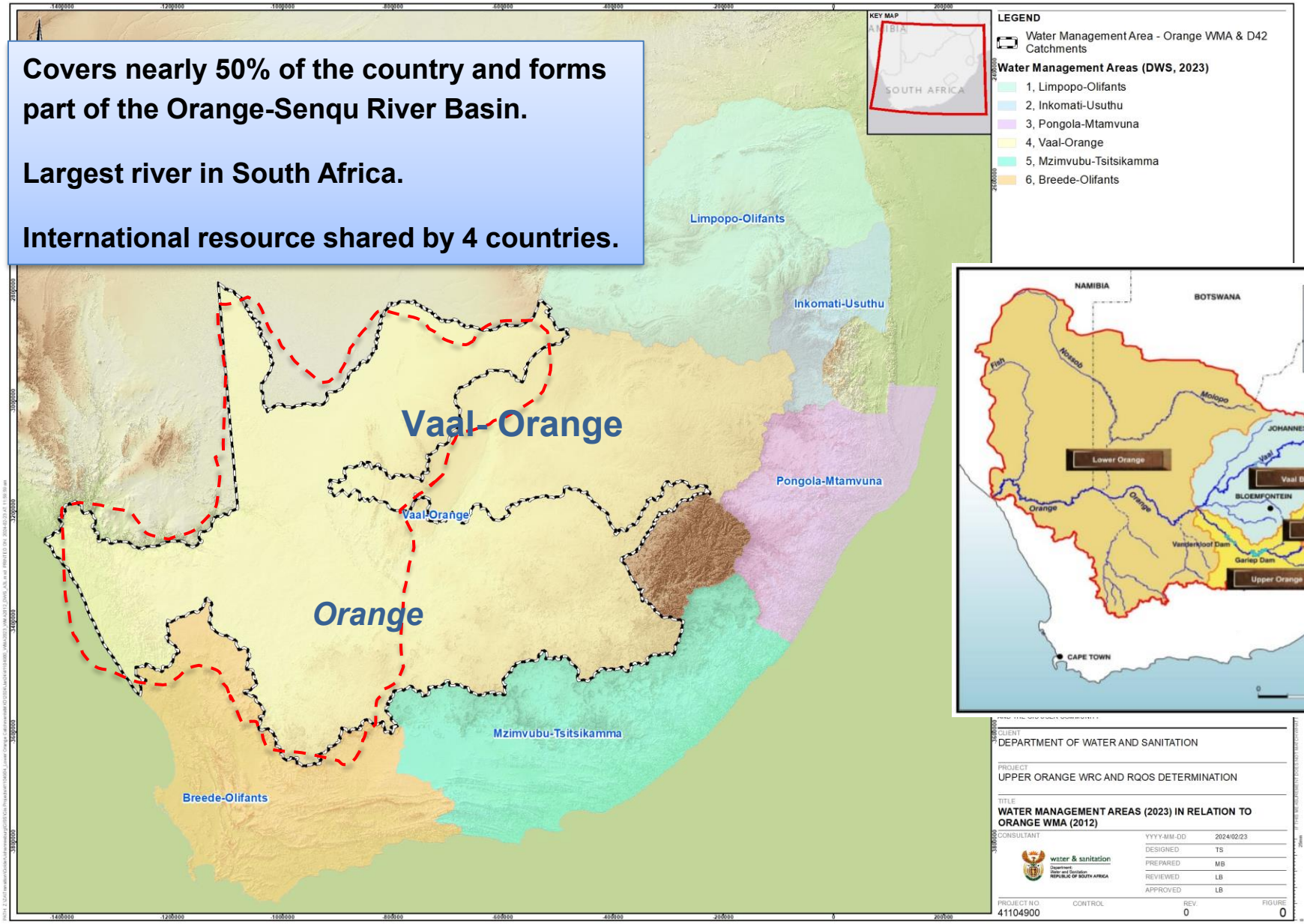
STUDY AREA

Lower Orange Catchment of the Vaal- Orange WMA (WMA 4)

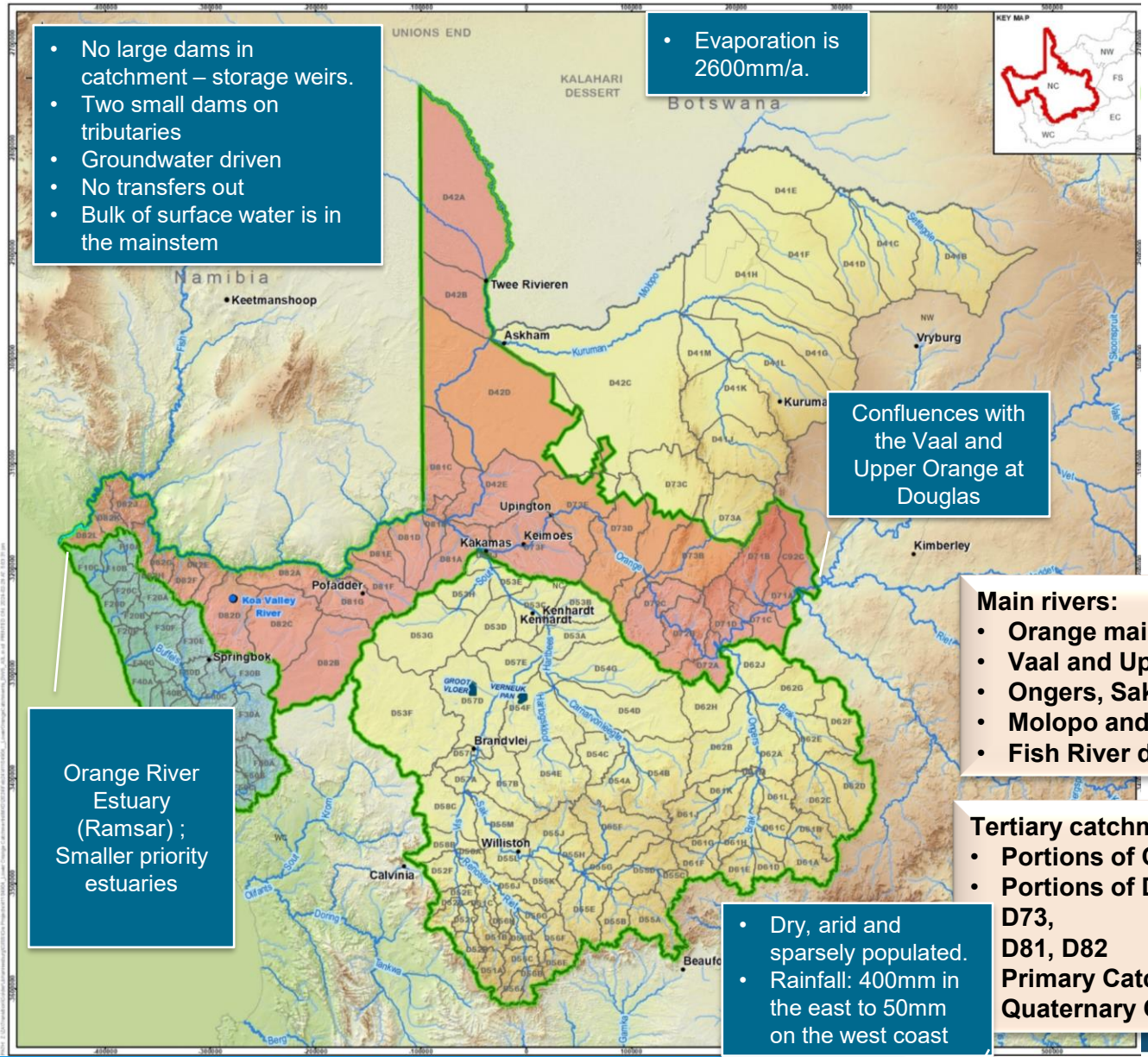
Covers nearly 50% of the country and forms part of the Orange-Senqu River Basin.

Largest river in South Africa.

International resource shared by 4 countries.



Lower Orange Catchment



- No large dams in catchment – storage weirs.
- Two small dams on tributaries
- Groundwater driven
- No transfers out
- Bulk of surface water is in the mainstem

- Evaporation is 2600mm/a.

Confluences with the Vaal and Upper Orange at Douglas

Orange River Estuary (Ramsar) ; Smaller priority estuaries

- Dry, arid and sparsely populated.
- Rainfall: 400mm in the east to 50mm on the west coast

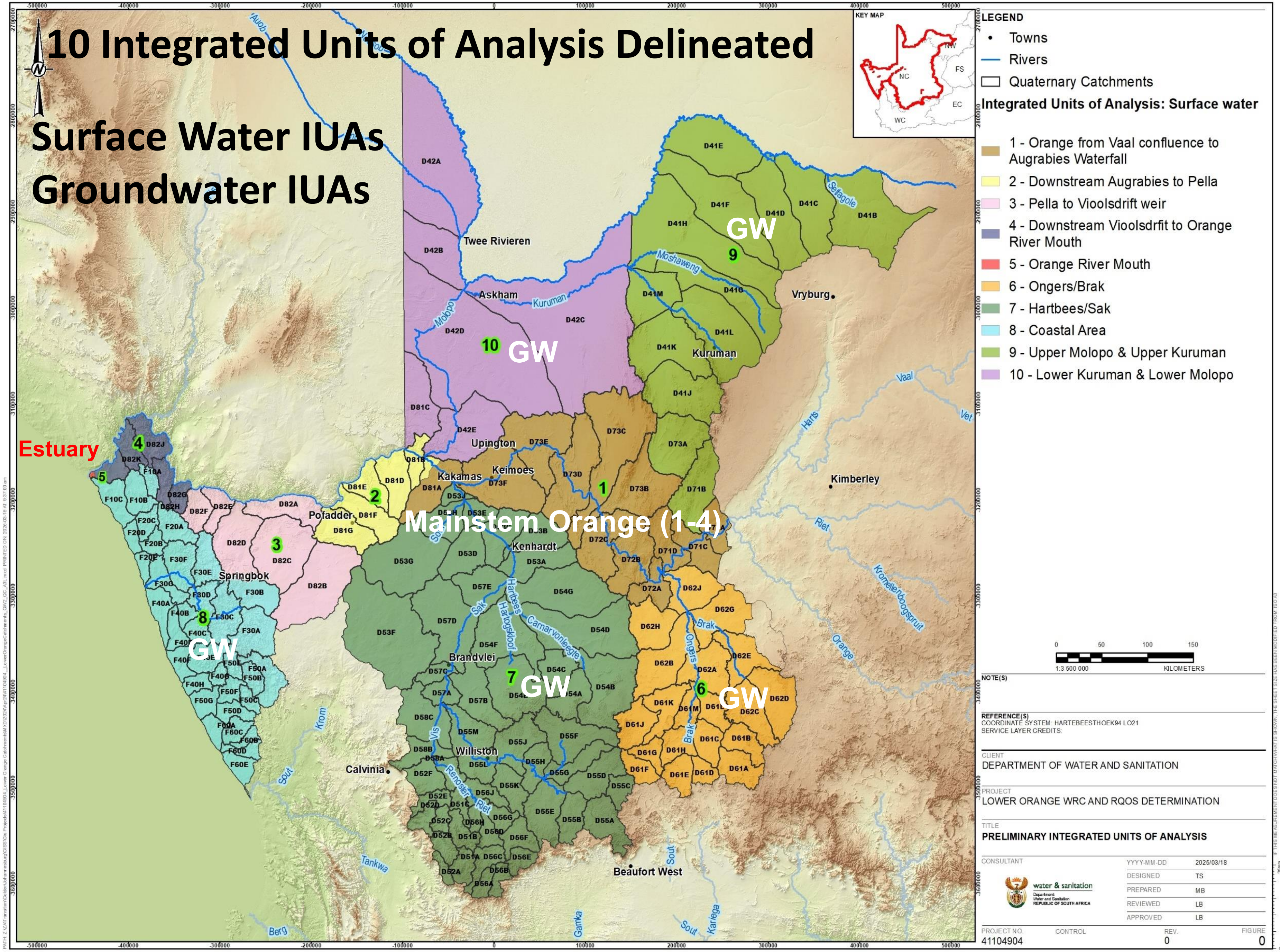
Orange River

Lower D drainage region comprising of the secondary drainage regions D4 to D8

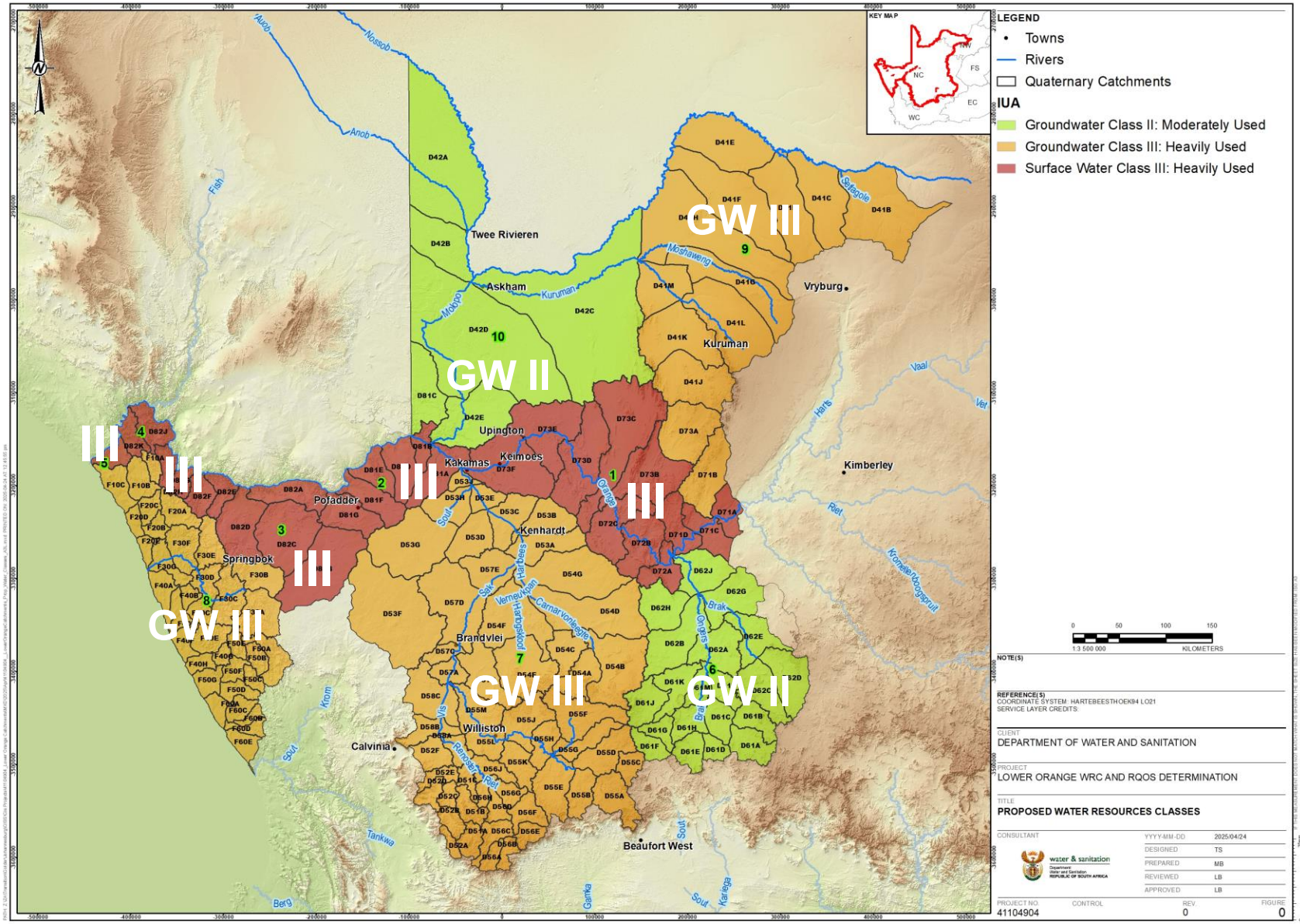
F catchment (exclusions)

Main rivers:
- **Orange mainstem**
- **Vaal and Upper Orange – main tributaries**
- **Ongers, Sak, Hartbees, Brak**
- **Molopo and Nossob, Kuruman Rivers.**
- **Fish River draining the southern part of Namibia**

Tertiary catchment areas:
- **Portions of C92B, C92C,**
- **Portions of D41, D42, D51 To D58, D61, D62, D71 to D73,**
  D81, D82
  Primary Catchment F – F10 to F50
  Quaternary Catchment F60A.


10 Integrated Units of Analysis Delineated
Surface Water IUAs
Groundwater IUAs
Estuary
Mainstem Orange (1-4)
GW
KEY MAP
NW
FS
NC
EC
WC
LEGEND
Towns
Rivers
Quaternary Catchments
Integrated Units of Analysis: Surface water
1 - Orange from Vaal confluence to Augrabies Waterfall
2 - Downstream Augrabies to Pella
3 - Pella to Vioolsdrift weir
4 - Downstream Vioolsdrfit to Orange River Mouth
5 - Orange River Mouth
6 - Ongers/Brak
7 - Hartbees/Sak
8 - Coastal Area
9 - Upper Molopo & Upper Kuruman
10 - Lower Kuruman & Lower Molopo
Twee Rivieren
Askham
Upington
Kakamas
Keimoes
Pofadder
Kenhardt
Springbok
Brandvlei
Williston
Calvinia
Beaufort West
Vryburg
Kuruman
Kimberley
Auob
Nossob
Molopo
Kuruman
Moshaweng
Setlagole
Vaal
Harts
Vet
Riet
Orange
Brak
Ongers
Sak
Hartbees
Hartogskloof
Carnarvonleegte
Vis
Renoster
Krom
Sout
Tankwa
Berg
Gamka
Kariega
0 50 100 150
1:3 500 000
KILOMETERS
NOTE(S)
REFERENCE(S)
COORDINATE SYSTEM: HARTEBEESTHOEK94 LO21
SERVICE LAYER CREDITS:
CLIENT
DEPARTMENT OF WATER AND SANITATION
PROJECT
LOWER ORANGE WRC AND RQOS DETERMINATION
TITLE
PRELIMINARY INTEGRATED UNITS OF ANALYSIS
CONSULTANT
YYYY-MM-DD 2025/03/18
DESIGNED TS
PREPARED MB
REVIEWED LB
APPROVED LB
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA
PROJECT NO. 41104904
CONTROL
REV. 0
FIGURE 0

Proposed Classes IUA Level



RESOURCE QUALITY OBJECTIVES

Resource Quality Objectives (RQOs)

- Purpose is *to establish clear goals relating to the quality of the relevant water resources*: provide limits or boundaries for the sustainable use of water resources

- In determining RQOs, *a balance must be sought between the need to protect and sustain water resources and the need to use them*
  - Must take account of user requirements and the class of the resource
  - Binding on all authorities and institutions
  - The RQOs may inform decision-making relating to the use of the water in a specific water resource.

- RQOs can be numerical and/or descriptive statements and may relate to the:
  - Water Quality
  - Quantity (pattern and timing of flow)
  - Character and condition of riparian habitat, and
  - Characteristics and condition of the aquatic biota.

Criteria for setting Resource Quality Objectives

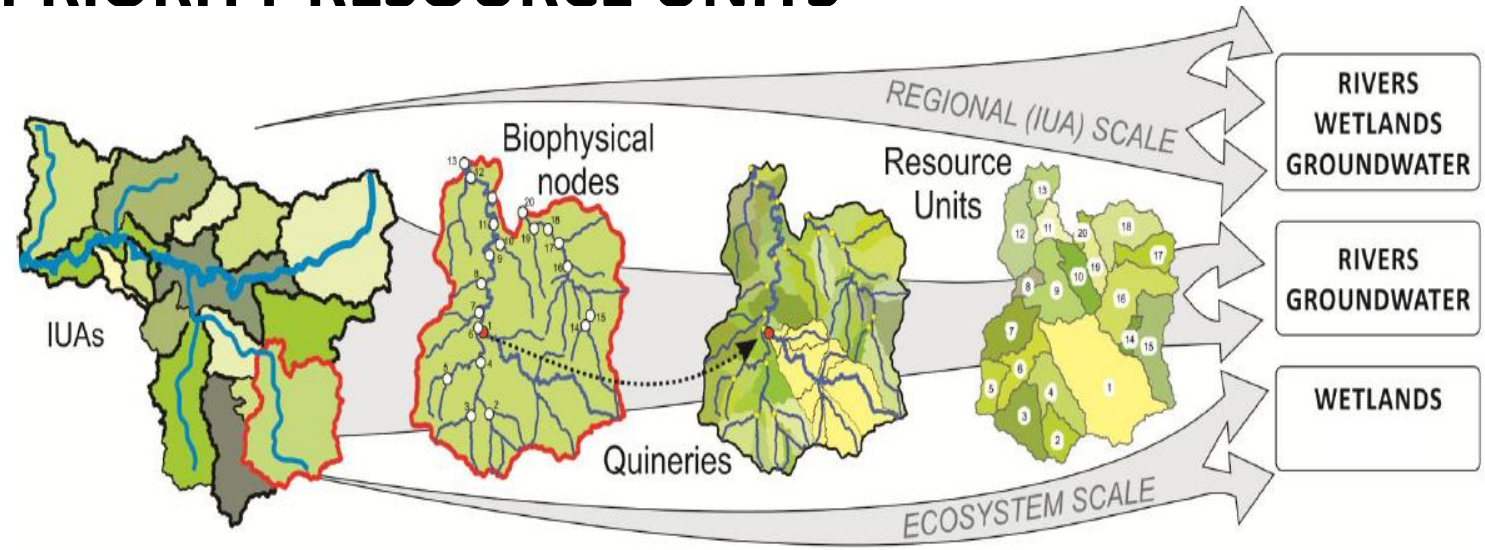
- Simple, easily measured, understood, applied
- Use existing information where possible
- At appropriate scale and must detect change
- Comparable, repeatable, defensible
- May be drivers or response indicators
- Narrative and/or numeric
- Meaningful in terms of the Act

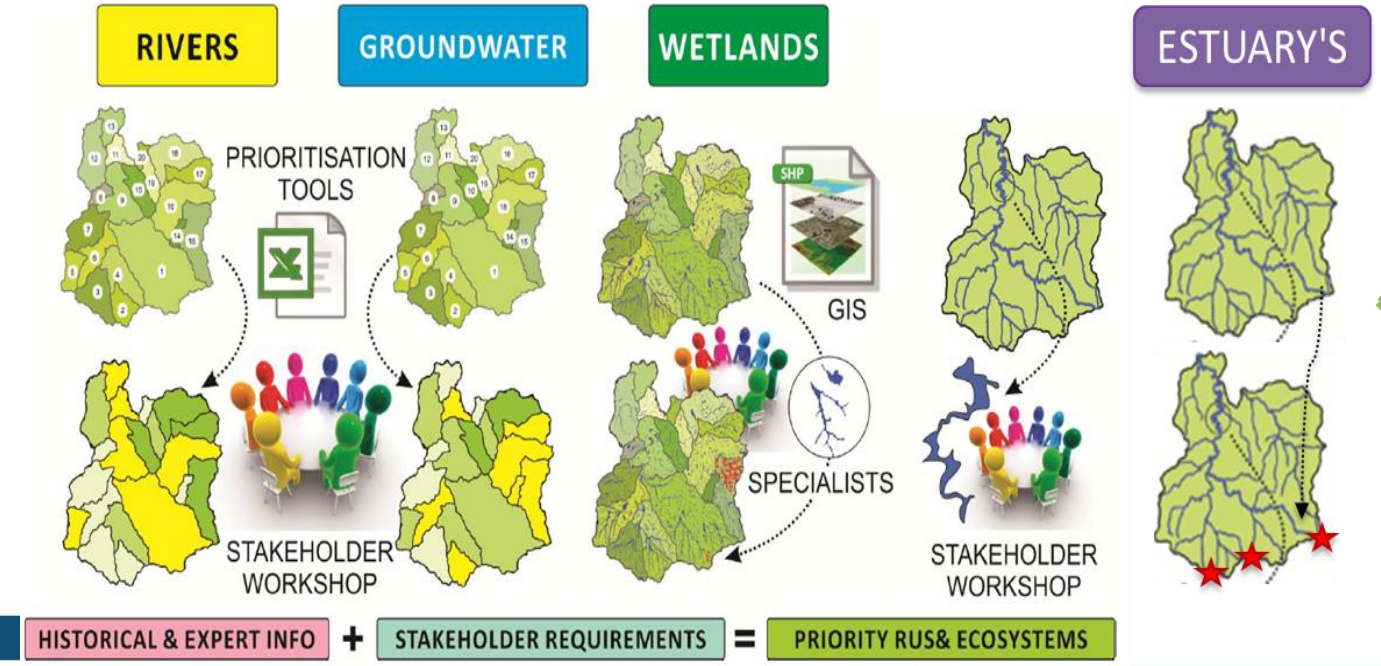
- RQOs cannot/do not:
  - Be applied to an individual licence
  - Replace the need for other monitoring programmes
  - Include every available indicator of resource quality
  - Be considered as absolute “truths”

RESOURCE UNITS' PRIORITISATION

WHERE SHOULD RQOs BE SET? (Prioritisation)

PRIORITY RESOURCE UNITS





Ecological considerations

Water use impacts considerations

DELINEATION OF RESOURCE UNITS

- **RU resource units** delineated
  - 27 river and estuary units
  - 28 Groundwater RUs
  - Priority wetlands/wetland clusters (linked to the river RUs)

PRIORITY RESOURCE UNITS: RIVERS

- Position of RU within IUA
- Importance of each RU to users
- Level of threat posed to the water resource quantity and quality for users and ecology (resource stress)
  - High utilisation
  - Compromised water quality; and/or
  - Future water resource developments which are planned
- Present Ecological State, Ecological importance/ sensitivity
- Strategic Water Resource Areas
- Freshwater Ecosystem Priority Area (upstream/within)
- Conservation sensitivities (specifically conservation targets set by the DEA)
- Importance for ecosystem processes/ biodiversity value)

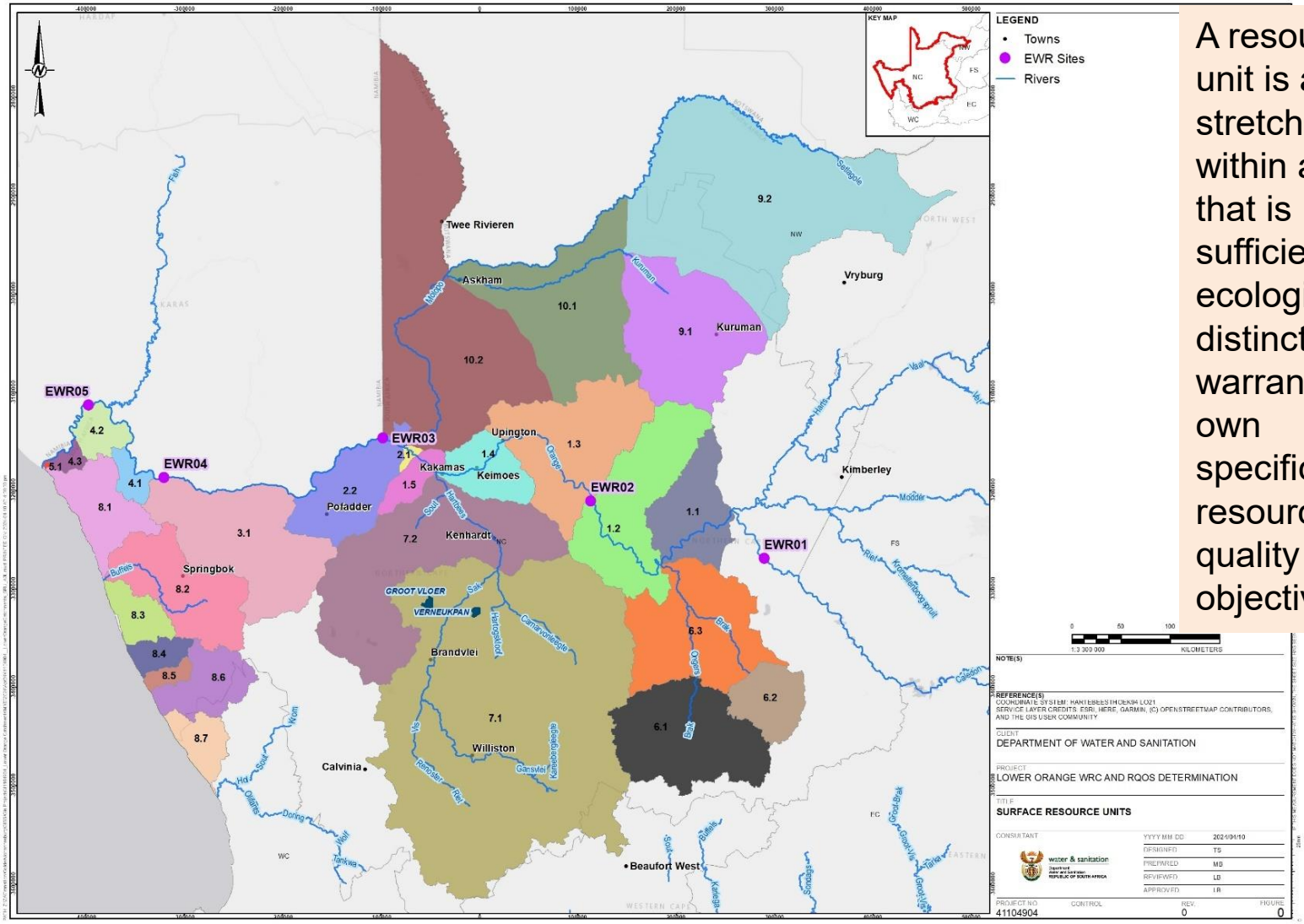
PRIORITY RESOURCE UNITS: RIVERS

- Threatened or sensitive vegetation ecosystems
- Alien vegetation infestation was assessed and considered if a problem
- Sensitive aquatic macroinvertebrates (water quality, flow, habitat)
- Fish support areas, fish sanctuaries, fish corridors with IUCN red listed fish species
- If any priority wetlands or groundwater areas, contributing to baseflows of rivers
- Social-Cultural Importance
- Management considerations
- Practical considerations

Ultimately:

- Prioritise mainstem Orange River
- Requiring different EWRs, due to different flow patterns
- Reaction of habitat and biota to stress
- Require different management and operational structures

Resource Units: 27 surface resource units



A resource unit is a stretch of river within an IUA that is sufficiently ecologically distinct to warrant its own specification of resource quality objective

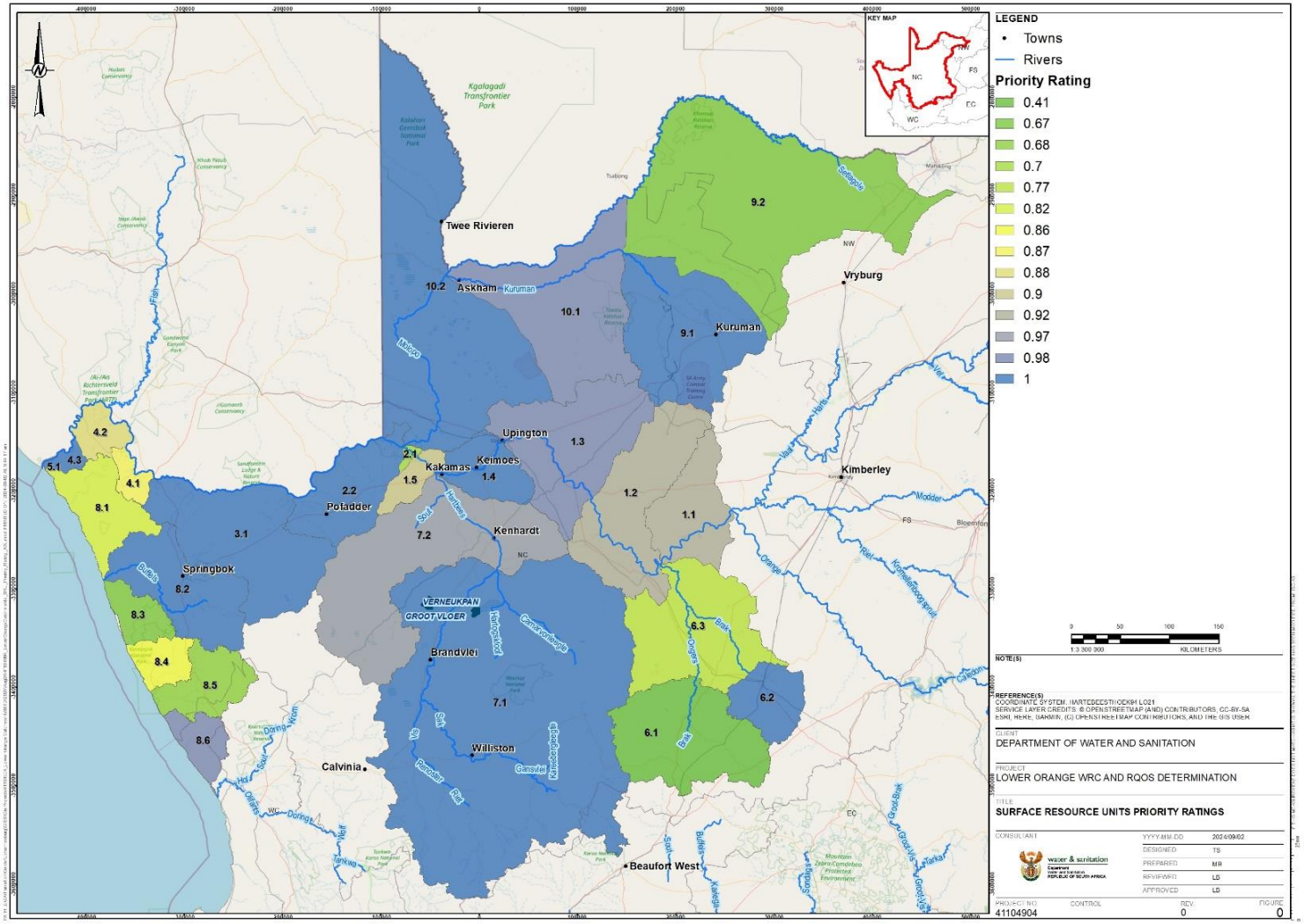
Prioritised River and Estuary Resource Units

- **23** of 27 units

Not prioritised

Medium Priority

High Priority

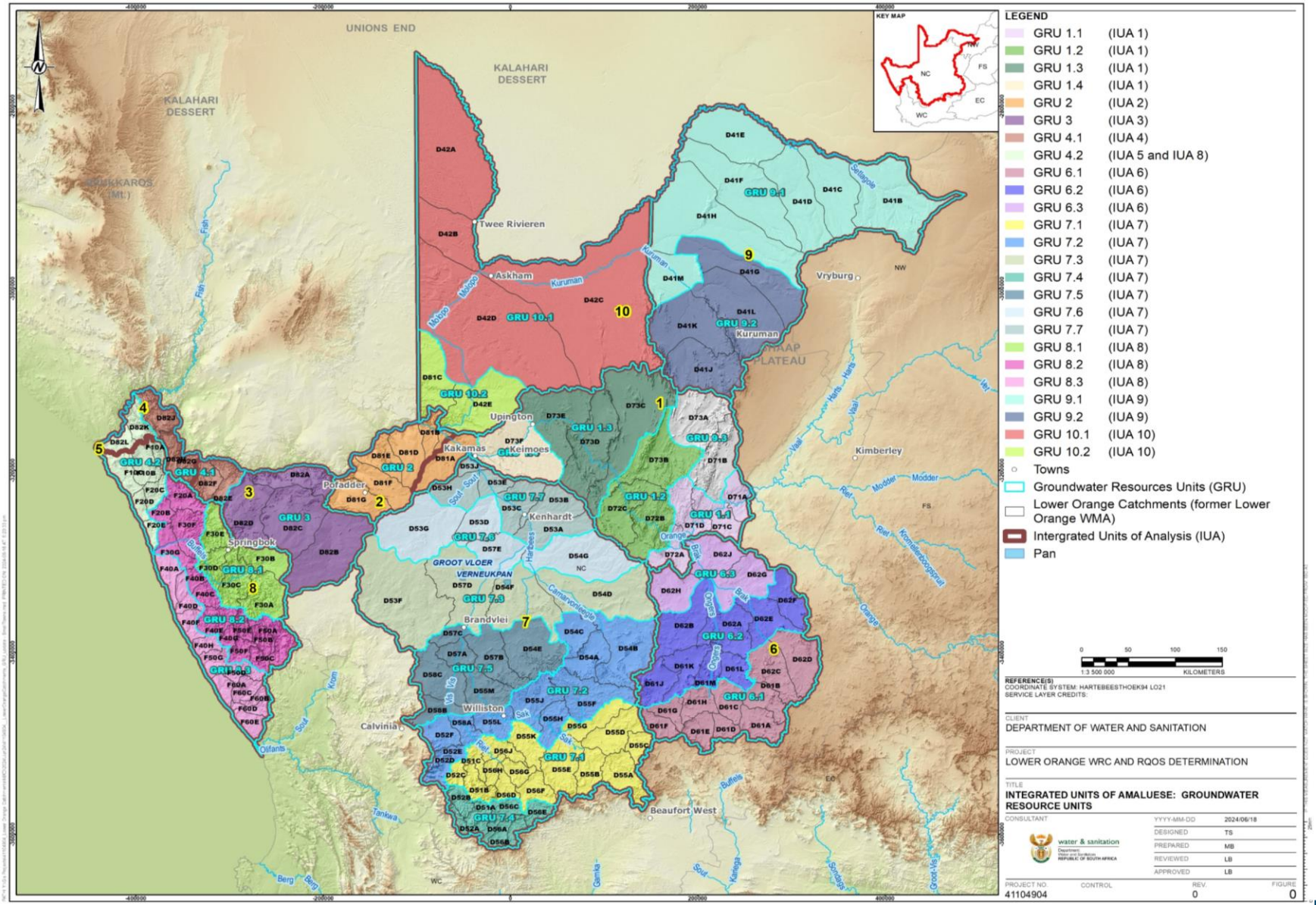


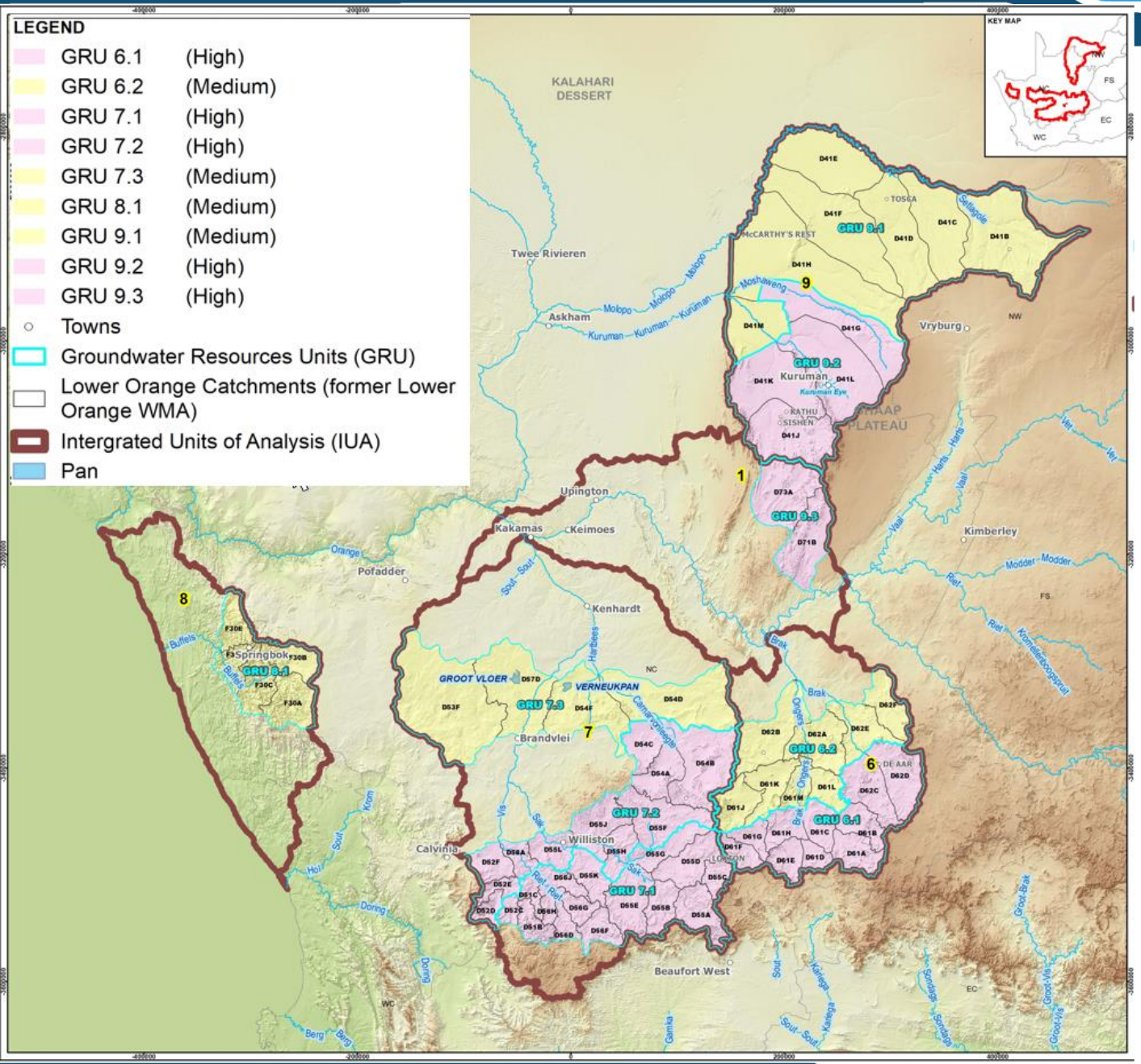
PRIORITY RESOURCE UNITS: GROUNDWATER

- Considerations and Criteria for GW RU rating:
  - Groundwater use (WARMS, NGA, density)
  - Strategic GW Areas (SW, GW, SW-GW)
  - Groundwater Dependency
  - Baseflow Component
  - Aquifer vulnerability
  - **Stress Factor**
  - **Water Quality**

- The GWRU delineation based on aquifer type and other physical, management and/or functional criteria
- Quaternary catchment forms basis of basic resource unit

28 Groundwater Resource Units





Priority Groundwater Resource Units based on:

Stress Factor which is the ration between groundwater use and recharge **(Q_{use} /Re)**; and

Quality (QI) – based on the domestic water classification (C0-C4).

●

Medium ⇨ SI = <0.5 and QI = <C2,

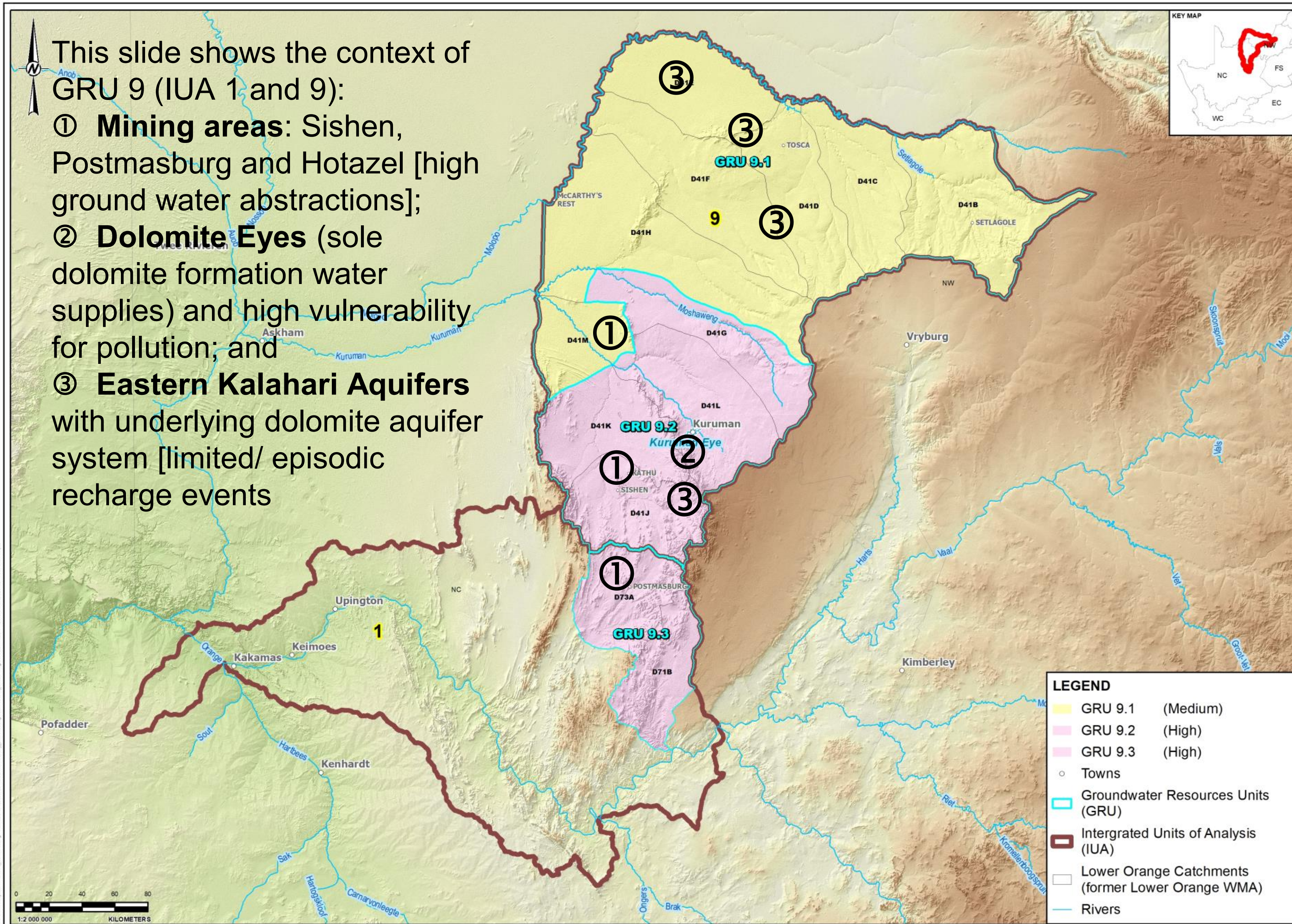
High ⇨ SI = >0.5 and QI = >C2.

This slide shows the context of GRU 9 (IUA 1 and 9):

① **Mining areas**: Sishen, Postmasburg and Hotazel [high ground water abstractions];

② **Dolomite Eyes** (sole dolomite formation water supplies) and high vulnerability for pollution; and

③ **Eastern Kalahari Aquifers** with underlying dolomite aquifer system [limited/ episodic recharge events



PRIORITY WETLANDS

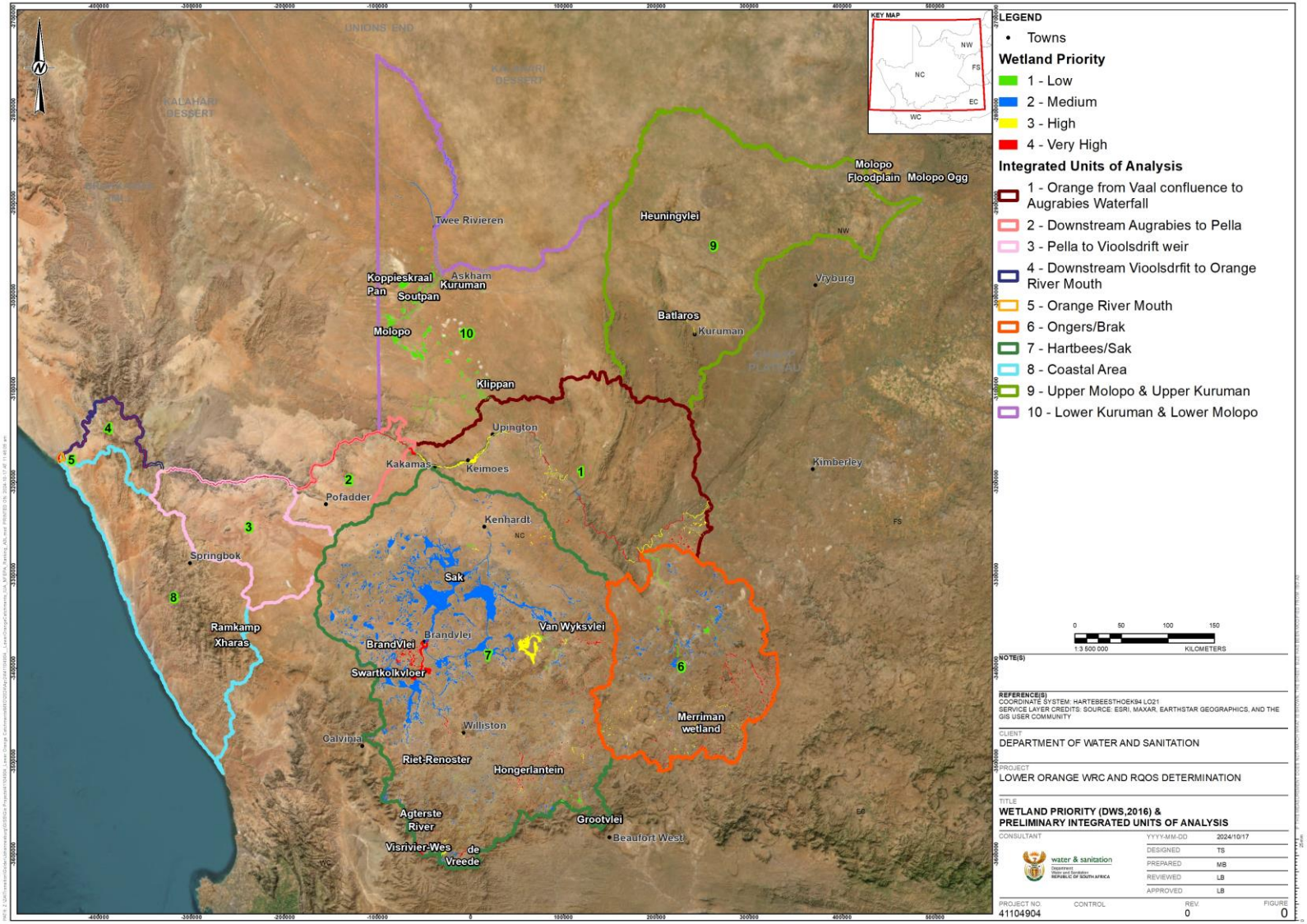
- The delineation of the Wetland Resource Units (WRUs) was undertaken considering the following:
  - Identification of potential priority wetland areas
    - National Wetland Map 5
    - Screening - Attributes/Characteristics
    - Important bird areas
    - Hydrogeomorphic unit types and their services
    - Located upstream of water supply areas (as applicable)
  - Identification of criteria
    - PES
    - Theat status score
    - Critical biodiversity areas
    - FEPA wetlands
  - Final selected priority Wetlands

- The identification of priority wetlands was focused on identifying systems at an ecosystem level and is strongly reliant on knowing where important wetland systems are.
- Existing wetland coverages/knowledge (& additional)

PRIORITY WETLANDS

Priority Wetland	Wetland	IUA	Catchment	Type	Coordinates
1	Merriman	6	D61A	In-channel wetlands	-31.222040°; 23.613541°
2	Agterste River	7	D52B	In-channel wetlands	-32.184566°; 20.442429°
3	Brandvlei	7	D57C	Depression	-30.513907°; 20.481722°
4	De Vreede	7	D56A	Channelled Valley Bottom wetland	-32.514320°; 20.855526°
5	Grootvlei	7	D55A	Channelled and Unchannelled Valley Bottom wetland	-32.163926°; 22.471803°
6	Grootvloer	7	D57D	Depression	-30.040114°; 20.603565°
7	Hongerlantein	7	D55K	In-channel wetlands	-31.659053°; 21.250350°
8	Narooga Pan	7	D57D	Depression	-30.373035°;20.396123
9	Riet-Renoster	7	D58A, D51C, D56J	In-channel and Channelled Valley Bottom wetland	-31.601148°; 20.618905°
10	Swartkolkvloer	7	D58C	Depression	-30.755058°;20.066265°
11	Van Wyksvlei	7	D54C	Depression	-30.438115°; 21.773985°
12	Visrivier-wes	7	D52A	Channelled and Unchannelled Valley Bottom wetland	-32.424881°; 20.397755°
13	Ramkamp	8	F30 & F50	Unchannelled Valley Bottom wetland	-30.32454444°; 18.0863702°
14	Xharas	8	F30	Valley head seep and Channelled Valley Bottom wetland	-30.3387778°;18.1073694°
15	Batlaros	9	D41L	Channelled Valley Bottom wetland	-27.298556°; 23.327279°
16	Heuningvlei	9	D41H	Depression & Hillslope Seepage wetlands	-26.313500°; 23.143620°
17	Kuruman	9	D41L	Channelled Valley Bottom wetland	-27.448869°; 23.436466°
18	Klippan	10	D42D	Depression	-27.969600°; 21.279200°
19	Koppieskraal	10	D42D	Depression	-26.982333°; 20.279445°
20	Soutpan	10	D42D	Depression	-27.110332°; 20.440887°

Prioritised Wetland/Wetland Systems



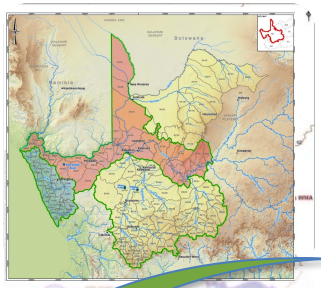
PRIORITY RESOURCE UNITS: ESTUARIES

- Estuaries is a single RU based on the Estuarine Functional Zone
- Water resource importance (use/quality)
- High ecological importance (resource is currently/future stressed)
- Previous assessments
- Further considerations/inclusions:
  - High Ecological Category: A, A/B or B (High EC);
  - Critically endangered species
  - Carbon sequestration (mangrove, salt marsh)
  - Nursery areas

SUB-COMPONENT PRIORITISATION AND INDICATOR SELECTION

WHAT SHOULD RQOs BE SET FOR?

RESOURCE QUALITY OBJECTIVES



Prioritisation of RUs for RQO Development

Selection of Components (Habitat, Biota, Quality, Quantity) per RU

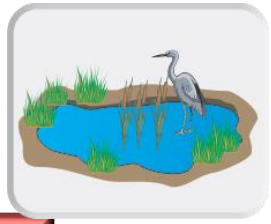
Selection of Sub-components and Indicators

Fish, Aquatic Invertebrates, Aquatic birds, diatoms

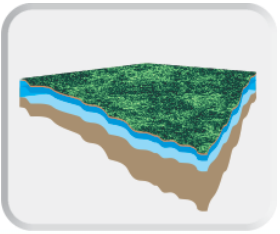
Instream, Riparian, Dam Habitat

Salts, Nutrients, Pathogens, Toxics, pH, Turbidity

Low flow, High Flow



groundwater



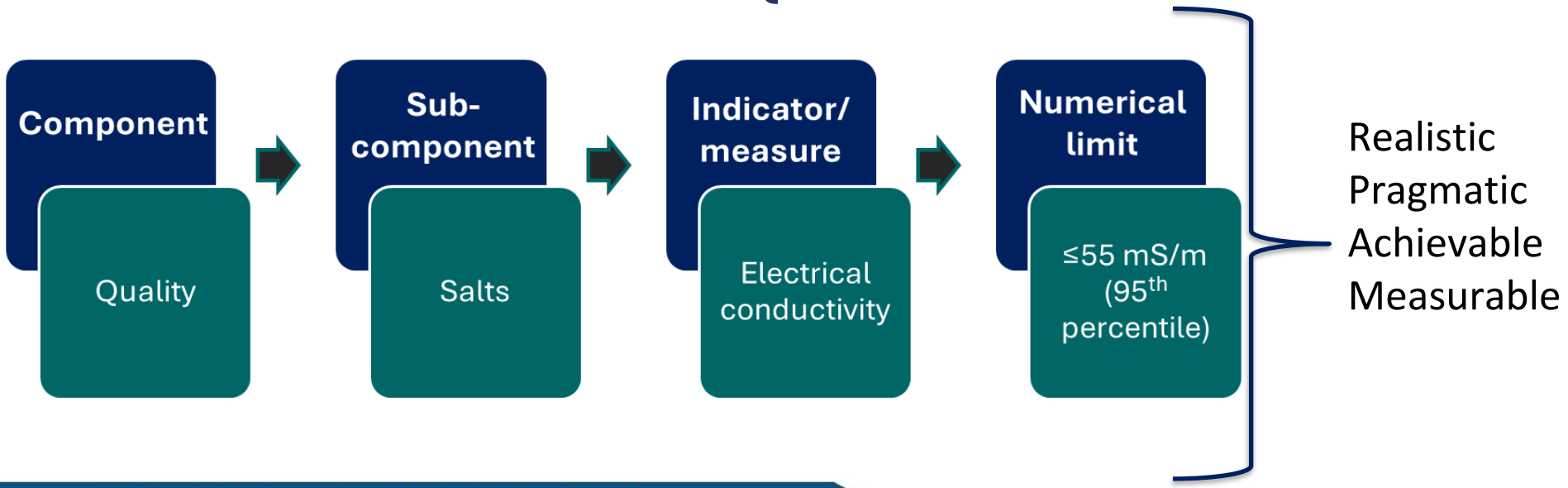
Water Level, Abstraction, Water Quality, Protection Zones

- Water resource RUs
  - RU evaluation tool
    - To evaluate and select the most useful indicators per priority RU for RQOs
  - Expert judgement
  - Stakeholder input

RESOURCE QUALITY OBJECTIVES

- Components – sub-components – indicators: for setting the RQOs
- Based on:
  - Activities that impact on water resources
  - User requirements
- Protection of the resource

Indicators and numerical limits or descriptive statements for RQOs should be set



SUB-COMPONENTS FOR WHICH RQOs HAVE BEEN SET

Rivers	
Component	Sub-component
Quantity	Low Flows
	High Flows
Quality	Nutrients
	Salts
	System variables
	Toxics
	Pathogens
Habitat	Geomorphology
	Riparian vegetation
	Integrated Habitat (instream and riparian)
Biota	Fish
	Macroinvertebrates
	Diatoms

Estuaries	
Component	Sub-component
Hydrodynamics	Mouth condition
	Abiotic states
Quality	Salinity
	Dissolved inorganic nitrogen
	Dissolved inorganic phosphate
	Water clarity
	Dissolved oxygen
	Toxic substances
	Pathogens
Habitat	Intertidal
	Subtidal
	Substrate type
Biota	Microalgae
	Macrophytes
	Macroinvertebrates
	Fish
	Birds

Groundwater
Quantity (abstraction)
Aquifer water level
Water quality
Protection zones

Wetlands	
Component	Sub-components
Quantity	Water inputs
Quantity	Distribution and retention
Quality	Nutrients, salts, system variables
Habitat	Vegetation, PES
Biota	Birds, Aquatic Inverts

SETTING OF RESOURCE QUALITY OBJECTIVES

Rivers

- Approach:
  - Data retrieved from previous studies for the catchment
  - Intermediate: RQOs for relevant indicators (DWS, 2016)
  - Rapid 3: RQOs for relevant indicators, geomorphology and riparian vegetation (IHI as surrogate)
  - Field verification: used RQO evaluation tool to identify sub-components
    - Rivers: REMP Data (inverts and fish)
    - Other previous EWR studies
- Water quality:
    - Largely mainstem Orange River (regional monitoring; Gariep Watch)
    - DWS, 2008 – setting RQOs for water quality for Reserves in accordance to the ecological category for water quality
    - Present status or ecological water quality requirement (stricter)
    - Inferred from diatoms and macroinvertebrates (both respond to WQ changes)
    - Health risk guidelines or RQOs for *Escherichia coli* (as used by the National Microbial Monitoring Programme (NMMP) of South Africa (DWAF, 2002)

SETTING OF RESOURCE QUALITY OBJECTIVES

Estuaries

- Approach:
  - Data retrieved from previous assessments for the catchment (once off sampling)
  - Priority estuaries: Orange Estuary and 6 smaller coastal
    - NBA, 2018, plus revisions
    - DWS, 2016 Reserve Study

Groundwater

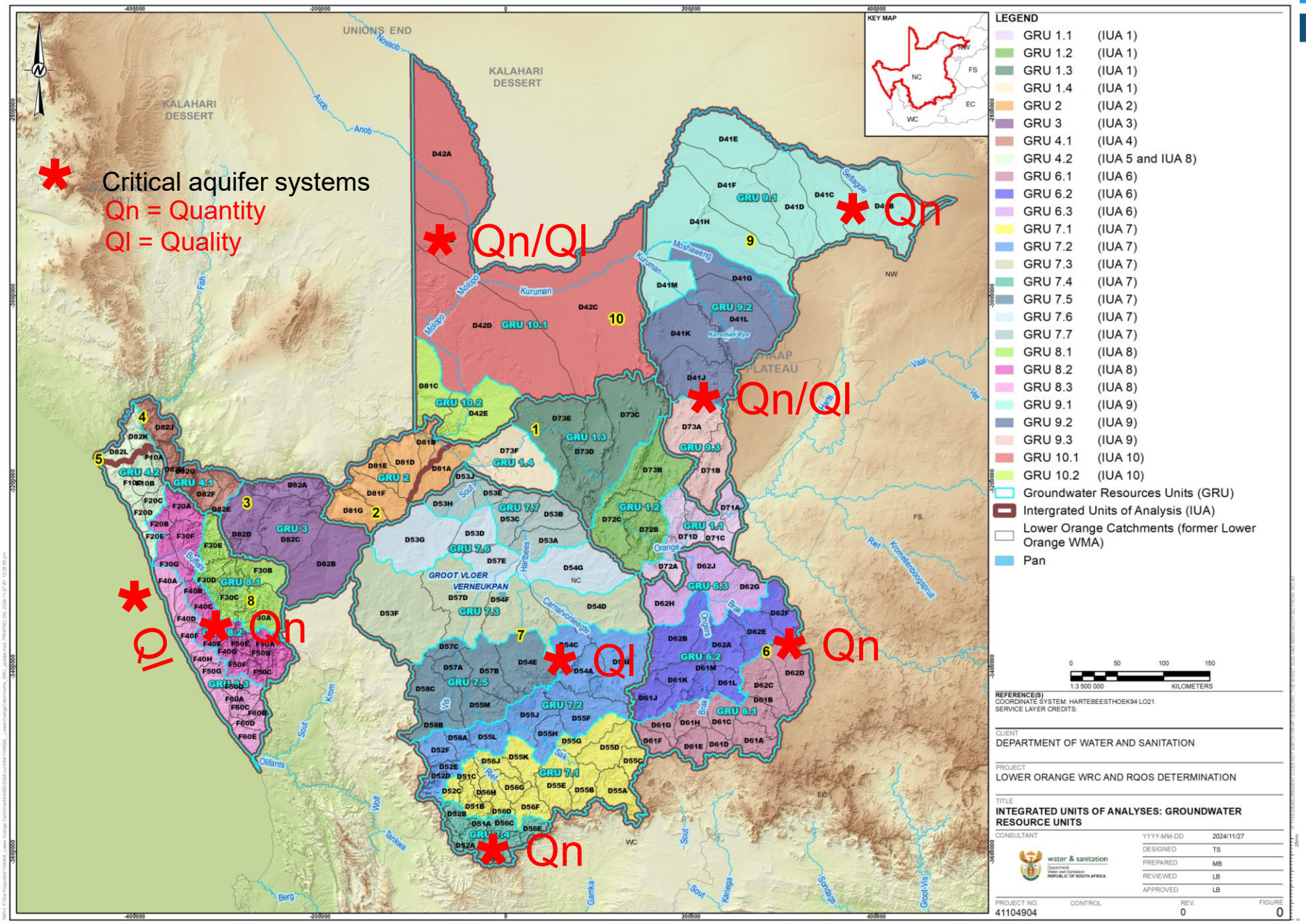
- Approach:
  - Data retrieved from available information for the study area
  - Priority groundwater:
    - RQOs for indicators
      - Abstraction Rates, water levels, constituents of concern
    - Water Levels - Hydstra
    - Chemistry

Wetlands

- Approach:
  - Data retrieved from all previous assessments for this catchment (limited)
  - RQOs only set for priority wetlands for relevant indicators (availability)

DRAFT RESOURCE QUALITY OBJECTIVES PROPOSED

Draft RQOs for Groundwater


Critical aquifer systems
Qn = Quantity
Ql = Quality
Qn/Ql
Qn
Qn/Ql
Qn
Ql
Qn
Ql
Qn
Qn
KALAHARI DESSERT
KALAHARI DESSERT
UNIONS END
KEY MAP
LEGEND
GRU 1.1 (IUA 1)
GRU 1.2 (IUA 1)
GRU 1.3 (IUA 1)
GRU 1.4 (IUA 1)
GRU 2 (IUA 2)
GRU 3 (IUA 3)
GRU 4.1 (IUA 4)
GRU 4.2 (IUA 5 and IUA 8)
GRU 6.1 (IUA 6)
GRU 6.2 (IUA 6)
GRU 6.3 (IUA 6)
GRU 7.1 (IUA 7)
GRU 7.2 (IUA 7)
GRU 7.3 (IUA 7)
GRU 7.4 (IUA 7)
GRU 7.5 (IUA 7)
GRU 7.6 (IUA 7)
GRU 7.7 (IUA 7)
GRU 8.1 (IUA 8)
GRU 8.2 (IUA 8)
GRU 8.3 (IUA 8)
GRU 9.1 (IUA 9)
GRU 9.2 (IUA 9)
GRU 9.3 (IUA 9)
GRU 10.1 (IUA 10)
GRU 10.2 (IUA 10)
Groundwater Resources Units (GRU)
Intergrated Units of Analysis (IUA)
Lower Orange Catchments (former Lower Orange WMA)
Pan
1:3 500 000
KILOMETERS
DEPARTMENT OF WATER AND SANITATION
LOWER ORANGE WRC AND RQOS DETERMINATION
INTEGRATED UNITS OF ANALYSES: GROUNDWATER RESOURCE UNITS
41104904

Groundwater Resource Quality Objectives (RQOs)

Establishment of **RQO Indicators-Measures-Narratives** for groundwater resource units is based on the following measurable hydrogeological parameters:

- **Quantity** (Mm^3/a as measures and limits):
  - Recharge – Mm^3/a (merely from chloride mass balance methodology + GRA II Assessments);
  - Groundwater Use – Mm^3/a (estimated from GRA II Assessments and updated WARMS dataset and hydrocensus surveys) and
  - Groundwater Stress Index (calculation indicating the aquifer stress factor – Specifies an upper limit of 65% a Poor Aquifer Condition)
  - Aquifer water level depth (metres below ground level obtained from groundwater monitoring programs).
    - Water depth and water level depth trend (indicator and measure) is (i) an indicator for aquifer depletion due to abstraction and should be followed by (ii) a phase where abstraction is decreased to allow water level recovery; and
    - Specify water limits such a (i) Dynamic Water Level limit (an operational level range) and (ii) Critical Water Level (not less than 5 m above the "master water strike depth)".

Groundwater Resource Quality Objectives (RQOs)

- **Quality** (mgTDS/L and specific hydrochemical constituent concentrations as measures and limits):
  - Total Dissolved Solids – Provides an direct indicator of the groundwater quality status
    - TDS as aquifer water quality-type indicator; and/or
    - TDS trend (neutral, up/down time series) and gradient (measure of rising/recessing trend) for aquifer water quality status
  - Water quality dissolved constituents present and concentrations:
    - Aquifer water quality type: A measure of specific baseline-aquifer water quality type(s), i.e., Ca/Mg-HCO_3, Na-HCO_3, Na-Cl, Ca/Mg-SO_4 – the measure is to remain aquifer water type to the baseline water type by preventing hydrochemical pollution or other deteriorating sources;
    - Water quality trend (indicator) and gradient (measure of rising/recessing trend over time) using specific hydrochemical constituents like Na-Cl or Ca/Mg-SO_4; and
    - Specific CoCs like Nitrate, fluoride, ammonium (NH_4) or ortho-phosphate (PO_4)

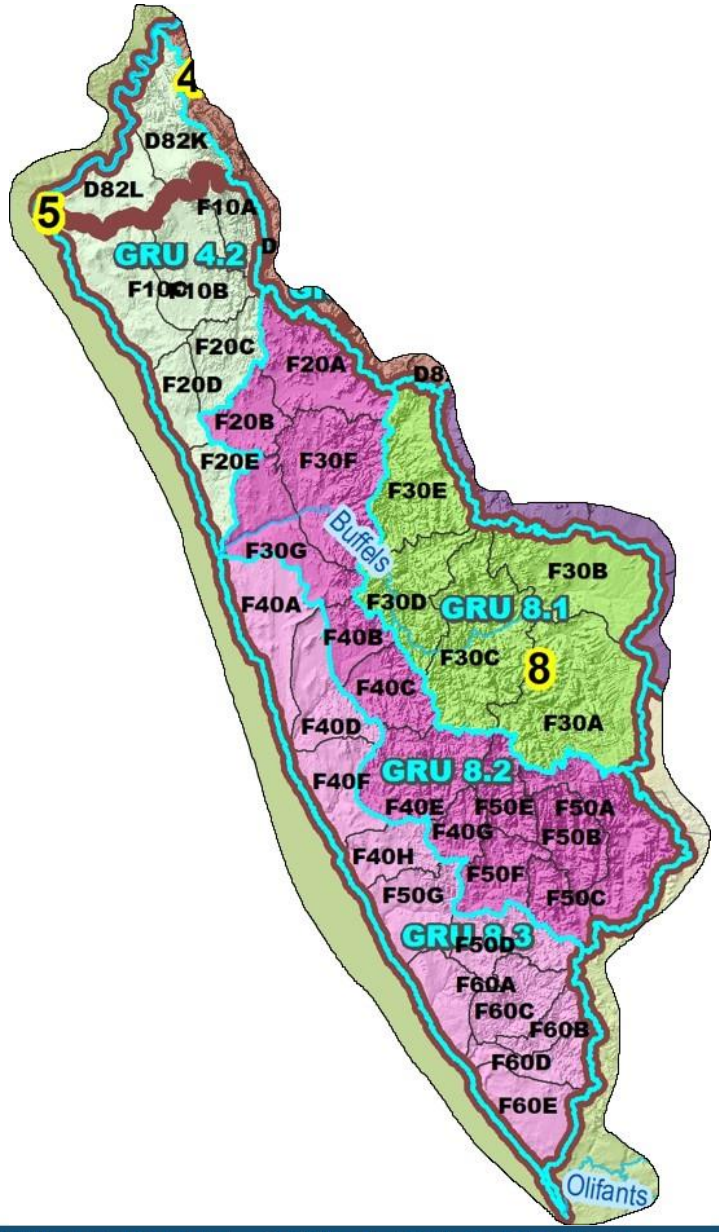
Groundwater Resource Quality Objectives (RQOs)

- **Aquifer Vulnerability** – (specific indicators that arise from primary or secondary conditions that may impacts on the vulnerability of the aquifer system posing a concern/threat for the health/aesthetic status of the aquifer system). Several Aquifer Vulnerability attributes have been included as indicators with proposed measures to impose specific protection protocols for the groundwater resource(s).
  - Depth to water level – Shallow aquifer systems (<60 mbgl)
    - Measure: radius of influence ([spatial metres] between abstraction point and potential impacted source (wetlands, dolomite eyes and flood plain alluvial aquifers));
    - Preferential recharge zones [demarcations] of dolomite (karst) aquifer systems having potential pollution risk (due to poor waste and wastewater treatment); and
    - Limit on groundwater level depletion to protect indigenous flora (such as the Kathu Camelthorn Forest in the .

Groundwater Resource Quality Objectives (RQOs)

- Water level depletion (alien vegetation and irrigated land)
  - Measure: arial coverage (ha's) and groundwater level impact of uncontrolled alien tree population expansion along drainage channels (rivers) and large veld areas (starts with satellite imagery in critical areas); and
  - Measure: expansion of hectares used for groundwater irrigation schemes in river flood plains and large aquifer systems (DLMTs).
- Aquifer Recharge (mm/a) and Aquifer Abstraction (groundwater use)
  - Measure: annual estimations of recharge volumes to specify annual "allocable yield" volumes; and
- Hydraulic Conductivity (HC)
  - Measure: As an indicator some aquifer formations (fractured and weathered thick sandstone formation have high hydraulic conductance's that may allow high-yielding boreholes that could allow over-abstraction of the aquifer water balances — bulk water supply schemes.
  - Measure: aquifers with high HC susceptible to significant lateral impacts (i.e., sandstone/dolomite aquifer types) due to high groundwater flux in aquifer and storativity (/storage) that may enhance the migration of unwanted polluted substances to enter the deeper parts of the aquifer system.

IUA 8 - GRU 8.1, 8.2 & 8.3



WATER RESOURCE CLASSIFIACTION: III (Class 3 (C))

Primary groundwater quality impacted by marine aerosols and water-rock formation interaction (elevated salinity, e.g. NaCl and fluoride). Water quality criteria is the most critical measure/objective due to natural conditions/ climate impact(s).

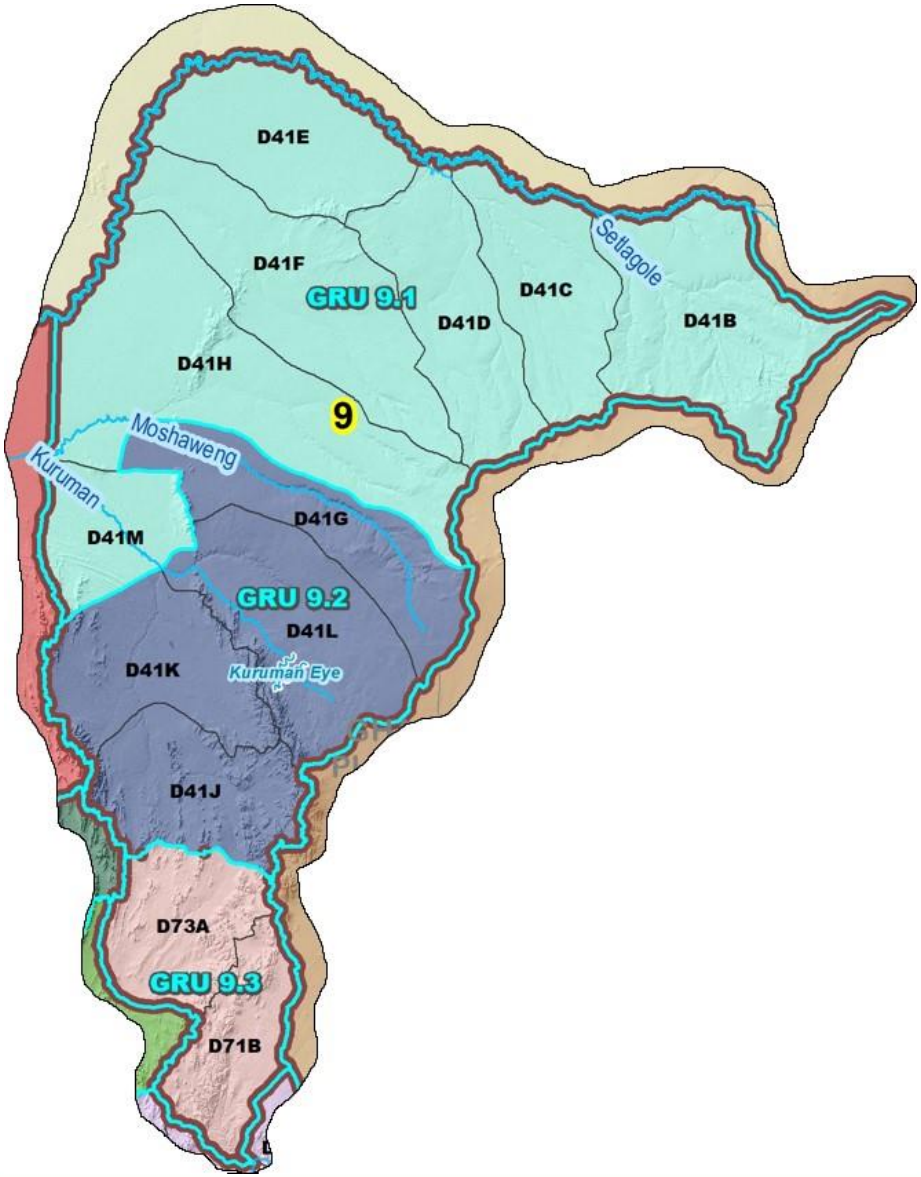
RESOURCE QUALITY OBJECTIVES:

Quantity:
SI status is Moderately Used (~48%).
RQOs:
1 - Allocable Yield Categories: a C1;
2 – Annual water level trend should be stable/oscillating according to the annual recharge phases.

Quality:
Current WQC = Marginal WQT Class 2 for all GRUs
RQOs:
1 – Upper limit for TDS be limited to 2400 mgTDS/L;
2 - WQl Trend Indicator: NaCl dilution in aquifers.

Vulnerability:
1 –Background NO3 & F Municipal Well Fields and stock kraals.;
2 –Note: Insignificant to Low Borehole Yield Classification.

IUA 9 - GRU 9.1, 9.2 & 9.3



WATER RESOURCE CLASSIFIACTION: III (Class 3 (C))

Shallow hard rock formations (high recharge) and dolomite aquifer (high potential for serious pollution form surface flows). High demand for groundwater exploitation (no surface water resources available). Significant mining developments (dewatering) taking place and high rural population growth (high domestic use).

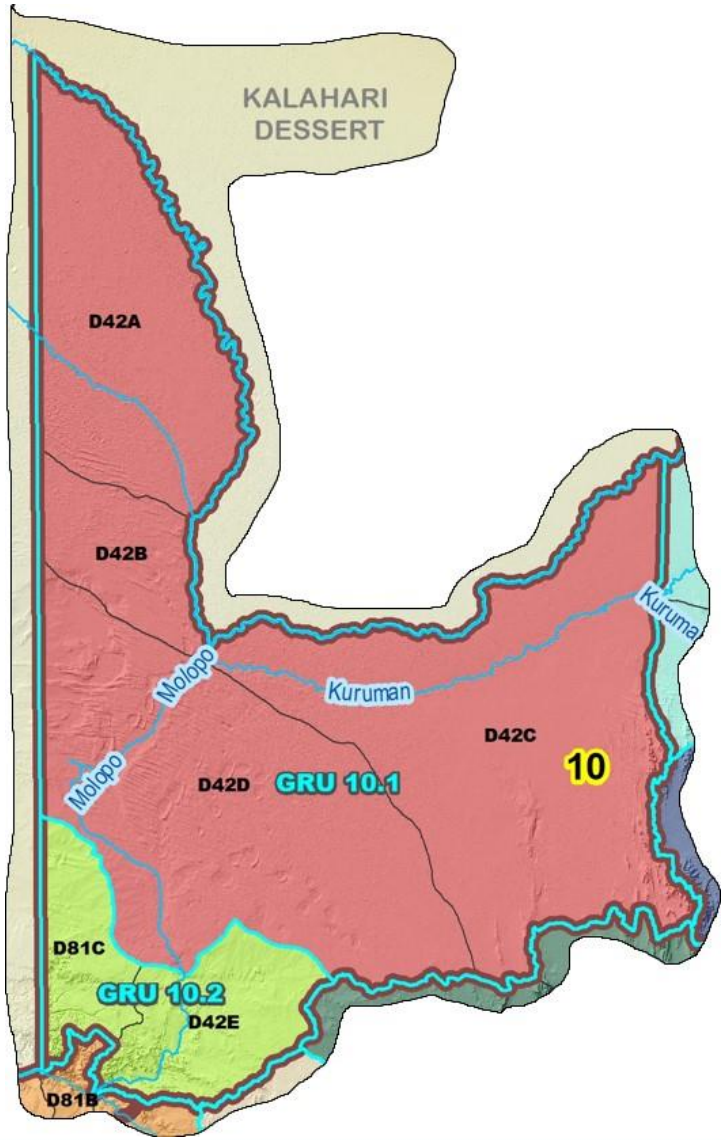
RESOURCE QUALITY OBJECTIVES:

Quantity:
SI status is Moderately (9.1 at 42%) and Heavily Used (9.2 & 9.3 at ~89%).
RQOs:
1 - Allocable Yield Categories: a upper limit Class C1 (9.1) and C3 (9.2 & 9.3);
2 – Water trend analyses should not remain negative for >2 HCs.

Quality:
Current WQC = Marginal WQT Class 2 for all GRUs
RQOs:
1 – Upper limit for TDS be <1000 mgTDS/L; and
2 – "Three Tire" water quality limits proposed.

Vulnerability:
1 – Water level recession trends <2.5m/a MAX 1½-yrs.

IUA 10 - GRU 10.1 &10.2



WATER RESOURCE CLASSIFIACTION: II (Class 2 (B))

Very limited groundwater recharge (MAP <250 mm/a to 75 mm/a (GRU10.2)
Kalahari Group Aquifer Systems with only sporadic recharge events (flush flooding in Molopo and Kuruman River. Low yielding vulnerable freshwater aquifers in Lower Kuruman River (Van Zylsrus – Andriesvale Area).

RESOURCE QUALITY OBJECTIVES:

Quantity:
SI status is Moderately (42%).
RQOs:
1 - Allocable Yield Categories: a Class C2 recommended;
2 – Borehole yields should be limited to prevent saline water intrusion from deeper saline aquifer system.

Quality:
Current WQC = Marginal WQT Class 2 for all GRUs
RQOs:
1 – Upper limit for TDS be <1000 mgTDS/L;
2 – Specific limits for Na, TAL, Cl and SO4.

Vulnerability:
1 – Water level recession trends <0.5m/a MAX 1½ - yrs
2 – Over abstraction from unique T-Qk Aquifer Systems.

Groundwater RQO tables – what you will see

Sub-component		Indicators	Measures	Context o/t RQO / Narrative
IUA 9 (GRUs 9.2, 9.3) **Complex aquifer combinations including shallow hard rock formation (high recharge) and dolomite aquifer (high potential for serious pollution form surface flows).** **High demand for groundwater exploitation (no surface water resources available).** **Significant mining developments taking place and high rural population growth (high domestic use)**				
Quantity (Qn)	Aquifer water level (table) depths (mbgl) or elevation of aquifer saturation elevation (mamsl)	Rainfall Depths	Groundwater Annual Recharge (mm/a)	Seasons with lower rainfall depths have lower recharge rates. Consider actual annual rainfall figures instead of Long-Term average values. Test scenarios using depleted rainfall input.
		Borehole water level (depth metres below ground level).	Water Level (time series) trend analysis.	An indicator of recharge and abstraction balance) .
	Sustainable Use:	Stress Index (factor) (Water Use volumes). Upper limit of SI value = 65% (or 0.65). Allocable Yield (AIY): Difference between water used (BHN+EWR+GwBF)+Total Use) and an annual-based recharge value.	Groundwater recharge values and Total Groundwater Use figures. Establish water use figures for main water users. SI MAX 0.65 Allocable Yield (MIN 2.0 Mm3/a)	Indicator of "Allocable Yield" and status of aquifer storage volume (89% Alloc'd). Important aspect of calculation of Total Water Use in SI Classification. Available Volume (2025) = 96 Mm3/a Water Use Sectors (Stock watering & irrigation): 0.8 and 35Mm3/a.

Sub-component		Indicators	Measures	Context o/t RQO / Narrative
Quality (QI)	TDS, Macro element concentrations and Constituents of Concern (CoCs) and Microbial Status.	Monthly salinity measurements (TDS mg/L). Measure TDS-values for time series analysis.	TDS (salinity): Concentration should be limit to ≤700 mgTDS/L. TDS trend analyses should not indicate a rising trend over 2 consecutive years. Calculated TDS-Trend Analyses.	Baseline water quality indicator (natural water quality status to remain within a 10% oscillation). Indicator of poor recharge/over-abstraction/pollution over time.
		Macro element concentrations: Sodium; TAL; Chloride; and Sulphate. CoC: Fluoride, Nitrate, Ammonia and Orthophosphate.	Quarterly analyses required and individual concentrations should be limit to a Class 1 (Good) water quality criteria: Sodium: <60 mgNa/L. Long-term (7.5-yr) trend should not approach +10% TAL: dominant anion hydrochemical constituent – should remain <400 mgHCO3/L. Chloride: <53 mgCl/L. Long-term (7.5-yr) trend should not approach+10%. Sulphate: <27 mgSO4/L. Long-term trend should not approach+10%.	As per Reserve Determination specifications. In addition, any of these indicators may have relevance to pollution sources from agricultural and domestic water treatment related activities. Long-term TDS trend should not approach +10% (not to overrun 770 mgTDS/L). Water quality objective: QI = C1 (Good water quality type).
		Microbiological status (Total coliform counts) Nutrients Nitrate: NO3, mgN/L; Toxin– Fluoride: F, mgF/L; Toxin– Arsenic: As, mgAs/L; and Diss. Metals: Iron and Manganese (mgFe-Mn/L).	Total coliform counts: <10 counts/100 ml) Nitrate: Less than 10 mgN/L; Fluoride: <1.0 mgF/L; Arsenic: <0.05 mgAs/L; Iron-Manganese: <0.2 mgFe/L and <0.4 mgMn/L.	Total coliform counts and nitrate/nitrite concentrations are indicators of domestic pollution and should be regarded as critical water quality indicators – annual trends are therefore required through specific monitoring programmes. Additional care: PO4 and HN4.

Sub-component		Indicators	Measures	Context o/t RQO / Narrative
Vulnerability Status	Aquifer water level trend	Annual positive or negative water level trend (time series dataset) – water level recession rate (M/a)	Annual water level recession rate must be less than 2.5 m/a. If an ongoing negative trend is observed, abstraction yield (L/s) should be decreased by subsequent intervals of 12.5% per annum until stable trend is observed (i.e., until sufficient recharge has occurred to reset the negative trend.	Water level trend should be stable over time and reporting natural seasonal oscillations driven by wet/dry climate cycles – any deviation from this trend-pattern should be regarded as an indicator of aquifer stress (too low recharge and/or over-abstraction). If trend remains negative (+2 Hydrological Cycles), a special investigation is required to identify and address the cause of the water level recession.
	Hydro-chemical trends:	Time series trends of TDS obtained from quarterly water quality analyses (monitoring program/network required).	Medium-term trend (5-yr cycle) increases should not approach +10% (as indicated by the Reserve Determination guideline). "Three Tire" Water Quality Approach: T1, T2 and T3:	Quality trend(s) should stay within natural annual oscillation (annual recharge freshening). Medium-term (18 to 24 months) negative trend must be investigated (source identification). The critical constituent for the area is nitrate due to industrial and domestic waste generation.
	Aquifer Hydraulic Charac-teristics.	Hydraulic Conductivity Aquifer System(s).	Mapping of high yielding aquifer systems (Aquifer Zoning).	Potential to over-abstract aquifer when BYC indicates High to Significant BYCs. Stress Index Limitation (65% or 065). High HC unsaturated zone(s) enhances preferential infiltration into to saturated zone.

Sub-component		Indicators	Measures	Context o/t RQO / Narrative
Protection Criteria	Hydro-chemical trends:	Multi analytical parameter limits established based statistical evaluations of groundwater quality datasets	**"Three Tire" Water Quality Approach: T1, T2 and T3:** **Where: In mining/industrial /high level agricultural zones,**	T1–Site area of activities, allow up to 95th Percentile driven by impact: pH: 6.1 to 8.31; NO_3–N: 71 mg/l; Salinity TDS: 1800 mg/L; Sodium: 170 mg/L Chloride: 770mg/l; Sulphates: 160 mg/l; and Fluoride: 0.8 mg/l.
				T2–Buffer Area: Allow up to 75th Percentile supported by buffer area background signatures: pH: 6.1 to 8.1; NO_3–N: 9.8 mg/l; Salinity TDS: 1000 mg/L; Sodium: 60 mg/L Chloride: 91 mg/l; Sulphates: 50 mg/l; and Fluoride: 0.43 mg/l.
				T3–Background or Reference Area: Allow up to MEDIAN -value +10% in key CoCs as indicated above (Quality).

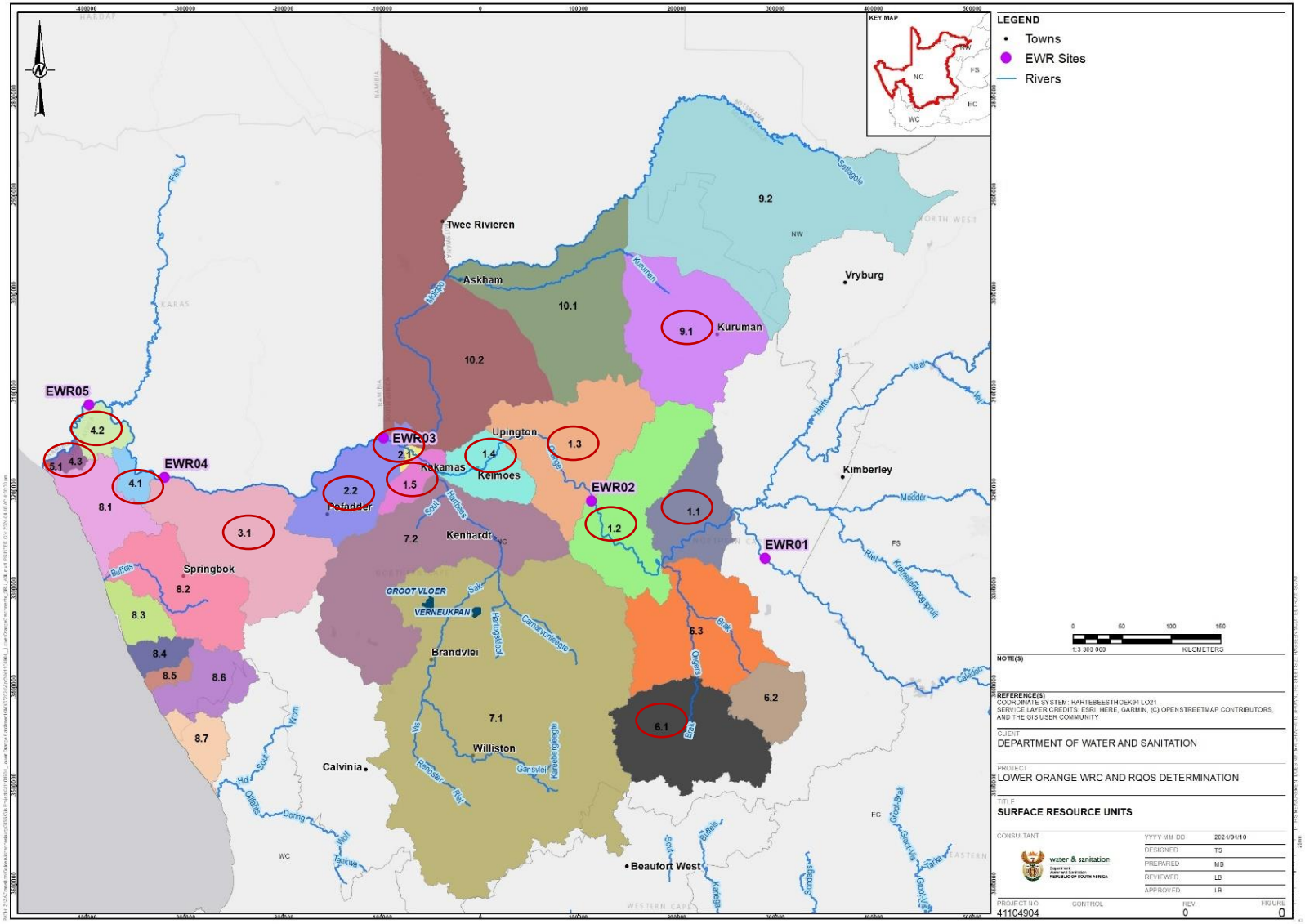
Draft RQOs - Rivers

SETTING OF RESOURCE QUALITY OBJECTIVES

Rivers

- Approach:
  - Understanding the catchment
  - Water resource classification proposed classes
  - Data retrieved from previous assessment/ studies for the catchment
  - Intermediate: RQOs for relevant indicators (DWS, 2016)
  - Rapid 3: RQOs for relevant indicators, geomorphology and riparian vegetation (IHI as surrogate)
  - Field verification: used RQO evaluation tool to identify sub-components
    - Rivers: REMP Data (inverts and fish)
    - Other previous EWR studies
- Water quality:
    - Largely mainstem Orange River (regional monitoring; Gariep Watch)
    - DWS, 2008 – setting RQOs for water quality for Reserves in accordance to the ecological category for water quality
    - Present status or ecological water quality requirement (stricter)
    - Inferred from diatoms and macroinvertebrates (both respond to WQ changes)
    - Applicable guidelines

13 Resource Units: Proposed River RQOs



Example River RU

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure			Context/Rationale for RQO/Numerical limit
1.3 Orange River from Boegeberg weir to Upington	Quantity	Low flows	EWR maintenance low and drought flows: Orange River at LO_EWR02 (-28.969493; 28.17843) in D73C nMAR = 10 772.6 x$10^6 m^3$ TEC=C category	Maintenance and drought flows required for the Orange River upstream of the EWR site		Maintenance flows (m^3/s	Drought flows (m^3/s)	EWR implementation (maintenance of required ecological status)
					Oct	28.211	15.0	
					Nov	36.708	22.0	
					Dec	39.920	22.0	
					Jan	47.269	22.0	
					Feb	61.393	33.0	
					Mar	60.014	33.0	
					Apr	53.153	15.0	
					May	39.716	15.0	
					Jun	30.813	15.0	
					Jul	24.956	15.0	
					Aug	23.653	15.0	
					Sep	24.231	15.0	
	Quality	Nutrients	Nutrient levels must be improved to support healthy aquatic ecosystem integrity, water user requirements and sustain ecological status.	Total Inorganic Nitrogen (TIN) as N	≤1 mg/L (50th percentile)			These variables are indicators of nutrient enrichment of water resources (N:P ratios). There is an impact of algae observed in the reach
				Orthophosphate as P	≤0.06 mg/l (50th percentile)			
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)			
				Chlorophyll-a (periphyton/phytoplankton)	≤ 20 ug/l (50th Percentile)			
		Salts	Salinity concentrations must be maintained/improved to support the aquatic ecosystem, domestic and irrigation water users and maintain the ecological state.	Electrical Conductivity	≤55 mS/m (95th percentile)			Fitness for use and maintenance of present state (prevention of decline)
				Total Dissolved Salts (TDS)	≤300 mg/l (95th percentile)			
				Sulphate	≤50 mg/l (95th percentile)			
				Calcium	≤35 mg/l (95th percentile)			
				Chloride	≤40 mg/l (95th percentile)			
		Pathogens	The presence of pathogens should not pose a risk to human health and impact on agricultural product quality.	Escherichia coli	≤130 Colony forming counts per 100 mL			Fitness for use – water user requirements. WWTWs are negatively impacting on microbiological quality
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements	pH range	6.5 (5th percentile) and 9.0 (95th percentile)			Fitness for use for users and ecosystem quality requirements.
			Baseline monitoring must be undertaken to determine seasonal trends turbidity to confirm a numerical limit. The trends in total suspended solids concentration must be monitored.	Turbidity	Should not change by >10% from established background concentration.			Water clarity is an indication of improved water quality. Sediment impacts from upstream land uses.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved Oxygen	≥ 7 mg/l O_2 (95th percentile)			Low oxygen levels associated with organic matter emanating from upstream activities including WWTW are negatively impacting

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context/Rationale for RQO/Numerical limit
1.3 Orange River from Boegeberg weir to Upington	Quality	Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health or agricultural produce.	Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications. Ecological Reserve manual (2008). South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Manganese/Iron – Domestic user water quality guideline (SAWQGs, 1996). Strictest of Ecological specifications.
				Ammonia as N	≤ 0.073 milligrams/litre (mg/l) (95th percentile)	Ecological specification. Ecological Reserve manual (2008).
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data. Australian drinking water guideline.
				Mancozeb	≤0.009 milligrams/litre (mg/l)	USEPA drinking water guideline
				Glyphosate	≤0.7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
	Biota	Fish	The Ecological Category should be maintained at a Category C.	FRAI Category and Score	FRAI >62%	The ensure there is no degradation of ecological status to EC of D/E
			A slow-deep velocity-depth class within reach is required throughout the year to ensure population integrity of juvenile indicator fish species as listed. This velocity depth class is linked to flow regulations, seasonality that is required for operation of the system.	Key species and abundance	Enteromius trimaculatis (ETRI) - Present at 25% to 50% of sites (FROC = 3) Labeobarbus aeneus (LAEN) - Present at 25% to 50% of sites (FROC = 3) Austroglanis sclateri (ASCL) - Present at 25% to 50% of sites (FROC = 3)	Presence of <25% FROC of the indicator species at the sites and indicate loss of flow and habitat.
			A fast-shallow velocity-depth class in reach during summer high-flow period should be maintained, to support the population integrity of the listed indicator adult fish species.			
			Riffles, minimally embedded cobbles and gravels for main stem Orange River (for spawning habitats) must be available.		Maintain habitat types (i.e. riffles and embeddedness of instream cobbles must be prevented and controlled) through source control measures of sedimentation (erosion)	Concern is increased sedimentation of rapids and riffles, with excessive algal growth on all substrates.

Resource Unit	Compon-ent	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context/Rationale for RQO/Numerical limit
1.3 Orange River from Boegeberg weir to Upington	Biota	Fish	Ensure no illegal fish netting (i.e. gill netting)		Regular visual observations and compliance monitoring through the DWS and relevant role-players in the catchment.	Significant increase in illegal fishing along Orange River. Decline in fish populations observed.
		Instream	The Ecological Category should be maintained at a Category C or greater.	Score and category	IHI: instream score ≥62%	Loss and degradation of instream and riparian habitat
		Riparian habitat	The Ecological Category should be maintained at a Category C or greater.	Score and category	IHI: riparian score ≥62%	
			Alien Invasive Plant (AIP) clearing and control within the riparian zone. Ensure alien macrophytes instream are controlled.		Monitor and manage through the IHI compliance	
			Revegetate riparian zone with indigenous vegetation for bank stability, erosion prevention and habitat integrity		Monitor and manage through the Riparian IHI compliance	
		Aquatic inverte-brates	The Ecological Category should be maintained within a C Category.	MIRAI Category and Score	MIRAI score ≥62	
			To ensure that the SASS scores attained, support the specified Ecological Category.	SASS5 Total Score and ASPT	To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >120; ASPT value: >6.1	
			To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa:	Dominant taxa		
			Baetidae >2sp		Minimum abundance of an B attained (10 - 100 individuals). If Baetidae >2sp is missing in two consecutive surveys or has a single individual present in two consecutive surveys. Velocities decrease below 0.6m/s for longer than a week, water quality deterioration and biotopes become exposed.	
			Heptageniidae		Minimum abundance of an A attained (atleast 10 individuals). If Heptageniidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys. Velocities decrease below 0.6m/s for longer than a week, water quality deterioration and SIC become exposed.	
			Ensure that no family dominates the macroinvertebrate assemblage, defined as D (>1000) abundance for more than two consecutive surveys.	Taxon dominance		
		Diatoms	Ecological water quality should be maintained as moderate quality	Specific Pollution Sensitivity Index (SPI); Percentage pollution tolerant values (%PTV)	SPI: 9-13 PTV: 20 to < 40%	

Resource Units 1.1 to 1.4 in IUA 1:

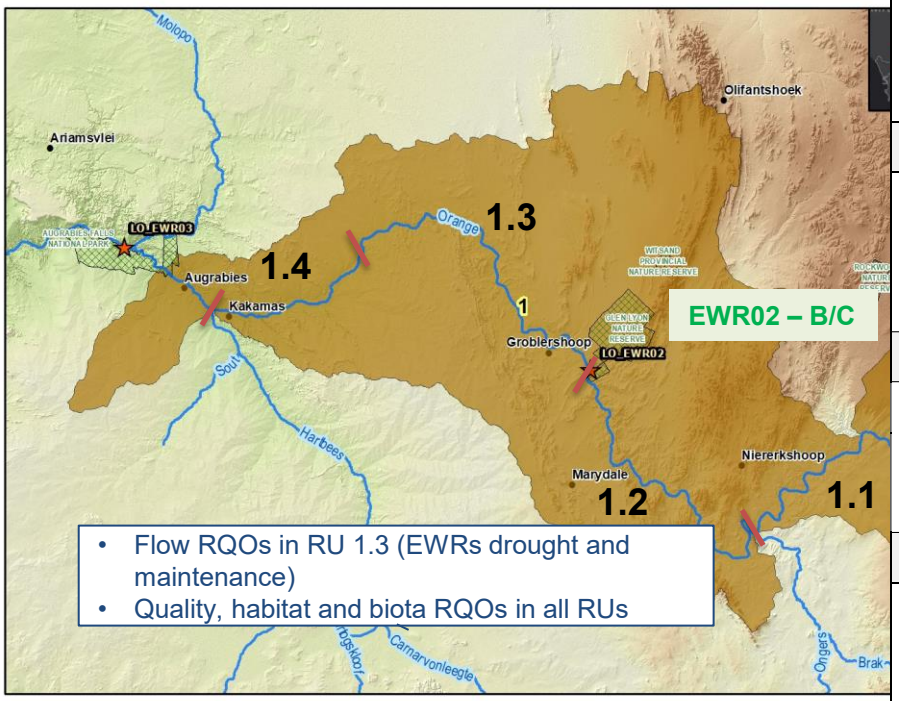
1.1 Lower Orange River to the Brak River confluence

1.2 Orange River from Brak River to Boegeberg weir

1.3 Orange River from Boegeberg weir to Upington

1.4 Orange River from Upington to Hartbees River confluence

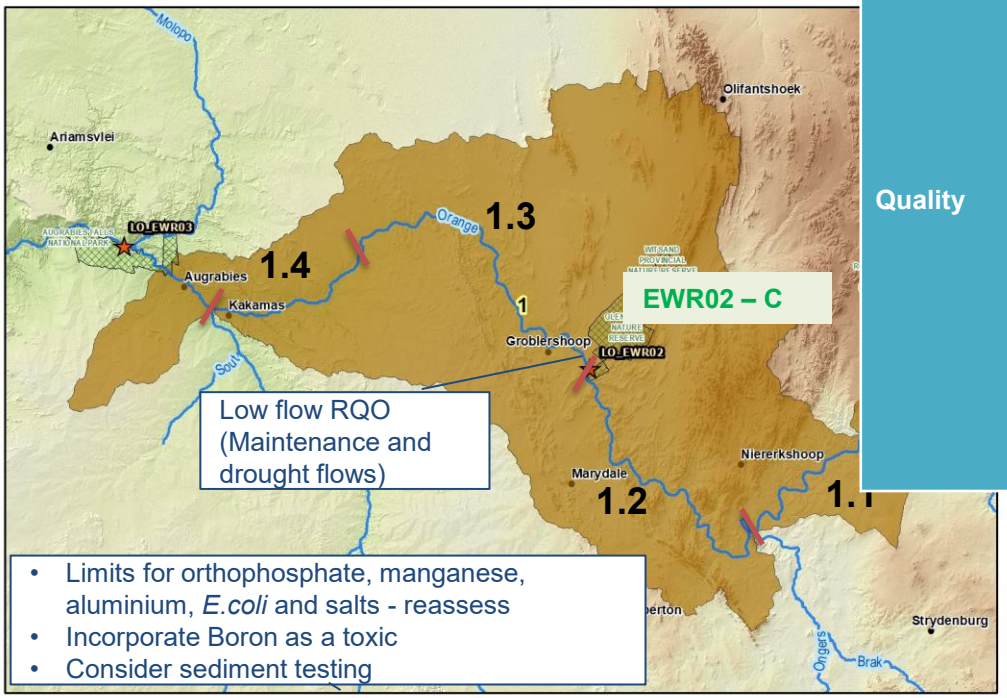
1.5 Orange River from Kakamas to Augrabies



Class III

IUA 1 – Lower Orange River from the Upper Orange confluence to Augrabies
Resource Unit 1.1: Orange River to the Brak River confluence
Mainstem, land activities and impacts homogenous along reach from the Vaal River confluence (intensive agriculture), flow and quality similar, includes the De Hoek (Irene) weir and WMS monitoring point. PES is predominantly a D category. Includes a groundwater SWSA. Inter-basin transfers - to downstream agricultural users and Namibian allocation. Large scale commercial farms (large abstractions and return flows). Mazelsfontein/Katlani weir area along the reach. Upstream water quality impacts (Douglas, Prieska poor quality).
Resource Unit 1.2: Orange River from Brak River to Boegeberg weir
Mainstem. Contribution of the Brak River tributary confluence and system break at Boegeberg weir (with Soutloop inflow). Land use similar and reach homogenous in terms of flow and quality. Intensive agriculture and town impacts. PES category C. Reach is FEPA fish sanctuary (has good fish diversity). Boegeberg weir and WMS monitoring point. Inter-basin transfers - to downstream agricultural users and Namibian allocation. Large scale irrigated agricultural schemes. Mining activities: alluvial diamond mining and Tiger's - future prospecting. Prieska - Urban area and associated sewage works discharge.
Resource Unit 1.3: Orange River from Boegeberg weir to Upington
Mainstem. RU extends to Upington (impact of the urban centre). Land use similar and reach homogenous in terms of flow and quality (intensive agriculture). PES category D. Reach is FEPA fish sanctuary area (has good fish diversity). Inter-basin transfers - to downstream agricultural users and Namibian allocation. Upington (impact of the urban centre). Land use similar: intensive agriculture - large scale irrigated agricultural schemes. Agro-processing industries (possible water quality impact). Loss Instream habitat and fish migration.
Resource Unit 1.4: Orange River from Upington to Hartbees River confluence
Mainstem. Upington at the start of the RU results in an impact and change to water quality, with a PES category of D/E, warranting a separate RU. Reach also dominated by intensive agricultural activity. Includes the Neusberg weir and WMS monitoring point. Reach is FEPA fish sanctuary area. RU extends to the Hartbees River confluence as a logical break in system just upstream of Kakamas. Inter-basin transfers - to downstream agricultural users and Namibian allocation. Hydropower at Neusberg - link via canals operation (minimum volume to turbine). Large scale irrigated agricultural schemes. Agro-processing industries (possible water quality impact). Upington (impact of the urban centre) - sewage Works – 16ML discharge.
Resource Unit 1.5: Kakamas to Augrabies Waterfall
Mainstem. RU dominated by intensive agricultural activity. Extends from Hartbees contribution to reach, to logical break at Augrabies Waterfall. Flow and quality similar (impacted). PES is predominantly a C/D category. Reach is FEPA. Inter-basin transfers - to downstream agricultural users and Namibian allocation. End of canal return flows. Diffuse return flows (contribution to baseflows). Intense irrigation agricultural use at Kakamas. Kakamas Town impacts. Sewage works discharging poor quality effluent.

Resource Unit 1.1 to 1.5 in IUA 1 - Orange River from the Upper Orange confluence to Augrabies



Component	Sub-component	Indicators
Quality	Nutrients	• TIN as N ≤ 1.0 milligrams/litre • Orthophosphate ≤0.06 mg/l • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤250mg/l /300 mg/l (1.3 to 1.5) • EC 40 mS/m /55 mS/m (1.3 to 1.5) • Sulphate ≤40mg/l /50 mg/l (1.3 to 1.5) • Calcium ≤35mg/l • Chloride ≤35mg/l / 40 mg/l (1.3 to 1.5)
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Aluminium (Al) ≤ 0.105 mg/l , Iron (Fe) ≤ 0.1 mg/l, Manganese (Mn) ≤ 0.15 mg/l (0.05), Pesticides (endosulfan, atrazine and glyphosate)

FRAI Category and Score	FRAI ≥62% (C category)
MIRAI	MIRAI ≥62% (C category)

Class III

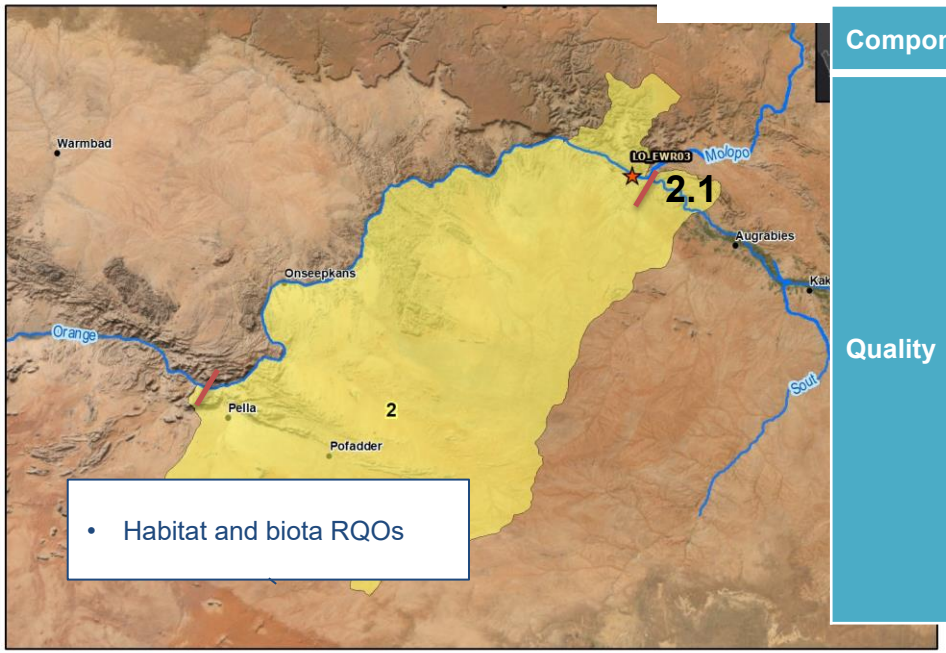
Resource Unit 1.5: Kakamas to Augrabies Waterfall
Mainstem. RU dominated by intensive agricultural activity. Extends from Hartbees contribution to reach, to logical break at Augrabies Waterfall. Flow and quality similar (impacted). PES is predominantly a C/D category. Reach is FEPA. Inter-basin transfers - to downstream agricultural users and Namibian allocation. End of canal return flows. Diffuse return flows (contribution to baseflows). Intense irrigation agricultural use at Kakamas. Kakamas Town impacts. Sewage works discharging poor quality effluent.

Resource Unit 2.1 in IUA 2: Augrabies Gorge

Class III

IUA 2 – Lower Orange River from downstream Augrabies to Pella
Resource Unit 2.1: Augrabies Gorge
Mainstem. Reach within the Augrabies National Park. Tourism activity and conservation area warranting a separate RU for higher protection. PES is B category. Reach is FEPA fish sanctuary. (has unique threatened fish species). Impacts from upstream activities are present. Intense irrigation, WWTWs discharges and urban/agro-processing industrial contributions. Releases are made for inter-basin transfers downstream.

No flow RQO



Component	Sub-component	Indicators
Quality	Nutrients	• TIN as N ≤ 1.0 milligrams/litre • Orthophosphate ≤0.06 mg/l • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤300mg/l • EC 55 mS/m • Sulphate ≤50mg/l • Calcium ≤40mg/l • Chloride ≤50mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Aluminium (Al) ≤ 0.105 mg/l , Iron (Fe) ≤ 0.1 mg/l, Manganese (Mn) ≤ 0.15 mg/l (0.05), Pesticides (endosulfan, atrazine and glyphosate)

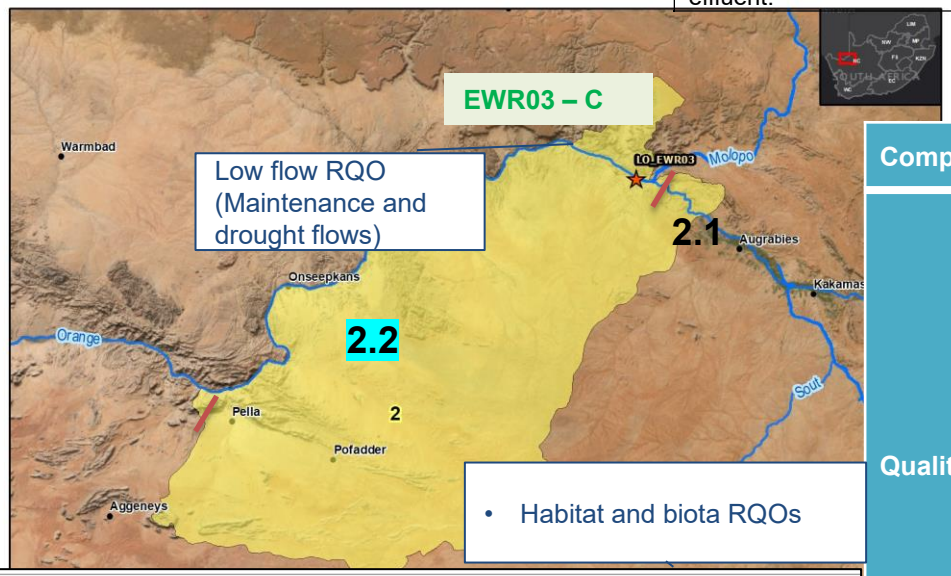
- Reevaluate salinity and sulphates to more appropriate ranges.

FRAI Category and Score	FRAI ≥62% (C category)
MIRAI	MIRAI ≥62% (C category)

Resource Unit 2.2 in IUA 2: Below Augrabies Gorge to Pella

Class III

Resource Unit 2.2: From below Augrabies Gorge to Pella
Mainstem. Land use activity changes with intensive irrigation along reach (Blouputs irrigation). Molopo River tributary contribution at the start of the RU, to Pella at outlet of IUA. Flow and quality (similar). PES is B and C category along reach. Includes flow and water quality monitoring at Pella. Inter-basin transfers - to downstream agricultural users and Namibian allocation. Impacts of Blouputs and Onseepkans, Pofadder Towns. Mining activities are present. Sewage works (package plants in Onseepkans and Blouputs) discharging poor quality effluent.



Component	Sub-component	Indicators
Quality	Nutrients	• TIN as N ≤ 1.0 milligrams/litre • Orthophosphate ≤0.06 mg/l • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤350mg/l • EC 60 mS/m • Sulphate ≤60mg/l • Calcium ≤40mg/l • Chloride ≤60mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Aluminium (Al) ≤ 0.105 mg/l , Iron (Fe) ≤ 0.1 mg/l, Manganese (Mn) ≤ 0.15 mg/l (0.05), Pesticides (endosulfan, atrazine and glyphosate)

FRAI Category and Score	FRAI ≥62% (C category)
MIRAI	MIRAI ≥62% (C category)

- Sulphate: currently 60, recommendation to be changed to 45. Average recorded is 48. TDS recorded 200-316 mg/l. Chloride lowest was 31 and the highest was 48.9. Definite increase from 2023-2025.
- Proposed 45mg/l for sulphate and 300 mg/l for TDS.
- Confirm the increase in sulphate along the reach (review quality over distance)

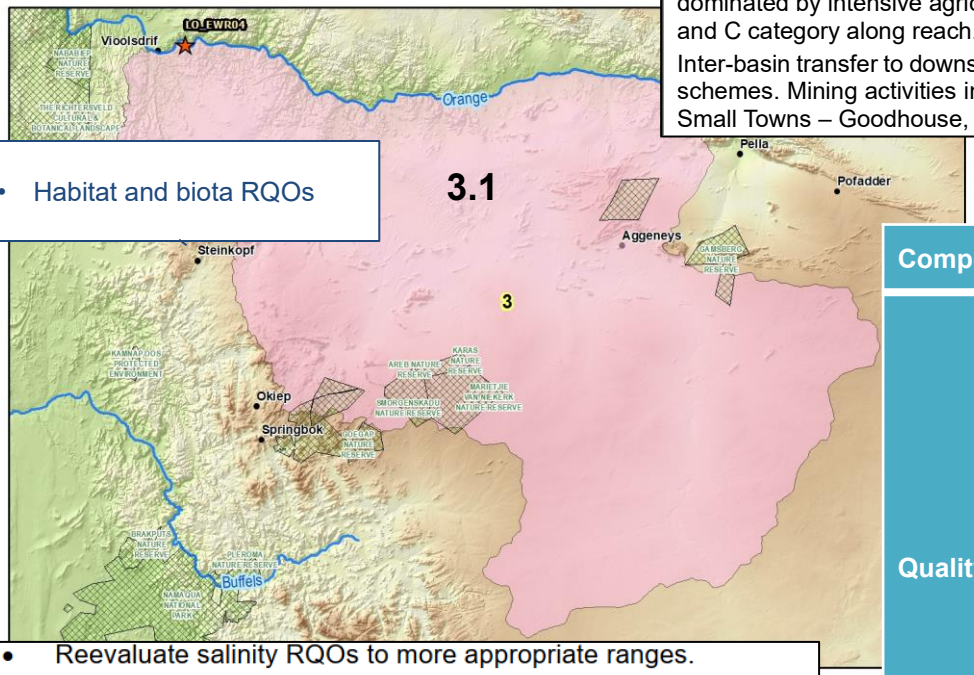
- Remove reference to total coliforms, making range stricter for *E.Coli*.
- Incorporate Boron and sediment testing where feasible.
- Possibility of incorporating whole effluent toxicity testing.
- Concern around the issuing of licences in line with water quality parameters (e.g., Nitrates less than 1).
- Re-evaluate manganese and aluminium limits.

Resource Unit 3.1 in IUA 3: Pella to Vioolsdrift weir (IUA)

Class III

Resource Unit 3.1: As IUA delineation (from Pella to Vioolsdrift weir)
Mainstem. RU delineated as the IUA. Vioolsdrift weir forms a logical break in the system. Comprises part of the Orange River Gorge Ecoregion. Similar land activity and reach is relatively homogenous. The area is dominated by intensive agricultural on both sides of the Orange River (South African and Namibian). PES is B and C category along reach. Inter-basin transfer to downstream agricultural users and Namibian allocation. Large scale irrigated agricultural schemes. Mining activities include alluvial diamond mining, heavy minerals. Cattle grazing leading to erosion. Small Towns – Goodhouse, O Kiep, Springbok (domestic abstraction).

- Habitat and biota RQOs



- Reevaluate salinity RQOs to more appropriate ranges.
  - Align to RU 2.2 water quality RQOs
  - Proposed EC 45 mS/m, 45mg/l for sulphate and 300 mg/l for TDS., chloride 40 mg/l
  - Confirm the increase in sulphate along the reach (review quality over distance)
- Remove reference to total coliforms, making range stricter for *E.Coli*. (100 cfu/100ml)
- Incorporate Boron and sediment toxicity testing where feasible.
- Possibility of incorporating whole effluent toxicity testing.
- Re-evaluate manganese and aluminium limits.

Component	Sub-component	Indicators
Quality	Nutrients	• TIN as N ≤ 1.0 milligrams/litre • Orthophosphate ≤0.06 mg/l • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤350mg/l • EC 60 mS/m • Sulphate ≤60mg/l • Calcium ≤40mg/l • Chloride ≤60mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Aluminium (Al) ≤ 0.105 mg/l , Iron (Fe) ≤ 0.1 mg/l, Manganese (Mn) ≤ 0.15 mg/l (0.05), Pesticides (endosulfan, atrazine and glyphosate)

No flow RQO

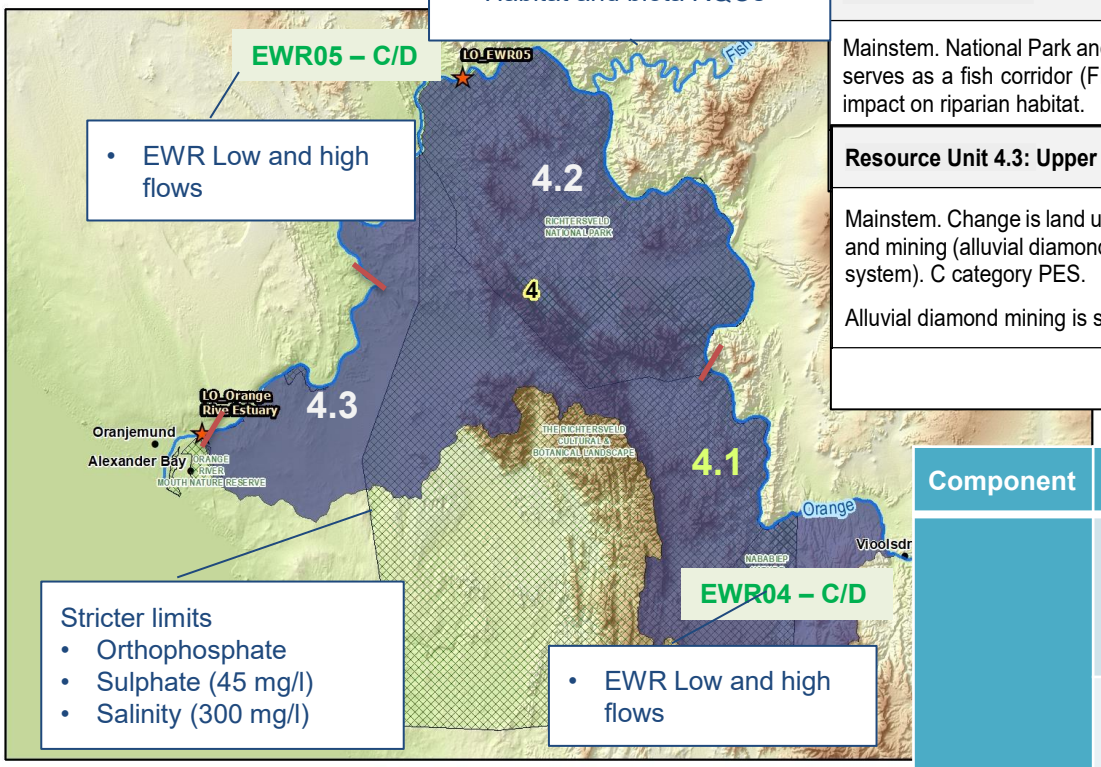
FRAI Category and Score	FRAI ≥62% (C category)
MIRAI	MIRAI ≥62% (C category)

Resource Units 4.1 to 4.3 in IUA 4:

Class III

FRAI Category and Score	FRAI ≥62% (C category)
MIRAI	MIRAI ≥62% (C category)

- Habitat and biota RQOs



- EWR Low and high flows

Stricter limits
- Orthophosphate
- Sulphate (45 mg/l)
- Salinity (300 mg/l)

- EWR Low and high flows

Resource Unit 4.1: Vioolsdrift weir to D82H

Mainstem. Extends from the weir to the logical break at the conservation area of the Richtersveld Park. Intensive irrigation along reach (Noordoewer Irrigation Scheme – Namibia), and diamond mining. FEPA and a fish corridor in D82H. PES is a B and C category along reach. Inter-basin transfer to agricultural users and Namibian allocation. Vioolsdrift Town.

Resource Unit 4.2: Richtersveld National Park

Mainstem. National Park and critical conservation area (A!-Ais Richtersveld) warranting a separate RU. Reach serves as a fish corridor (FEPA). Tourism activity. PES of B/C category. Intense mining activities – serious impact on riparian habitat.

Resource Unit 4.3: Upper portion of D82L up to EFZ

Mainstem. Change is land use activities below the protected area – includes agriculture along the Orange River and mining (alluvial diamond mines) – warranting a separate RU. Extends to the estuary boundary (end of river system). C category PES.

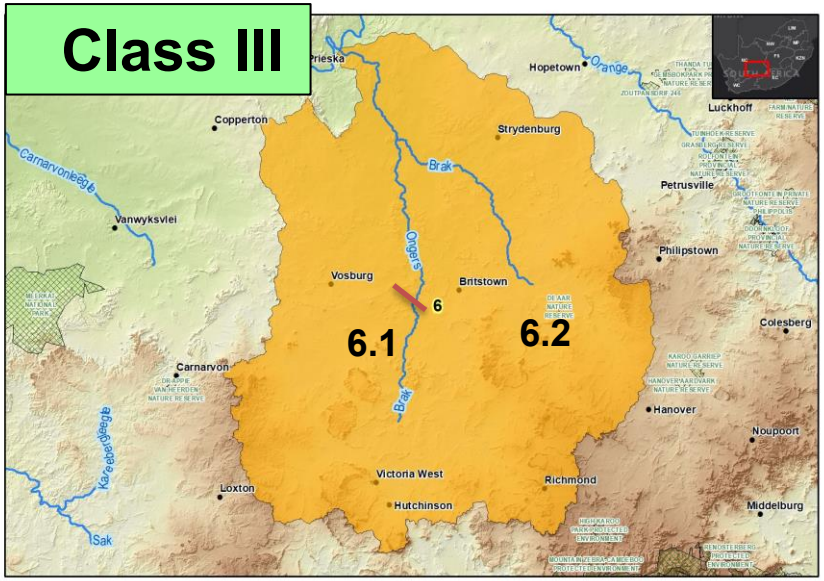
Alluvial diamond mining is significant (Sanddrift to Koeboes). WWTW impacts of small towns.

- Reevaluate salinity RQOs to more appropriate ranges.
  - Align to upper RUs
- Remove reference to total coliforms, making range stricter for *E.Coli*. (100 cfu/100ml)
- Incorporate Boron and sediment toxicity testing where feasible.
- Possibility of incorporating whole effluent toxicity testing.
- Re-evaluate manganese and aluminium limits

Component	Sub-component	Indicators
Quality	Nutrients	• TIN as N ≤ 1.0 milligrams/litre • Orthophosphate ≤0.06 mg/l • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤400mg/l • Sulphate ≤60mg/l • Calcium ≤40mg/l • Chloride ≤40mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Aluminium (Al) ≤ 0.105 mg/l , Iron (Fe) ≤ 0.1 mg/l, Manganese (Mn) ≤ 0.15 mg/l, Pesticides (endosulfan, atrazine and glyphosate)

Resource Unit 6.1 in IUA 6: Upper Ongers River to confluence with Groen River

Class III

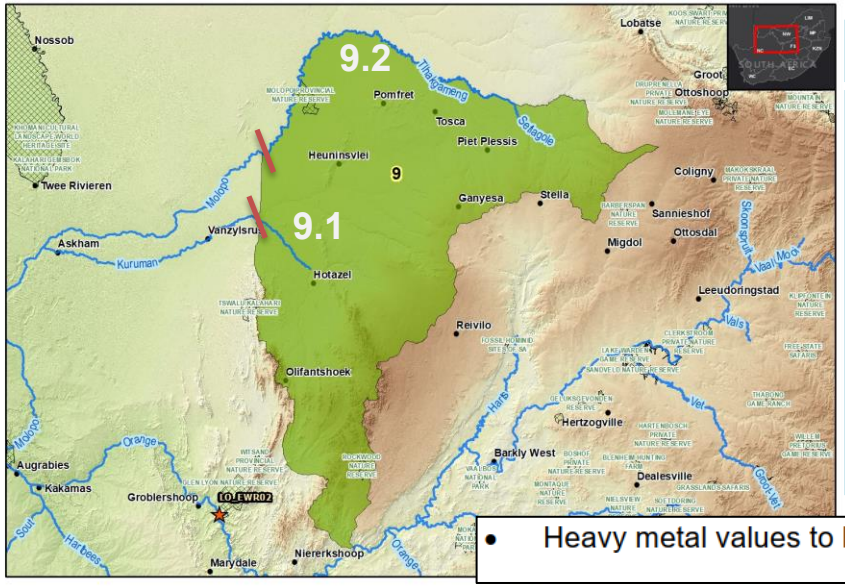


Component	Sub-component	Indicators
Quality	Nutrients	• Orthophosphate ≤0.125 mg/ • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 30 ug/l
	Salts	• Total Dissolved Solids ≤450 mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .

- To include fish RQO - addition of *Labeobarbus kimberleyensis* (LKIM) - Present at 10% of sites during summer (FROC=1).
- Confirm monitoring of the rivers (sampling)

Resource Unit 6.1: Upper Ongers River to confluence with Groen River
Area is homogenous in biophysical characteristics and land use. Commercial agriculture (livestock) and some mining. River systems are largely ephemeral. Logical break at Smart Syndicate Dam. Groundwater dependant. Victoria West Town impacts (WWTW).
Resource Unit 6.2: Upper reach of Brak River
RU incorporates the town of De Aar. Delineation driven by impacts of the town area and water use (water quality impacts). C and D PES category (for reaches assessed). RU includes a groundwater SWSA and FEPAs. Groundwater dependant area.

Resource Unit 9.2 in IUA 9: Upper Molopo and Upper Kuruman



Component	Sub-component	Indicators
Quality	Nutrients	• Orthophosphate ≤0.06 mg/ • Nitrate ≤ 1.0 milligrams/litre • Chlorophyll a ≤ 20 ug/l
	Salts	• Total Dissolved Solids ≤450 mg/l
	Pathogens	• Escherichia coli ≤130 cfu
	System Variables	• pH (6.5 and 9.0) and Dissolved oxygen (DO) ≥ 7 mg/l O_2 .
	Toxics	• Iron (Fe) ≤ 0.15 mg/l, Manganese≤ 0.1 mg/l

- Heavy metal values to be reviewed

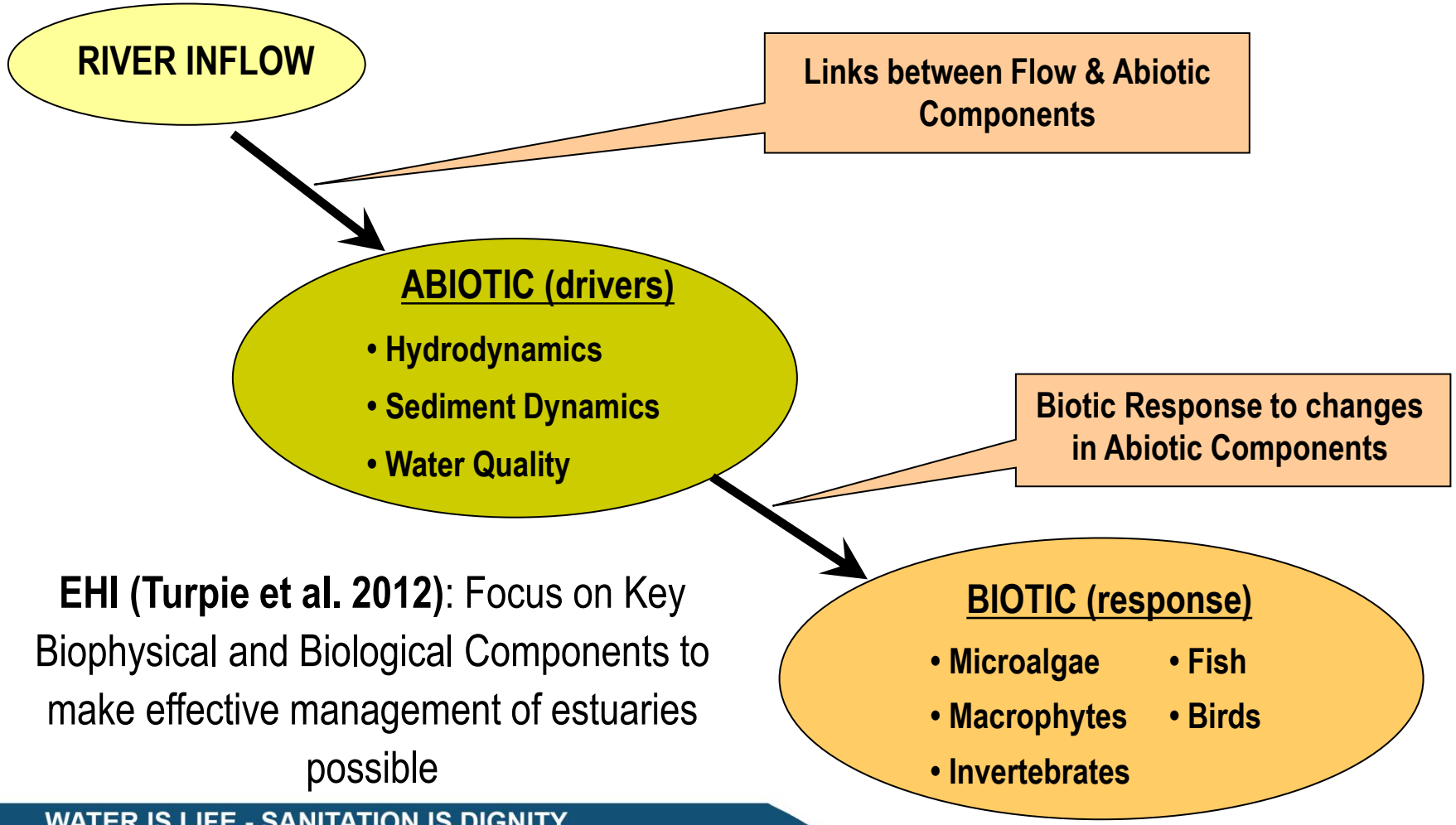
Class III

Resource Unit 9.1: Upper Kuruman and tributaries
RU delineated based on land use activities, high density area - mining, towns and agriculture. Water quality impacts. Rivers are largely ephemeral. High dependence on groundwater. Includes groundwater SWSA. Some tourism activities are present. PES C and D category for reaches assessed. Towns of Hotazel and Khartoum. Industrial and mining activities (iron ore) (Sishen Mine (dewatering).
Resource Unit 9.2: Upper Molopo
Land use homogenous. Rivers are largely ephemeral. Predominantly subsistence and some commercial agriculture (livestock and crop farming). Largely rural with numerous villages. Groundwater SWSA. PES C category for reaches assessed. Groundwater driven RU.

Draft RQOs: Estuaries

7 Steps Procedure for RQO Determination (DWS, 2011)

Step 4: Prioritise sub-components for RQO determination and select indicators for monitoring;



EHI (Turpie et al. 2012): Focus on Key Biophysical and Biological Components to make effective management of estuaries possible

DRAFT RESOURCE QUALITY OBJECTIVES: ORANGE RIVER ESTUARY

IUA 5 – Orange River Estuary
Resource Unit 5.1: Orange River Estuary

• The Orange Estuary is delineated as a RU. The estuary is a management unit with requirements and ecological specifications that are different to river systems.
• The Orange River Estuary is rated as 'highly important':
  ○ The area is a RAMSAR site requiring additional protection and management.
  ○ Protected Area on the Namibian side
  ○ Desired protected area in the South African Biodiversity Plan
• Flow related pressures include flow modification.
• Non-flow impacts include structures in estuary (human development), wastewater discharges, algal blooms, mining activities, toxic substances, fishing effort in the estuary, grazing and hunting.

DRAFT RESOURCE QUALITY OBJECTIVES: ORANGE RIVER ESTUARY

- REC should be aimed at a Category A or at least its best attainable state.
- In the case of the Orange River Estuary, the best attainable state, based on reasonable reversibility of pressures was estimated as Category C.
- While the C Category is the ecological objective over the long term, a C/D category is recommended as the Target Ecological Category (TEC) (interim over the next 10 years -2035/2040) until such time that some of the interventions both flow (e.g. mouth closure) and non-flow can be implemented to alleviate the stresses (this includes the building of the Vioolsdrift Dam to re-regulate the flow requirements).

Orange River Estuary RQOs (1)

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
5.1 Orange River Estuary (8.5 km upstream)	Hydrology	Low Flows	Maintain a flow regime to create the required habitat for birds, fish, macrophytes, microalgae and water quality.	Base flows	Range: 2- 5 m³/s. Duration: 2 - 3 months at a time during the low flow period. Frequency: 2 - 4 years out of 10.
	Hydrodynamics	Mouth Condition	Maintain a mouth state to create the required habitat for birds, fish, macrophytes, microalgae and water quality. Increase retention time in winter	Mouth condition – Closure	2 > closure < 4 times in 10 years. Closed period 4 to 6 weeks
		Water Level	Maintain a mouth state to create the required habitat for birds, fish, macrophytes, microalgae and water quality. Increase retention time in winter. Maintain a seasonally variable water level regime that supports the recommended mouth breaching and closure cycles.	Water Level	Water level during closed state <2.5 m MSL.
	Quality	Salinity	Salinity intrusion should maintain biotic state (fish, invertebrates, macrophytes and microalgae)	River inflow (drought flows = 10% of the time)	25 > salinity < 40 lower reaches (0 - 6 km) 0 > salinity < 10 upper reaches (6 - 12 km) 0 > salinity < 5 backflooding zone (12 - 18 km)
				River inflow low flows	20 > salinity < 30 lower reaches for 5 > months < 7 of the year. 0 > salinity < 5 upper reaches for 5 > months < 7 of the year.
				River inflow high flows	Salinity > 1 for < 7 months of the year.
		Nutrients	Inorganic nutrient concentrations should maintain biotic state (fish, invertebrates, macrophytes and microalgae).	DIN + DIP: River inflow at Ernst Oppenheimer Bridge (D8H012Q01) or Sendelings Drift (low flows):	Maximum DIN consistently <100 µg/ℓ (e.g. two consecutive surveys) Maximum DIP consistently < 10 µg/ℓ

Orange River Estuary Draft RQOs (2)

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
			Reduce nutrient input in lower Orange River.	DIN + DIP: River inflow at Ernst Oppenheimer Bridge (D8H012Q01) or Sendelings Drift (high flows):	Maximum DIN consistently < 150 µg/ℓ Maximum DIP consistently < 20 µg/ℓ
				DIN + DIP: Estuary (low flows - except during upwelling when concentrations in saline areas can be higher):	Maximum DIN consistently >100 µg/ℓ Maximum DIP consistently >10 µg/ℓ
				DIN + DIP: Estuary (high flows)	Maximum DIN consistently >150 µg/ℓ Maximum DIP consistently >20 µg/ℓ
		System variables	System variables (pH, DO and turbidity) should maintain biotic state (fish, invertebrates, macrophytes and microalgae)	River inflow at Ernst Oppenheimer Bridge (D8H012Q01) or Sendelings Drift (low flows)	6.5 > pH < 8.5 DO >5 mg/ℓ Maximum Turbidity consistently <30 NTU (e.g. two consecutive surveys)
				River inflow at Ernst Oppenheimer Bridge (D8H012Q01) or Sendelings Drift (high flows)	6.5 > pH < 8.5 DO >5 mg/ℓ Turbidity: Naturally turbid (can be <200 NTU).
				Estuary (low flows):	6.5 > pH < 8.5 DO >5 mg/ℓ Turbidity variable, dictated by river inflow
				Estuary (high flows):	6.5 > pH < 8.5 DO >5 mg/ℓ Turbidity variable, dictated by river inflow
		Toxic substances	Presence of toxic substances not to cause exceedance of limits for biota. Should maintain biotic state (fish, invertebrates, macrophytes and microalgae)	Water column toxic substances: River inflow (at Ernst Oppenheimer Bridge (D8H012Q01) / Sendelings Drift) and estuary:	Concentrations must not exceed targets as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995 or future updates).
				River inflow (at Ernst Oppenheimer Bridge (D8H012Q01) / Sendelings Drift) and estuary: (Sediment toxic substance/ parameters not covered in SA guidelines)	Concentrations not to exceed targets as per Western Indian Ocean: Guidelines for Setting Water and Sediment Quality Targets for Coastal and Marine areas (UNEP *et al*. 2022)
	Physical Habitat	Sediment dynamics	Flood regime to maintain the sediment distribution patterns and	Suspended sediments Bathymetric surveys	Average clay content of suspended sediments in river upstream of estuary <65%.

Orange River Estuary Draft RQOs (3)

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
			aquatic habitat (instream physical habitat) so as not to exceed limits for biota.	LiDAR of EFZ	
	Biota	Microalgae	Phytoplankton biomass and cell density should not exceed prescribed limits. Median phytoplankton and microphytobenthos (MPB) biomasses should not exceed prescribed limits (TPC of 'very high' biomass). Decrease nutrient input and reduce base flows in winter where possible under current configuration.	Biomass using chlorophyll-*a* as an index. Community structure using phytoplankton groups and benthic diatoms.	Median phytoplankton *chl-a* should be > 8 µg/ℓ under 'normal flows'. Phytoplankton should be < 20 µg/ℓ and cell density should be < 10 000 cells/ml 'normal flows' (typical of blooms) Maintain median subtidal and intertidal benthic *chl-a* < 8 µg/ℓ and 42 mg/m². A 5% decrease in phytoplankton *chl-a* will relate to a 5% increase in microalgal score. This is mostly related to flow (low flow = higher residence time) and nutrients.
		Macrophytes	Maintain the diversity of macrophyte habitats in the estuary. Improve reeds and sedges covering Maintain submerged macrophyte *Stuckenia pectinata* (pondweed) in sheltered areas Macroalgae cover less than 1 ha. Increase vegetation cover in desertified marsh area by removal of causeway and improvement of tidal and flood channels. More than 50% of this area vegetated (approximately 250 ha).	Community structure using botanical survey and mapping (including alien invasive species).	Prevent further sedimentation in main channel and colonisation by vegetation. <50 % loss of reed and sedge habitats in non-flood year (due to salinity changes). > 300 ha of Reeds and sedges area cover. Presence of pondweed in non-flood years. Macroalgae cover < 1 ha in the estuary. > 200 ha vegetation cover in the desertified marsh area.
		Invertebrates	Retain Present State species richness and mix (low species abundance, high dominance).	Macrobenthos, Zooplankton and Macrocrustacea Community structure.	Species richness < 20 for zooplankton and macroinvertebrates respectively.

Orange River Estuary Draft RQOs (4)

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
			Indicator species such as *Capitella capitata*, should not dominate benthic species abundance at the majority of sampling sites since their presence indicates anoxia conditions in the sediment. However, *Capitella* will naturally occur in high abundance in stagnant or poorly drained backwater areas.		*C. capitata* does not numerically dominate benthic species abundance at more than five of sampled sites in the Orange River estuary.
		Fish	Maintain species composition of estuary-associated marine species, non-dependent marine species and indigenous freshwater species. All numerically dominant species are represented by juveniles. The overall biomass of the dominant species *Chelon richardsonii* should not drop below the limit as prescribed.	Fish Recruitment Index (FRI) Community structure	Composition of estuary-associated marine species - 35 - 40%, Composition of non-dependent marine species - 20%, Composition of indigenous freshwater species - 45 - 50%, Non estuary associated marine or freshwater species become proportionally dominant. 0+ juveniles recruitment. *C. richardsonii* biomass > 90%.
		Birds	The estuary should contain a rich avifaunal community that includes representatives of all the original groups, significant numbers of migratory waders and terns, as well as a healthy breeding population of resident waders. The estuary should support over 8 000 waterbirds in summer and over 6 000 birds in winter.	Winter and summer bird counts	Bird numbers should not continue on a downward trajectory. The five-year average numbers of the 14 species for which the estuary supports more than 1% of the southern African or global population should not fall to below half of the average numbers reported by Anderson et al. (2003): Blacknecked Grebe 125 Great White Pelican 473 Cape Cormorant 984

Numerical Limit/ measure	
Lesser Flamingo	1 031
Greater Flamingo	700
South African Shelduck	516
Cape Shoveller	373
Chestnutbanded Plover	97
Pied Avocet	891
Curlew Sandpiper	1 666
Kelp Gull	1 098
Hartlaub's Gull	707
Caspian Tern	165
Swift Tern	344
Damara Tern	58

DRAFT RESOURCE QUALITY OBJECTIVES: COASTAL ESTUARY

IUA 8: Coastal Areas

- IUA is primarily a groundwater driven system and, with the tributaries being ephemeral with very little to almost no surface flow.
- Coastal estuaries largely **groundwater driven estuarine systems**.
- Based on the groundwater categorisation, where aquifer stress, vulnerability and quality relevant for the groundwater classification, the proposed IUA class is Class III.
- The impact of marine aerosols and water-rock formation interaction along the West Coast GRU 8.3 is significant and puts a permanent (natural) **saline signature on the groundwater quality** (elevated salinity, *e.g*. NaCl and fluoride).

PES: Buffels, Swartlintjies, Spoeg, Groen & Sout

Component Category	Buffels	Swartlintjies	Spoeg	Groen	Sout
Hydrology	D/E	B	B/C	C	D/E
Hydrodynamics	D	B	B	C	E/F
Water quality	D	B	A/B	B	D
Physical habitat alteration	D	B	A/B	A	E
Habitat health	D	B	B	B	D/E
Microalgae	D	B	A/B	B	E
Macrophytes	E	C	A	B	E/F
Invertebrates	D	C/D	A	C	E
Fish	E	B	A	B	E/F
Birds	D	A/B	A	B	E
Biotic health	D/E	B/C	A	B	E
PES	↓ D	B	A/B	B	E
Confidence	Low	Low	Low	Low	Low

Coastal Estuaries Draft RQOs -Example of what you will see

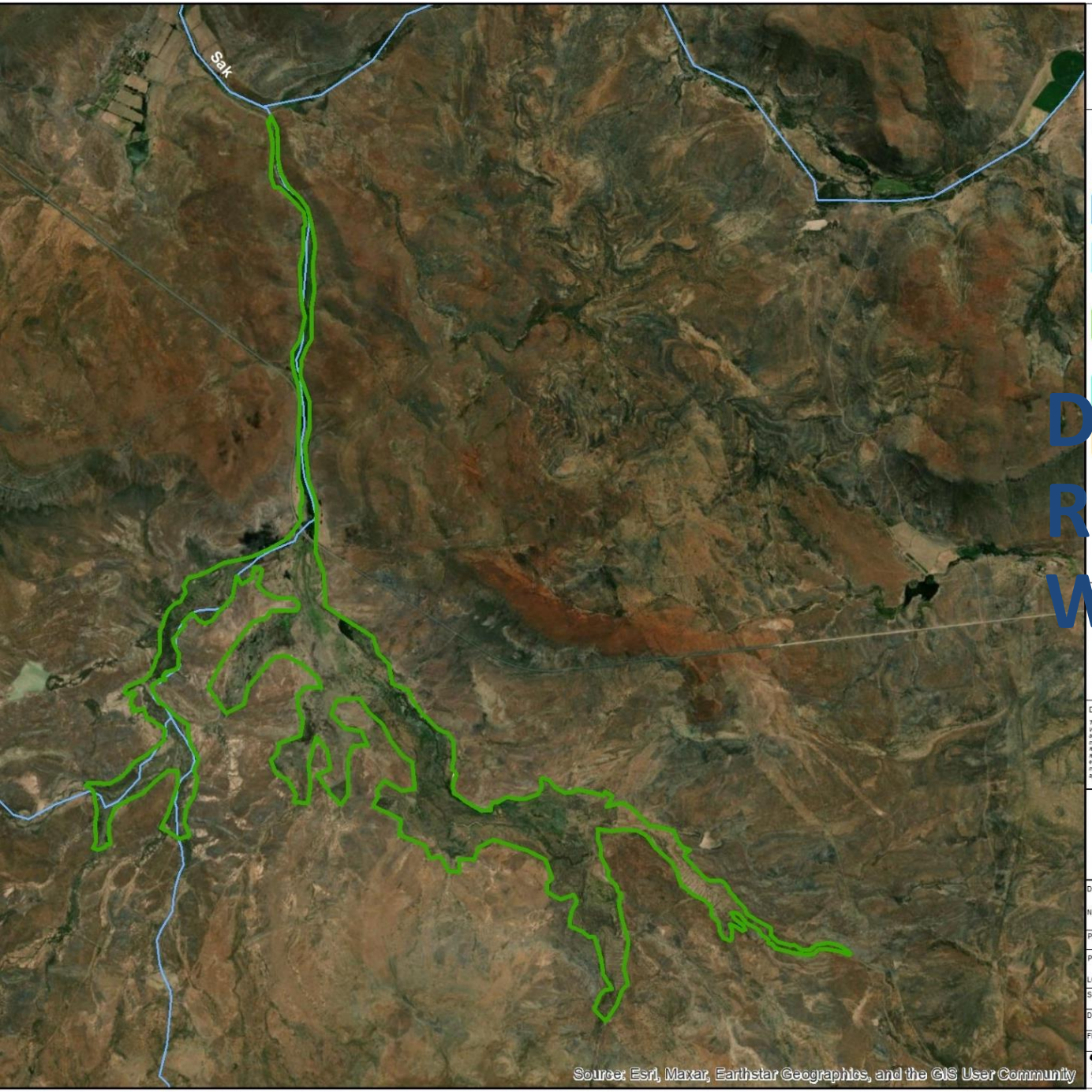
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context of the RQO and/ or Numerical limit
8.2 Buffels Estuary	Flow	Low Flows	Flows should not exceed natural, and seasonal distribution should not be compromised. Current baseflows into the estuary should be upheld to maintain present mouth state and salinity regime.	Base flows	Long term monitoring should be implemented to inform numerical limits.	Desktop simulations of the surface hydrology indicate little change in the surface water flows, however this does not take into consideration the impact of road infrastructure throughout the catchment, and specifically just above the estuary that acts as instream "farm dams". DWS, 2017
		High Flows (floods)	The distribution patterns of the flood components differ by no more than 10% in terms of magnitude, timing and variability from that Floods need to reach the estuary.	High Flows (floods)	Long term monitoring should be implemented to inform numerical limits.	
		Groundwater	Groundwater to be maintained at present levels.	Groundwater discharge	Long term monitoring should be implemented to inform numerical limits.	Groundwater is estimated to be significantly modified with ground water use far exceeding the recharge of the aquifer.
	Hydrodynamics	Mouth Condition	Mouth open conditions to be maintained within the current range. Rate at which mouth breaches to be increase.	Mouth condition	Long term monitoring should be implemented to inform numerical limits.	Very little information is available on the hydrodynamics of the small Lower Orange Estuarine Systems. If an estuary is very sensitive to flow modification (e.g. very small or shallow), and/or in an A or B Category, a ±5% variation is allowed for over a 5-year period. Buffels estuary is very seldom connected to the sea. Natural breaching by flood waters estimated to have occurred every 3 to 7. Open mouth conditions would only prevail for short periods (days to a week or two) as flood peaks in arid catchments

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context of the RQO and/ or Numerical limit
						generally is a matter of hours with little follow up flow.
		Sediment distribution patterns	Flood regime to maintain sediment distribution patterns and associated aquatic habitat (instream physical habitat). The suspended sediment concentration from river inflow does not deviate by more than 20% of the present sediment load-discharge relationship (to be determined). The sedimentation and erosion patterns in the estuary do not differ significantly from present (± 0.5 m) (to be determined). Changes in sediment grain size distribution patterns similar to present. The median bed sediment diameter deviates by less than a factor of two from present levels (levels to be determined). The sand/mud distributions in middle and upper reaches do not change by more than 20% from Present State over a five-year average.	Sediment composition (sediment particle size, organic content)	Long term monitoring should be implemented to inform numerical limits.	Sediment distribution patterns are impacted by impacts on connectivity in the estuary. The shifts in the hydrodynamics are largely due to structures (culverts, remnants of roads) and reduce groundwater input to the system. With estuarine connectivity being severely reduce, both within the system and to the catchment and marine environment.
	Quality	Salinity	Maintain variability in salinity regime. Measurable increase in salinity in the upper and middle reaches during the winter season	Salinity	Upper reaches: <5 PSU. Lower reaches: <20 PSU.	Salinity limits were derived from measured data or extrapolated for similar systems. Key determining estuarine features used in setting the salinity limits were estuary size, estuary depth, % mouth open and mouth position (*i.e.* perched/not perched). Data sets used include observations and field data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context of the RQO and/ or Numerical limit
		Dissolved inorganic nitrogen (DIN)	Instream concentration of nutrients as specified must be maintained to protect the aquatic ecosystem health and ensure the prescribed ecological category is met.	DIN	Entire estuary: average <0.3 mg/l (aim for Category C).	Available data on the water quality of the Buffels Estuary is limited. Based on a general understanding of water quality characteristics in estuaries along this part of the coast, as well as expert knowledge, target ranges were proposed for various water quality health categories, where the condition of any parameter had to be improved. Otherwise, the present (measured) water quality concentration is specified.
		Dissolved inorganic phosphorus (DIP)		DIP	Entire estuary: average >0.025 mg/l (aim for Category C).	
		Turbidity	Lower turbidity levels in estuary.	Total Suspended Solids (TSS), Secchi depth, and/ or Turbidimeter	Entire estuary: average <20 NTU except during floods	Very limited data is available ion turbidity in the estuary. Available data suggest that turbidity in the estuary is high. Harrison (1998) attributed the high turbidity measured in the lower reaches during September 1993 to high concentrations of suspended algae concentrations occurring at the time.
		Dissolved Oxygen	Estuary should be well-oxygenated throughout	Dissolved oxygen (mg/L)	Entire estuary: average ≥4 mg/l	Dissolved oxygen is an essential for most aquatic life. Anthropogenic sources that may influence dissolved oxygen concentration are those with high oxygen demand such as high organic content, biochemical oxygen demand or chemical oxygen demand. These include stormwater run-off, sewage discharge and certain industrial wastes. A frequently used

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context of the RQO and/ or Numerical limit
		Toxic substances	Substance concentrations in estuarine waters not to exceed targets as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995). Substance concentrations in estuarine sediment not to exceed targets as per WIO Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009).	Organic and inorganic constituents, and pathogens.	Substance concentrations in estuarine waters not to exceed targets as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995). Substance concentrations in estuarine sediment not to exceed targets as per WIO Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009). Long term monitoring should be implemented to inform numerical limits.	Various water quality constituents can stimulate algal growth or affect biological health. These are classified into organic and inorganic constituents, and pathogens. No data on toxic substances were available. It was assumed that diffuse runoff golf course and adjacent mining activities have contributed to some toxic contamination in the system.
	Biota	Microalgae	Maintain the distribution of different phytoplankton groups (diverse community composition). Control nutrient input from golf course to prevent microalgal blooms.	Biomass using chlorophyll-*a* as an index. Community structure using phytoplankton groups and benthic diatoms.	Long term monitoring should be implemented to inform numerical limits. Phytoplankton chl-a > 20 µg/L represents blooms and should not occur in this system.	Microalgae are an important carbon source for zooplankton and benthic invertebrates. Diversity and abundance typically highest in fresh upper reaches of estuary. Reduced flow and greater salinity intrusion increase microalgal biomass and diversity. Extended mouth closure likely to result in loss in diversity and phytoplankton biomass and increase in benthic microalgal biomass.
		Macrophytes	Maintain the distribution of current macrophyte habitats.	Community structure using	<20% change in the area covered by different macrophyte	The limits are set based on available data and field surveys (DWS, 2017). Macrophyte limits

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure	Context of the RQO and/ or Numerical limit
			Maintain habitat diversity including some freshwater wetland with reeds and rushes and submerged macrophytes such as pondweed (*Stukenia pectinata*). Growth of natural vegetation in areas where rooikrans is being removed.	botanical survey and mapping, including alien invasive species.	habitats (accounts for natural changes due to the dynamic nature of estuaries).	are based on historical data and descriptions and are considered to be of low confidence. Expert opinion and Google images were used to make the assessments.
		Invertebrates	Invertebrate community structure to be maintained.	Community structure: As sampled by plankton net, grab and dip nets/traps (as appropriate)	Population abundances of plankton and benthic assemblages (baselines to be set) should not deviate by more than 25% at any point in the opening and closure cycle.	
		Fish	Maintain current community structure. No alien fish species should occur. Fish should be free of lesions and other anomalies related to water quality. No fish kills should occur.	Community structure: As sampled by seine in open waters	2 to 3 species should occur and include estuarine resident and estuarine dependant marine fishes. Long term monitoring should be implemented to inform numerical limits.	Based on analysis of available data and expert opinion informed by first-hand knowledge of small west coast estuaries. Estuaries sampled by the researchers were categorised according to their salinity regime. Preliminary fish lists (% abundance and frequency of occurrence) were based on available information.
		Birds	Should be dominated by waders and water birds that comprise. Verify occurrence and cause of bird mortalities.	Winter and summer bird counts	Waders and water birds comprise: >15 species and >100 individuals. Long term monitoring should be implemented to inform numerical limits.	Changes in habitat, food availability and human disturbance affect community composition and species abundance. RQOs set for based on analysis of available data and expert opinion informed by first-hand knowledge of small west coast estuaries.



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Draft RQOs: Wetlands

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DATA SOURCE:

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LOWER ORANGE WRC &RQO

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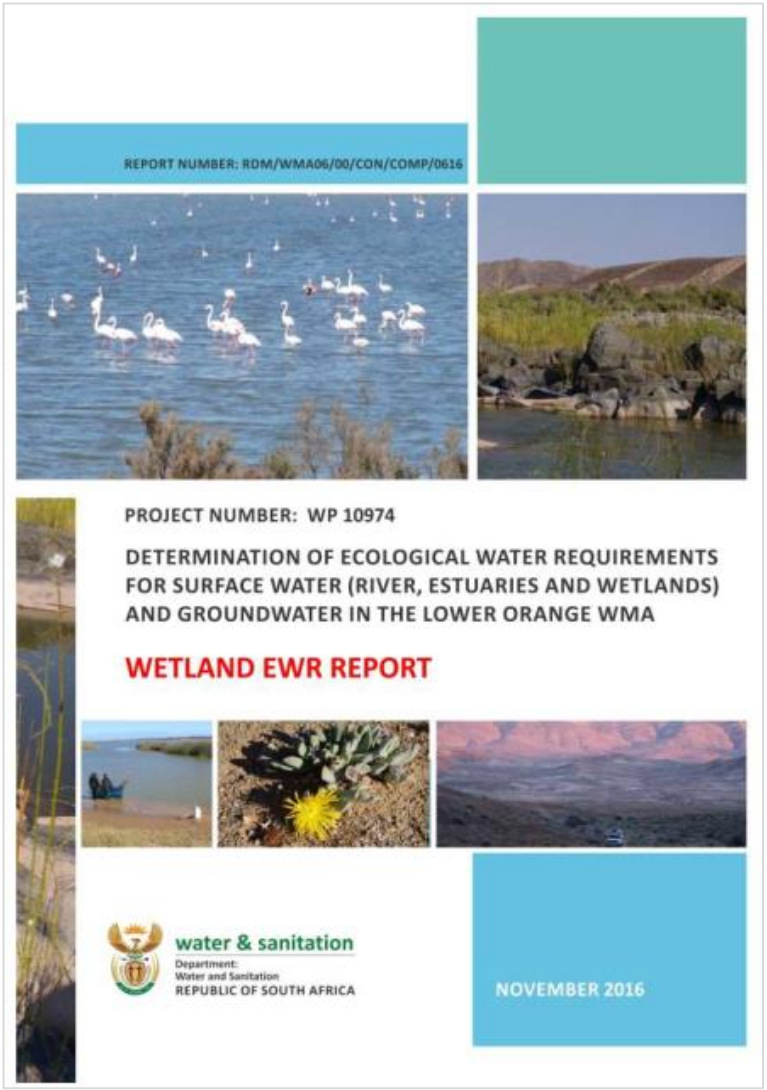
PROJECT

WETLAND BASELINE DATA

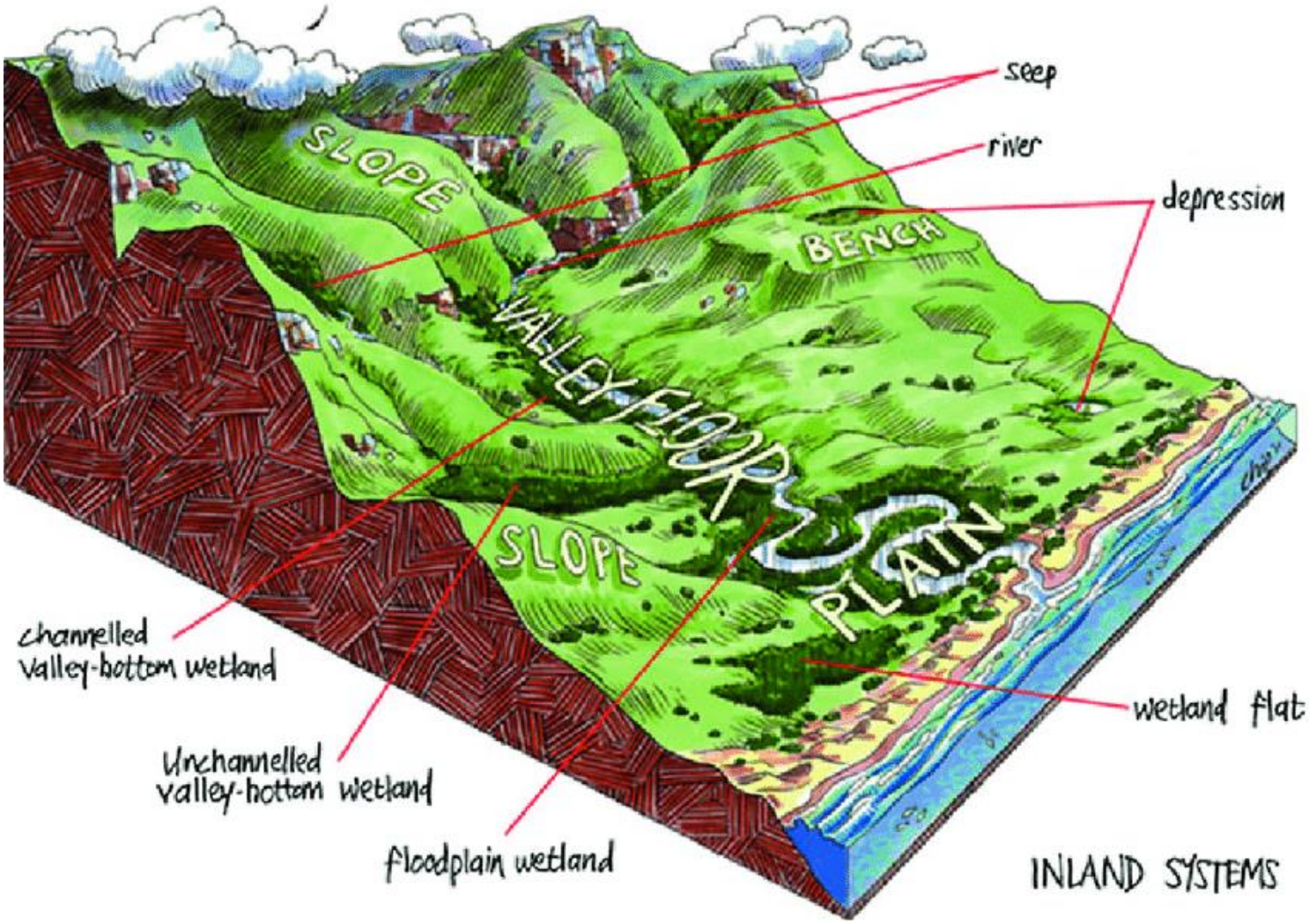
- Lower Orange Reserve Determination Study (2016).
- Scientific articles and theses, technical reports and rehabilitation/monitoring reports.
- 2025 Surveys



WETLAND RQO LIMITATIONS

- Current wetland information is limited, often due to access limitations.
- Limited to no flow or water quality data (especially updated information) are available for the majority of the priority wetlands.
- RQO's for the wetlands are qualitative.
- Due to limited data, confidence in the quantity and quality components is low and moderate for habitat and biota.

WETLAND TYPES



Taken from Ollis et al. (2013)

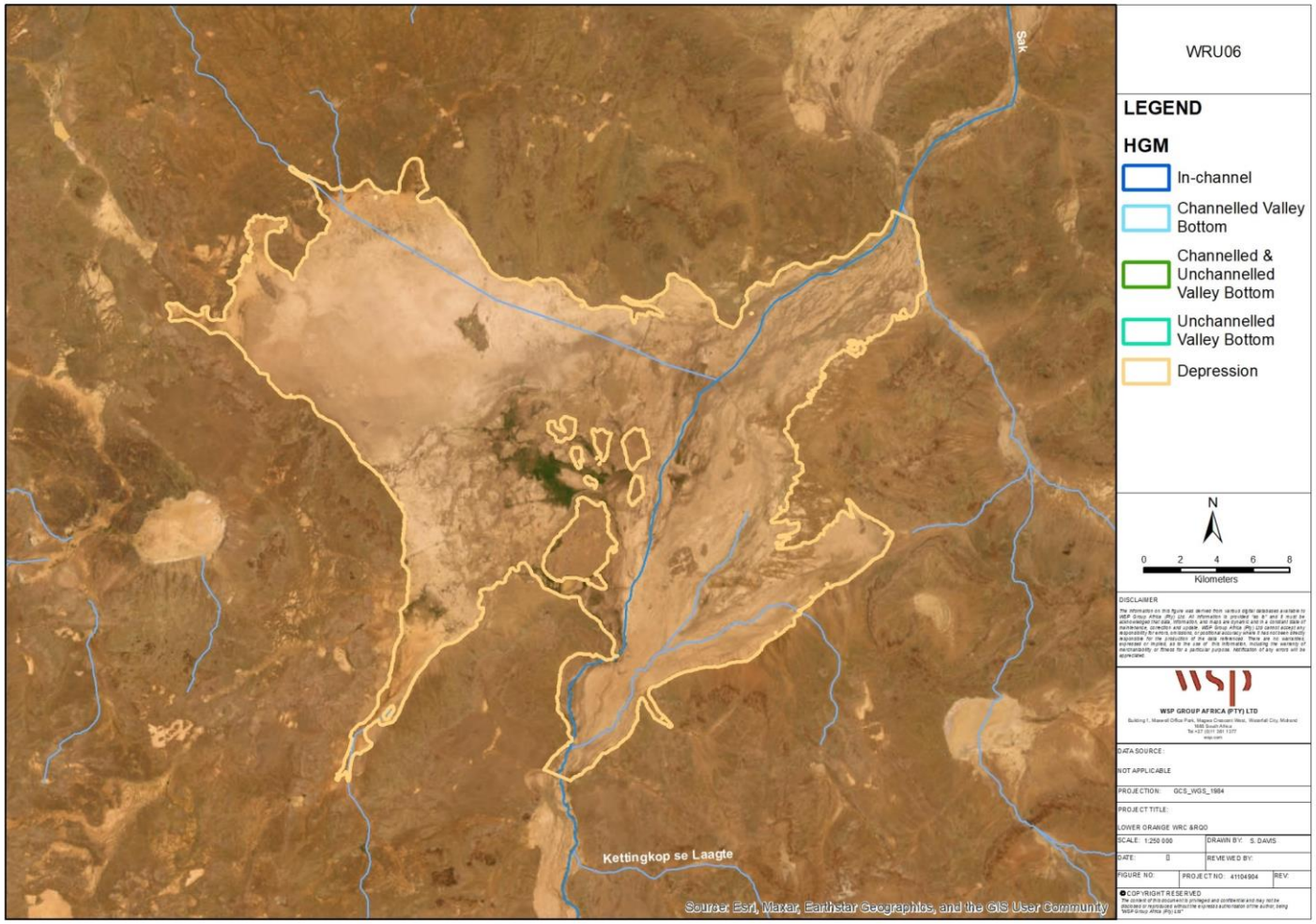
Proposed draft **RQOs for the 20 selected priority wetlands** within the Lower Orange River catchment

Priority Wetland	Catchment	IUA	IUA Name	Wetland	Type
1	D61A	6	Brak Catchment	**Merriman**	In-channel wetlands
2	D52B	7	Hartbees/Sak Catchment	**Agterste River**	In-channel wetlands
3	D57C	7		**Brandvlei**	Depression
4	D56A	7		**De Vreede**	Channelled Valley Bottom wetland
5	D55A	7		**Grootvlei**	Channelled and Unchannelled Valley Bottom wetland
6	D57D	7		**Grootvloer**	Depression
7	D55K	7		**Hongerlantein**	In-channel wetlands
8	D57D	7		**Narooga Pan**	Depression
9	D58A, D51C, D56J	7		**Riet-Renoster**	In-channel and Channelled Valley Bottom wetland
10	D58C	7		**Swartkolkvloer**	Depression
11	D54C	7		**Van Wyksvlei**	Depression
12	D52A	7		**Visrivier-wes**	Channelled and Unchannelled Valley Bottom wetland
13	F30 & F50	8	Coastal Areas	**Ramkamp**	Unchannelled Valley Bottom wetland
14	F30	8		**Xharas**	Valley head seep and Channelled Valley Bottom wetland
15	D41L	9	Upper Molopo and Upper Kuruman	**Batlaros**	Channelled Valley Bottom wetland
16	D41H	9		**Heuningvlei**	Depression & Hillslope Seepage wetlands
17	D41L	9		**Kuruman**	Channelled Valley Bottom wetland
18	D42D	10	Lower Molopo and Upper Kuruman to confluence with the Orange River	**Klippan**	Depression
19	D42D	10		**Koppieskraal**	Depression
20	D42D	10		**Soutpan**	Depression

Example - IUA7: GROOTVLOER

Wetland Characteristics

- Depression
- Connected to the Sak River and forms part of Bushmanland endoreic pans, one of the most extensive salt pan systems in South Africa.
- Possibly South Africa's largest pan overall.
- ±60 472Ha
- Diversion of catchment flows- irrigation.
- Ephemeral flooding makes it a key Branchiopod habitat



Example of what you will see - GROOTVLOER

IUA	Wetland	Wetland Type	PES	EIS	REC	Component	RQO	Indicator	Numerical Criteria
7	**Grootvloer**	Depression	C	High	B/C	Quantity	The relationship between the extent, depth and frequency of inundation to local rainfall and water inputs must be maintained.	Water quantity impacts must be managed so as not to undermine the ecological value of the pan. In particular, abstraction or artificial water inputs should be limited in the pan and pan catchment so that the depth and duration of inundation is maintained within the normal range for high, average and low rainfall years. Extent of dams and Surface Flow Reduction (SFR) activities (e.g. irrigated cultivation, plantations, etc.)	The relationship between the extent, depth and frequency of inundation to local rainfall and water inputs in the pan and pan catchment must not on average indicate a negative trend (reduction in inundation extent in relation to antecedent summer rainfall [October to April]). No increase from current extent of dams and SFR activities within the catchment.
						Quantity	Flow and inundation regime through seasonal river inflow and groundwater contribution must be maintained to attain good wetland condition.	REC category (driven by groundwater quantity RQOs) (D57D)	PES score as specified for Habitat
						Quality	Water quality impacts to the pan system must be restricted to ensure that the water and sediment chemistry remain within an acceptable normal range (anion and cation concentration to pan volume relationship) for the water	pH, Electrical Conductivity, TDS, Total Alkalinity as $CaCO_3$, Sodium, Calcium, Magnesium, Sulphate, Iron, Chloride, Potassium, Magnesium, Manganese, Aluminium, Phosphorous,	Maintain the water chemistry pan type applicable. Annual baseline monitoring PES score as specified for Habitat

IUA7: GROOTVLOER

IUA	Wetland	Wetland Type	PES	EIS	REC	Component	RQO	Indicator	Numerical Criteria
							Flow and inundation regime through seasonal river inflow and groundwater contribution must be maintained to attain good wetland condition.	REC category (driven by groundwater quantity RQOs) (D57D)	
						Quality	chemistry pan type applicable.	Silica, Fluoride Ammonia, Nitrate and Fluoride.	Sample April every year (when surface water present)
						Habitat	Maintain or improve current PES category.	PES Category - As a minimum undertake a WET-Health Level 1a PES assessment (as per the method described by Macfarlane *et al*., 2020). For the PES assessment the latest available National or Provincial Land Cover datasets should be utilised for the wetland catchment, while detailed manual digitising of land cover within the wetland should be undertaken off latest available aerial imagery and supplemented through field verification by an experienced wetland specialist. Repeat as soon as new National or Provincial land cover data is available but at least every 5 years if possible and report on this with a view to assess if there have been any changes in the state of the system.	PES score above 60%

IUA7: GROOTVLOER

<table>
<tr><th>IUA</th><th>Wetland</th><th>Wetland Type</th><th>PES</th><th>EIS</th><th>REC</th><th>Component</th><th>RQO</th><th>Indicator</th><th>Numerical Criteria</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Biota</td><td>The suitability of the local mosaic of depression wetland habitats for aquatic macroinvertebrates (Branchiopods) must be maintained.</td><td>Indicator Branchiopod species - No previous surveys conducted in this RU. Monitor annually.

OR

Wetland Present Ecological State as surrogate.</td><td>Branchiopod inventory limited and requires expansion, but species recorded in RU and in catchment D57D include:

<table>
<tr><th>Species</th><th>Status</th></tr>
<tr><td>Branchipodopsis browni</td><td>LC</td></tr>
<tr><td>Branchipodopsis transversus</td><td>EN</td></tr>
<tr><td>Streptocephalus cafer</td><td>LC</td></tr>
<tr><td>Streptocephalus indistinctus</td><td>LC</td></tr>
<tr><td>Streptocephalus ovamboensis</td><td>LC</td></tr>
<tr><td>Streptocephalus papillatus</td><td>LC</td></tr>
<tr><td>Streptocephalus purcelli</td><td>LC</td></tr>
<tr><td>Streptocephalus valkyrie</td><td>VU</td></tr>
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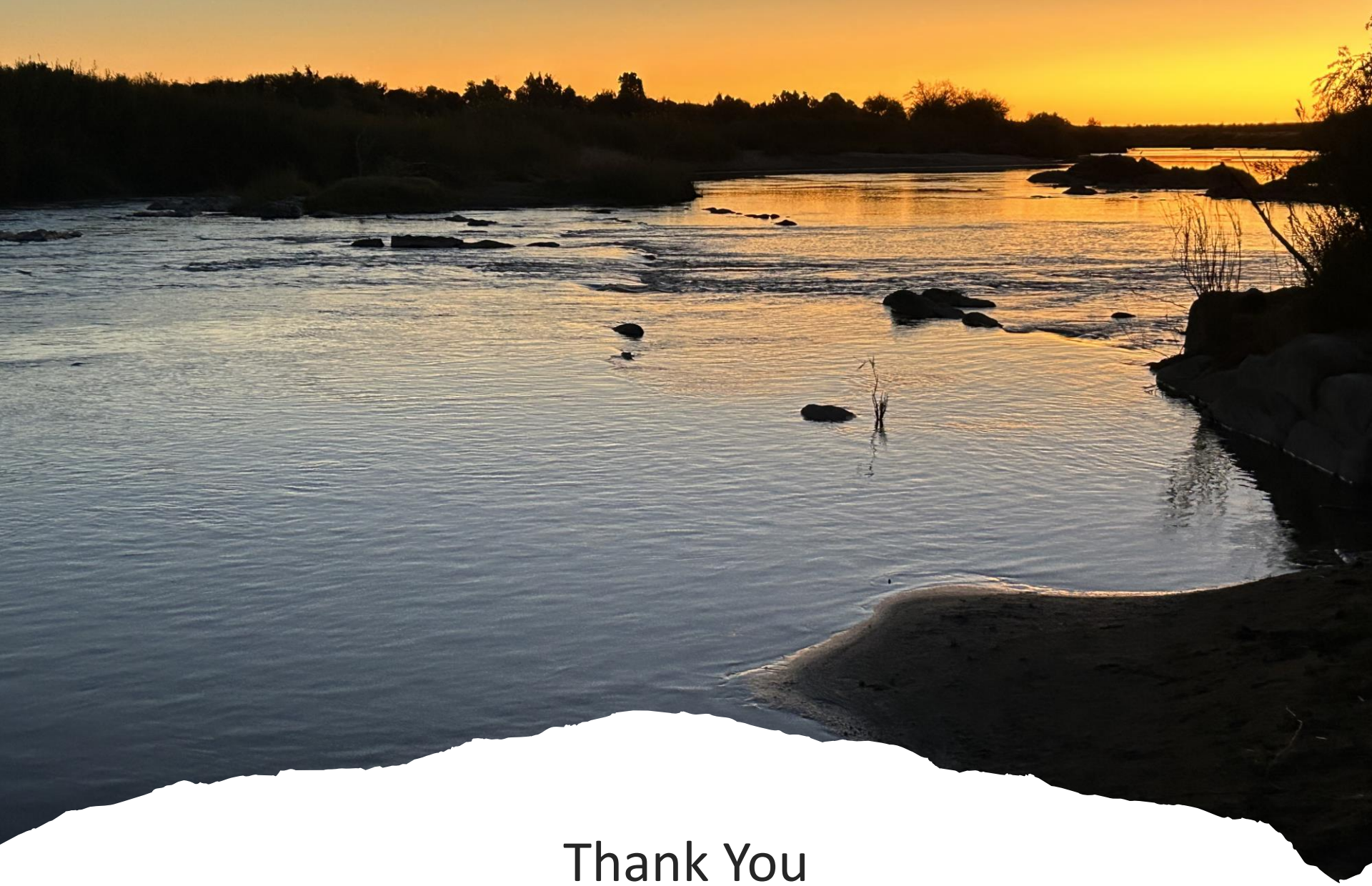

Thank You