A HIGH CONFIDENCE RESERVE DETERMINATION STUDY FOR SURFACE WATER, GROUNDWATER AND WETLANDS IN THE UPPER ORANGE CATCHMENT (WP11343)

Project Steering Committee (2) Meeting

Presented by: GroundTruth cc and Collaborators
Directorate: Reserve Determination
Platform: Team Meeting: Virtual

Date: 3 October 2023

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water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

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PRESENTATION AGENDA

- Re-cap on study objective and approach;
- Project progress since PSC1 (June 2022 – October 2023);
- PSC2 objective;
- Wetland component results and feedback;
- Groundwater Reserve component results and feedback;
- River's component results (eco-categorisation);
- Flow Management Plan;
- Integration component
- Proposed scenarios; and
- Next steps.

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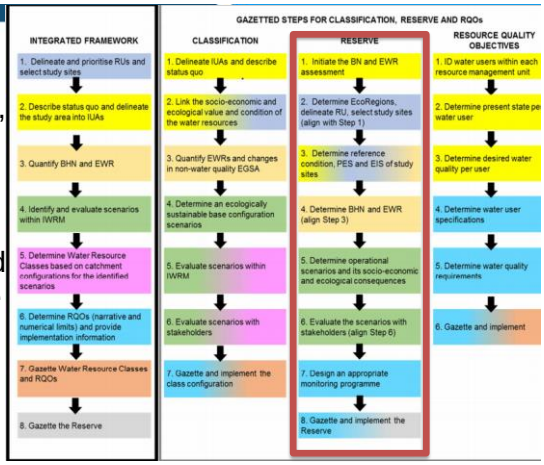
STUDY APPROACH

- Study is of a technical nature, supported by stakeholder engagement.
- The approach and methodology that are followed for this study is in accordance with the 8-step process as outlined in Regulation 810 (Government Gazette 33541) dated 17 September 2010



- Reserve determination process as specified in the 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017).
- Methodologies for Reserve determinations of rivers, wetlands and groundwater

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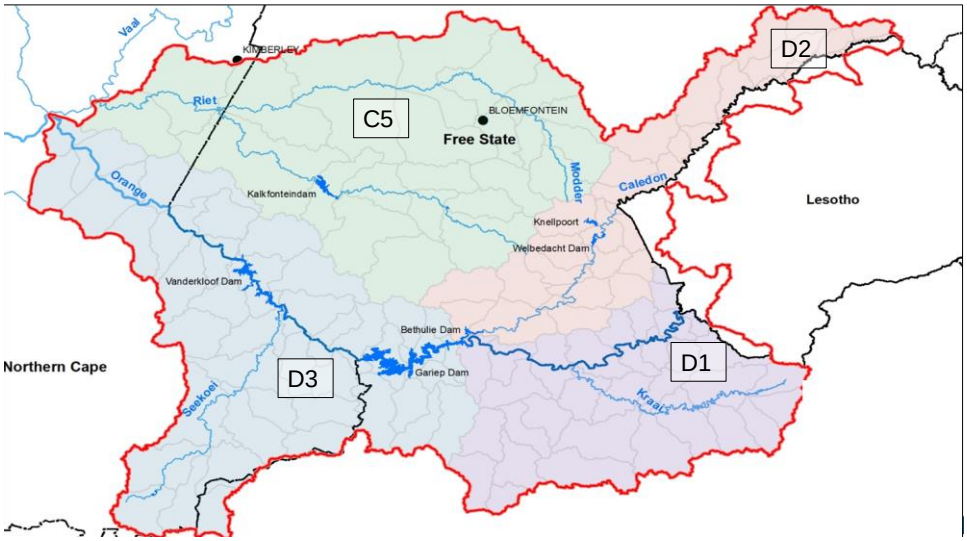
PROJECT PROGRESS SINCE PSC1

- Previously PSC1 meeting: 30 June 2022:
  - Background to study and the study area:



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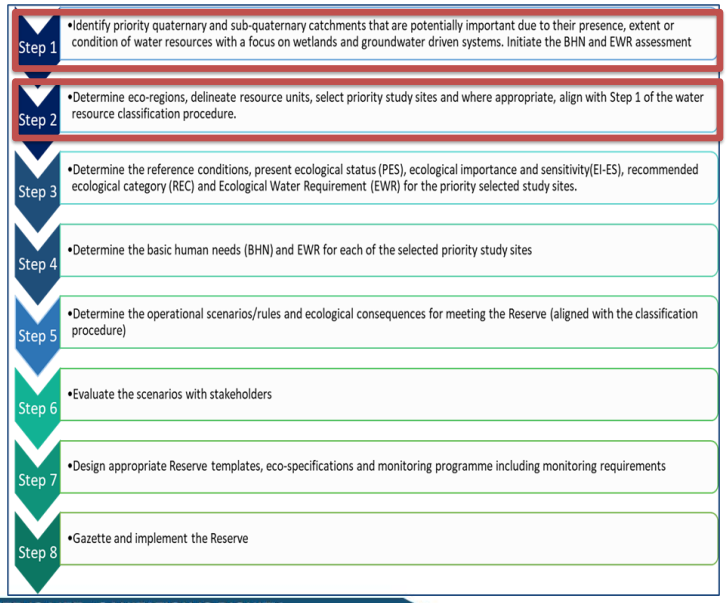
PROJECT PROGRESS SINCE PSC1



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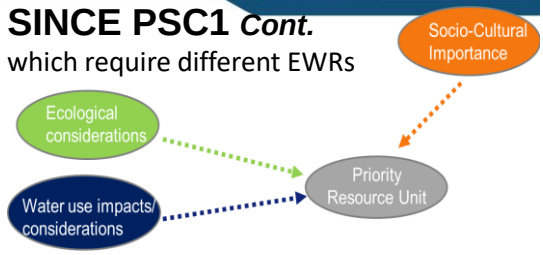
PROJECT PROGRESS SINCE PSC1 *Cont.*



- **Rivers:** linear stretches of rivers which require different EWRs
  - Considered a variety of factors
  - Eco-regions
  - Geomorphological classification
  - Water quality
  - Land use
  - Different flow patterns
  - Habitat integrity, the reaction of the habitat and biota to stress
  - Physical stream constraints
  - Management and operational structures (major dams, transfers)
- **Wetlands:** NWM5 special dataset, NFEPA, HGM types of wetlands, Crane sightings, nesting, breeding, other IBA, Critically Endangered/Endangered systems, wetlands with a PES A/B
- **Groundwater:** important GW systems, hotspot areas

- Areas of interaction (surface and groundwater)
- Water stressed areas
- Strategic water source areas (SW and GW)
- Local knowledge

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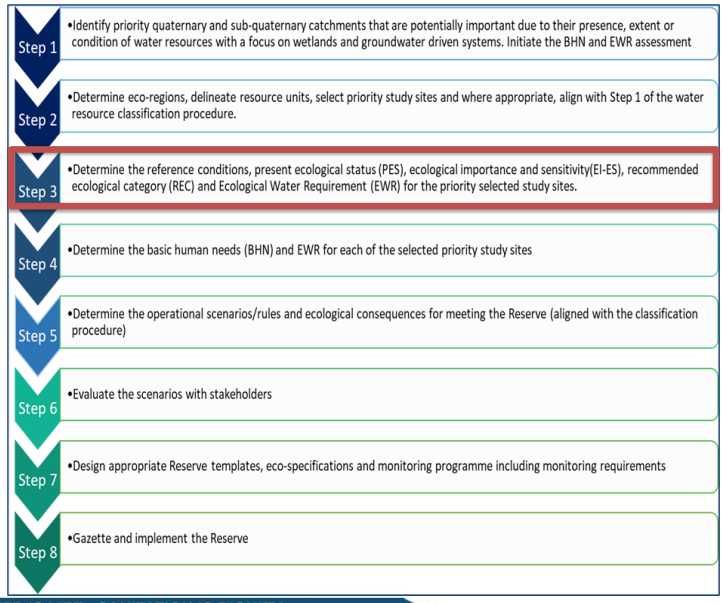
PROJECT PROGRESS SINCE PSC1



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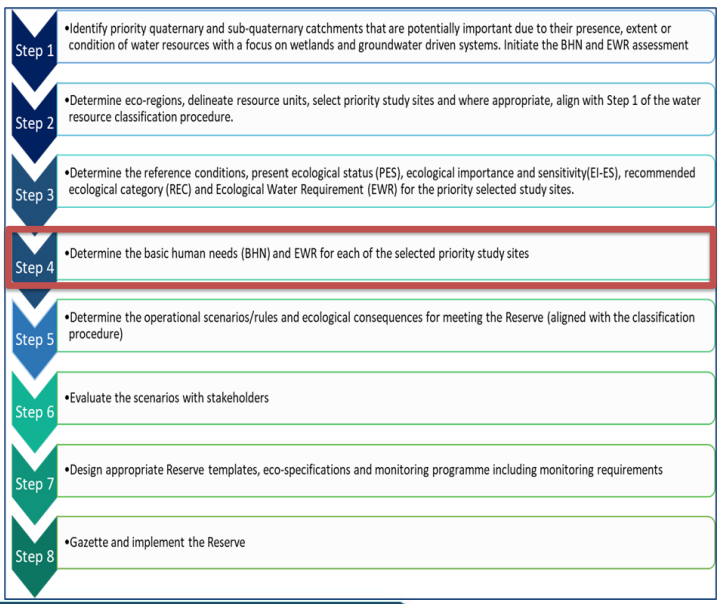
PROJECT PROGRESS SINCE PSC1



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OBJECTIVE FOR PSC2

- Provide feedback to the key stakeholders with regards to the following results for this high confidence study:
  - Wetland component;
  - Groundwater Reserve component;
  - Rivers
    - Eco-categorisation and EWR quantification process
    - Flow Management Plan
    - Integration component

WETLANDS: APPROACH

- The DWS Rapid Ecological Reserve Determination of Inland Wetlands (Rountree *et al.,* 2013) procedure was slightly modified and implemented in this study to determine the Recommended Ecological Category (REC) for the selected WRUs:
  - Step 1: Initiate the EWR and BHN assessment and identify priority quaternary and sub-quaternary catchments;
  - Step 2: Delineate Wetland Resource Unit (WRU) and select priority sites;
  - Step 3: Determine reference conditions; PES, EIS, and REC for the priority sites:
  - Step 5: Ecological consequences of operational scenarios/rules were modelled;
  - Step 7: Eco-specifications were set for all the WRU's which specify monitoring requirements for each WRU

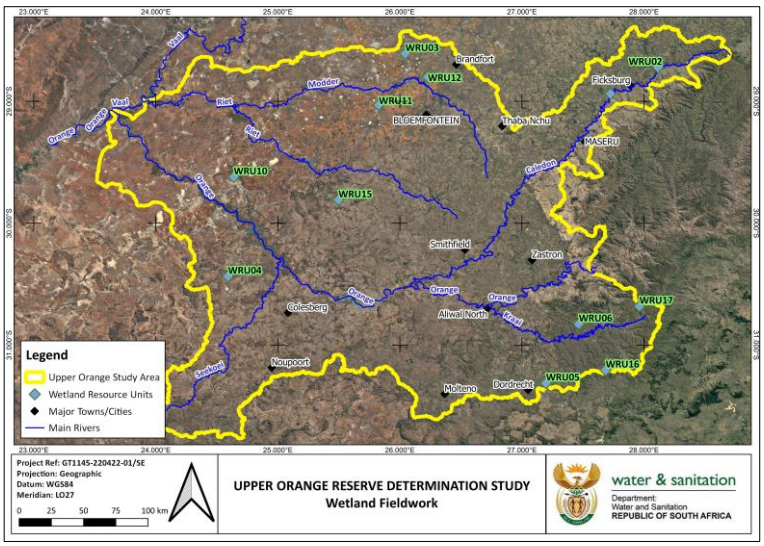
WETLANDS: APPROACH

- A total of 12 WRU's were visited and assessed;
- Each WRU was prioritized into one of three tiers prior to the fieldtrip which determined each WRU's overall importance and the level of detail necessary for the assessment. Tier 1 is very low detail and Tier 3 is moderate to high detail;
- Wetland fieldwork was conducted in April 2022;
- Final wetland report submitted to DWS; and
- A subset of WRU's will be presented here, with a focus on the Tier 2 and 3 wetlands.

WETLAND REPORT FEEDBACK

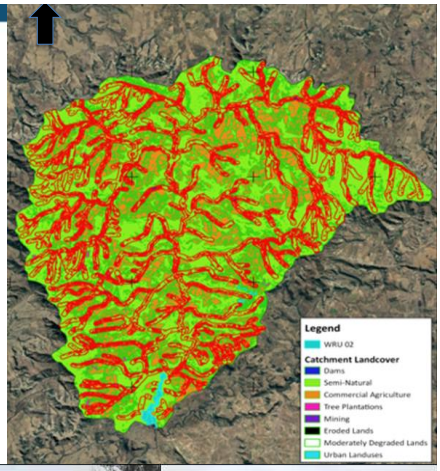
WRU Number	Quaternary Catchment	Tier	Associated River/Groundwater Area
WRU 02	D21G	2	Brandwater River
WRU 03	C52H	1	N/A
WRU 04	D31B	1	Hondeblaf River
WRU 05	D13G	1	Wolwespruit
WRU 06	D13E	1	Klein-Wildebeesspruit
WRU 10	D33C	1	Lemoenspruit
WRU 11	C52G	3	Kaalspruit
WRU 12	C52G	3	Rietspruit
WRU 13	D22G	2	Rantsho River
WRU 15	C51H	2	Prosesspruit
WRU 16	D13D	3	Rytjiesvlaktespruit
WRU 17	D13B	1	Kraai River

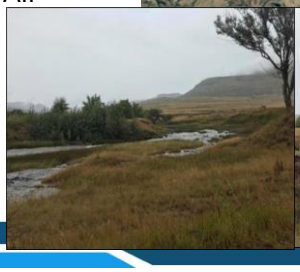
WETLAND REPORT FEEDBACK



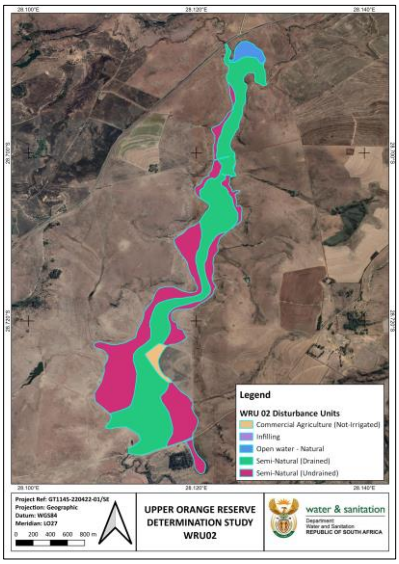
WETLAND: WRU02

- Catchment is 76 000ha with the following impacts:
  - Agriculture (32%), dams, urban areas, erosion, tree plantations and mining
- Wetland is a 258ha floodplain with the following impacts:
  - Infilling, extensive channel incision which is having a draining effect, agriculture (both cultivation and grazing), AIP encroachment
- Critically endangered wetland type





WETLAND: WRU02



Wetland PES Summary				
Wetland name	WRU 02 - Brandwater Floodplain			
Assessment Unit	Brandwater Floodplain 1			
HGM type	Floodplain wetland			
Wetland area (ha)	258.6 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	3.6	2.8	1.5	5.6
PES Score (%)	64%	72%	85%	44%
Ecological Category	C	C	B	D
Combined Impact Score	3.4			
Combined PES Score (%)	66%			
Combined Ecological Category	C			

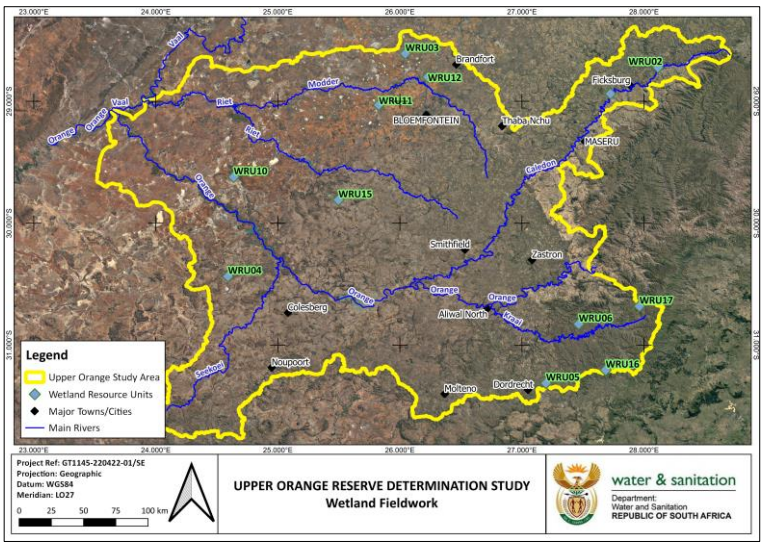
Brandwater Floodplain	
	Importance
Ecological Importance & Sensitivity	3.2
Hydro-Functional Importance	1.2
Direct Human Benefits	0.1
Overall Importance And Sensitivity Score	3.2
Overall Importance And Sensitivity Category	B

- REC is a **C** category
- Large scale channel incision and deactivation of large portions of the channel mean there are limited rehabilitation opportunities due to cost

WETLAND: WRU02

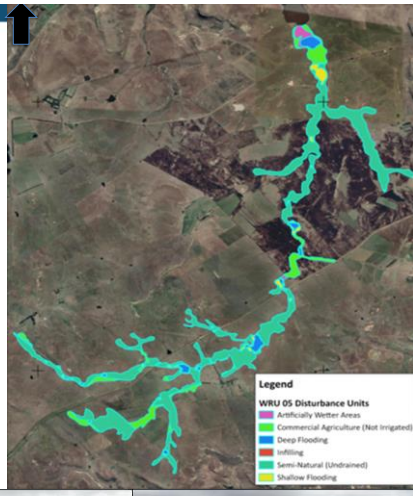
- **Eco-Specifications:**
  - Desktop landcover assessment every 3-5 years
    - Monitor integrity of flood outs and intensity of artificial drainage in these flood outs
  - No additional cultivation in the wetland
  - No further encroachment of AIPs
- Additional recommendations
  - Remove *Salix babylonica* (Willow) trees from the wetland

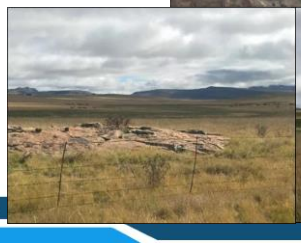
WETLAND REPORT FEEDBACK

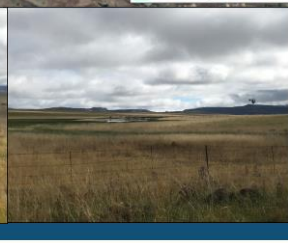


WETLAND: WRU05

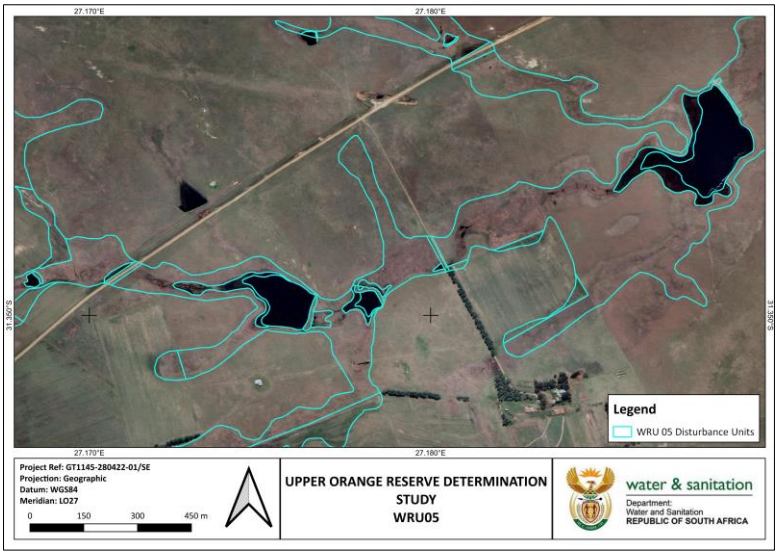
- Small catchment which forms the head of the Wolwespruit River:
  - Agriculture (25%), dams, boreholes and tree plantations
- Wetland complex comprises seep and unchannelled valley bottom wetlands with the following impacts:
  - Over 15 dams along UCVB wetland, infilling, agriculture (both cultivation and grazing), AIP encroachment







WETLAND: WRU05



WETLAND: WRU05

Wetland PES Summary				
Wetland name	WRU 05a			
Assessment Unit	Wolwespruit UCVB Wetlands			
HGM type	Unchannelled VB wetland			
Wetland area (ha)	340.0 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	2.4	2.2	1.7	4.8
PES Score (%)	76%	78%	83%	52%
Ecological Category	C	C	B	D
Combined Impact Score	2.8			
Combined PES Score (%)	72%			
Combined Ecological Category	C			

WRU 05a - Wolwespruit UCVB Wetlands	
	Importance
Ecological Importance & Sensitivity	3.2
Hydro-Functional Importance	2.6
Direct Human Benefits	0.8
Overall Importance And Sensitivity Score	3.2
Overall Importance And Sensitivity Category	B

- REC is **C** category as it is unrealistic to achieve a **B** category due to existing impacts in the wetlands

Wetland PES Summary				
Wetland name	WRU 05b			
Assessment Unit	Wolwespruit Seep Wetlands			
HGM type	Seep			
Wetland area (ha)	80.5 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	2.1	2.1	1.5	4.2
PES Score (%)	79%	79%	85%	58%
Ecological Category	C	C	B	D
Combined Impact Score	2.4			
Combined PES Score (%)	76%			
Combined Ecological Category	C			

WRU 05b - Wolwespruit Seep Wetlands	
	Importance
Ecological Importance & Sensitivity	2.8
Hydro-Functional Importance	1.8
Direct Human Benefits	0.4
Overall Importance And Sensitivity Score	2.8
Overall Importance And Sensitivity Category	C

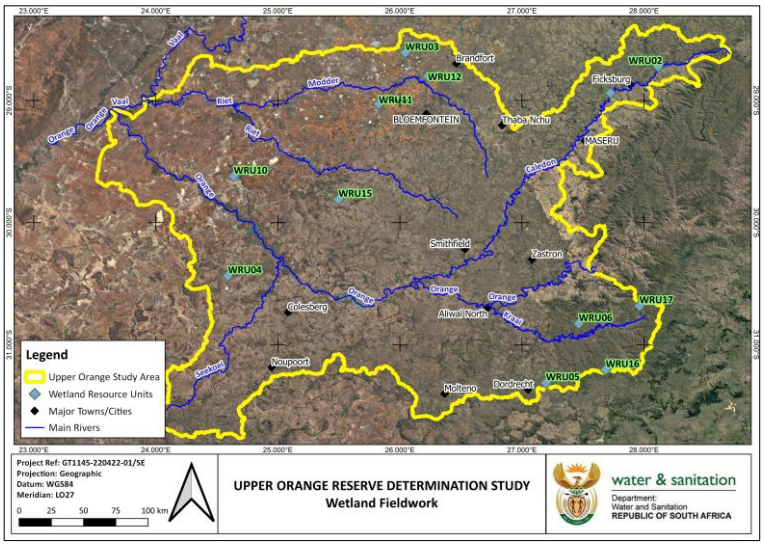
- Extensive dam, road and agricultural infrastructure has been constructed in the wetlands which cannot be easily reversed

WETLAND: WRU05

- **Eco-Specifications:**
  - A WET-Health assessment should be undertaken every 2-3 years with specific focus on the Hydrology module
  - The hydrology PES should not drop below a **C** category
  - No further dams or drains permitted in the wetlands
  - No further cultivation to be permitted in the wetlands

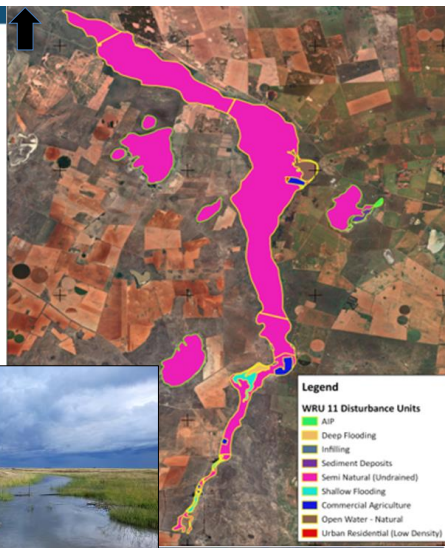
- Additional recommendations
  - A groundwater study must be undertaken before anymore boreholes/windpump are constructed in the wetland/catchment
  - Where possible, existing roads should be upgraded to allow throughflow

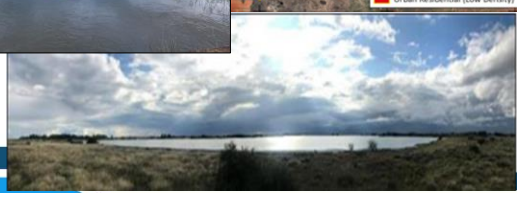
WETLAND REPORT FEEDBACK



WETLAND: WRU11

- Large catchment – approximately 200 000ha with many impacts:
  - Agriculture (37%), urban areas, urban commercial areas, plantations and degraded areas
- Wetland complex comprises valley-bottom and depression wetlands with impacts:
  - Large dam, extensive grazing, sedimentation, infilling and some channel incision





WETLAND: WRU11

Wetland PES Summary				
Wetland name	WRU 11a			
Assessment Unit	Kaalspruit Valley Bottom Wetlands			
HGM type	Channelled VB wetland not laterally maintained			
Wetland area (ha)	2839.3 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	1.9	2.2	1.9	4.1
PES Score (%)	81%	78%	81%	59%
Ecological Category	B	C	B	D
Combined Impact Score	2.5			
Combined PES Score (%)	75%			
Combined Ecological Category	C			

WRU 11a - Kaalspruit Valley Bottom Wetlands	
	Importance
Ecological Importance & Sensitivity	2.8
Hydro-Functional Importance	3.0
Direct Human Benefits	0.3
Overall Importance And Sensitivity Score	3.0
Overall Importance And Sensitivity Category	B

- REC is **C** category as it is unrealistic to achieve a **B** category in the valley-bottom wetlands due to existing impacts in the wetlands
- Appropriate buffer zones must be maintained
- Careful consideration of cumulative impacts of new agriculture

Wetland PES Summary				
Wetland name	WRU 11b			
Assessment Unit	Kaalspruit Depression Wetlands			
HGM type	Depression without flushing			
Wetland area (ha)	1050.6 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	2.3	2.6	2.7	4.2
PES Score (%)	77%	74%	73%	58%
Ecological Category	C	C	C	D
Combined Impact Score	2.9			
Combined PES Score (%)	71%			
Combined Ecological Category	C			

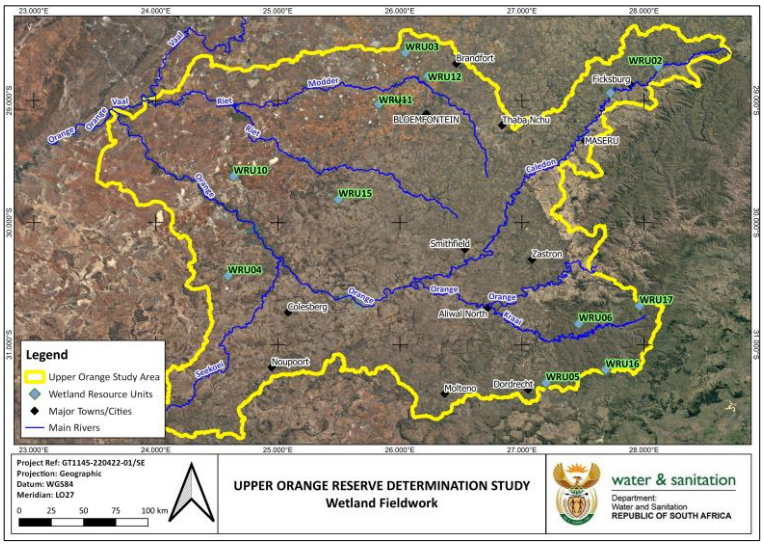
WRU 11b - Kaalspruit Depression Wetlands	
	Importance
Ecological Importance & Sensitivity	2.4
Hydro-Functional Importance	2.1
Direct Human Benefits	0.3
Overall Importance And Sensitivity Score	2.4
Overall Importance And Sensitivity Category	C

WETLAND: WRU11

- **Eco-specifications:**
  - No further cultivation to be permitted within the remaining intact wetlands
  - Formal buffer areas between cultivation and depression wetlands must be established and maintained
  - AIP species must be managed at current levels
  - No new roads to be approved or built through the wetlands

- Additional recommendations
  - Erosion occurring in the catchment of one of the depression wetlands should be rehabilitated

WETLAND REPORT FEEDBACK



WETLAND: WRU12

- Catchments range between 43 000 and 57 000 ha in size with impacts:
  - Large proportion (74%) is considered to be natural/semi-natural, agriculture (14%) and urban areas associated with Brandfort
- Two wetland types in WRU 12 namely a channelled valley-bottom and wetland flat with the following impacts:
  - Dams, grazing, erosion and point source pollution from the sewage works in Brandfort

WETLAND: WRU12

Wetland PES Summary				
Wetland name	WRU 12a			
Assessment Unit	Aardoringspruit Valley Bottom Wetland			
HGM type	Channelled VB wetland not laterally maintained			
Wetland area (ha)	665.9 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	3.3	1.4	1.0	4.2
PES Score (%)	67%	86%	90%	58%
Ecological Category	C	B	B	D
Combined Impact Score	2.6			
Combined PES Score (%)	74%			
Combined Ecological Category	C			

WRU 12a - Aardoringspruit Valley Bottom Wetland	Importance
Ecological Importance & Sensitivity	2.8
Hydro-Functional Importance	2.5
Direct Human Benefits	0.3
Overall Importance And Sensitivity Score	2.8
Overall Importance And Sensitivity Category	C

- REC is **C** category for both wetlands as it is not pragmatic to rehabilitate the wetland flat to a **B** category without large investment and removal of infrastructure

Wetland PES Summary				
Wetland name	WRU 12b			
Assessment Unit	Aardoringspruit Wetland Flat			
HGM type	Flat			
Wetland area (ha)	1075.4 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	3.4	2.2	1.9	5.4
PES Score (%)	66%	78%	81%	46%
Ecological Category	C	C	B	D
Combined Impact Score	3.3			
Combined PES Score (%)	67%			
Combined Ecological Category	C			

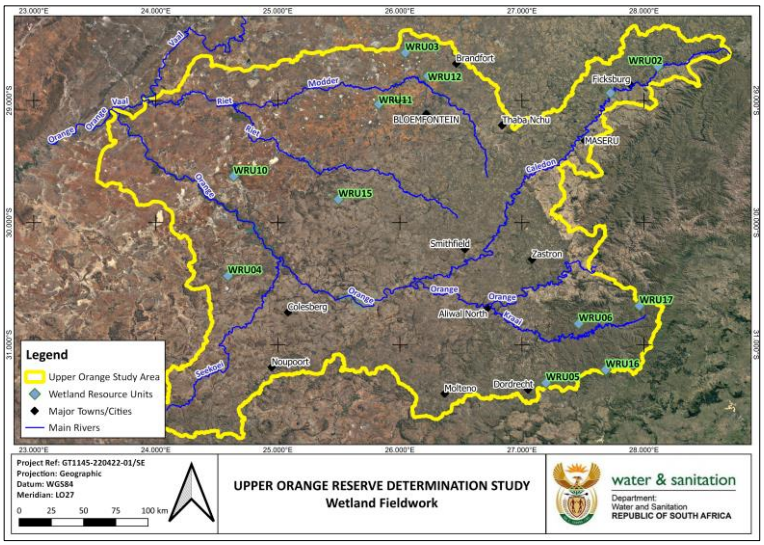
WRU 12b - Aardoringspruit Wetland Flat	Importance
Ecological Importance & Sensitivity	3.1
Hydro-Functional Importance	2.5
Direct Human Benefits	0.2
Overall Importance And Sensitivity Score	3.1
Overall Importance And Sensitivity Category	B

- Large potential for additional cultivation in the catchment which would need to be monitored

WETLAND: WRU12

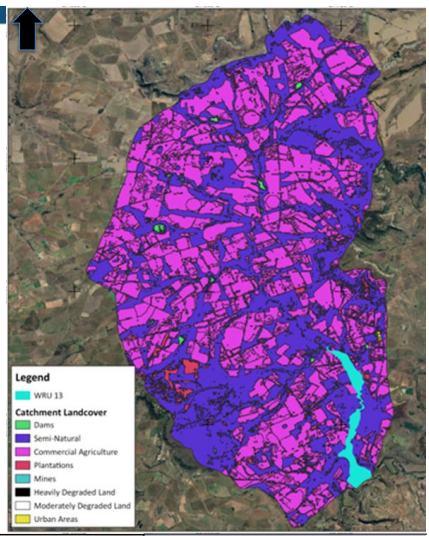
- **Eco-specifications:**
  - No further dams or roads to be constructed in the wetlands
  - No intensive cultivation to be permitted within the wetlands
  - Maintain current grazing regimes within the wetlands

WETLAND REPORT FEEDBACK



WETLAND: WRU13

- Catchment is approximately 30 000ha in size with extensive agriculture (33%) as the most prolific impact. Other impacts include:
  - Plantations, urban areas, dams, mines and erosion
- Three wetland units in the WRU:
  - Floodplain, channelled valley-bottom and unchannelled valley-bottom
- Fairly extensive impacts within the wetlands include:
  - Cultivation, grazing, AIP encroachment, channel incision, erosion



WETLAND: WRU13

Wetland PES Summary				
HGM type	Floodplain wetland			
Wetland area (ha)	95.0 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	4.9	3.1	2.8	7.0
Ecological Category	D	C	C	E
Combined Impact Score	4.5			
Combined PES Score (%)	55%			
Combined Ecological Category	D			

WRU 13a - Rantsho Floodplain Wetland	
	Importance
Ecological Importance & Sensitivity	3.0
Hydro-Functional Importance	2.8
Direct Human Benefits	0.7
Overall Importance And Sensitivity Score	3.0
Overall Importance And Sensitivity Category	C

Wetland PES Summary				
HGM type	Channelled VB wetland not laterally maintained			
Wetland area (ha)	71.4 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	2.8	1.6	1.6	4.9
Ecological Category	C	B	B	D
Combined Impact Score	2.7			
Combined PES Score (%)	73%			
Combined Ecological Category	C			

WRU 13b - Rantsho CVB Wetland	
	Importance
Ecological Importance & Sensitivity	3.0
Hydro-Functional Importance	2.5
Direct Human Benefits	0.3
Overall Importance And Sensitivity Score	3.0
Overall Importance And Sensitivity Category	C

Wetland PES Summary				
HGM type	Unchannelled VB wetland			
Wetland area (ha)	108.1 ha			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	4.7	2.8	3.4	7.0
Ecological Category	D	C	C	E
Combined Impact Score	4.5			
Combined PES Score (%)	55%			
Combined Ecological Category	D			

WRU 13c - Rantsho UCVB Wetland	
	Importance
Ecological Importance & Sensitivity	3.2
Hydro-Functional Importance	3.0
Direct Human Benefits	0.7
Overall Importance And Sensitivity Score	3.2
Overall Importance And Sensitivity Category	B

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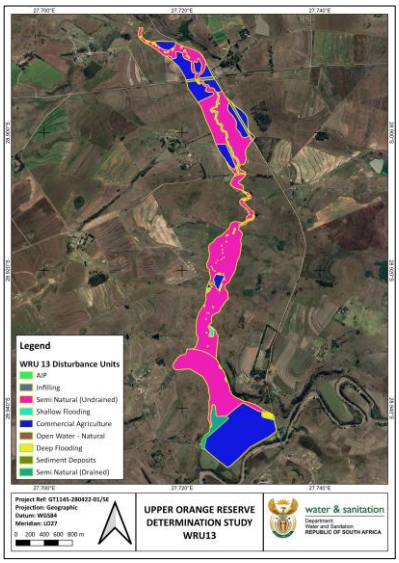
WETLAND: WRU13

- REC is **C** category for all wetlands in WRU 13
  - The REC for the floodplain wetland could be achieved if some of the cultivation in the wetland was reduced or altered to low-impact crops along with the removal of AIPs
  - The REC for the unchannelled valley-bottom could similarly be achieved with the reduction of intensity of cultivation in the wetland and through the rehabilitation of the gullies which threaten the integrity of the wetland



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WETLAND: WRU13

- **Eco-specifications**
  - No further cultivation or intensive land uses
  - No further infrastructure (dams or roads) to be constructed in the remaining intact wetlands
  - No further degradation of water quality – agricultural and livestock operations to be periodically monitored for discharge into WRU 13
  - No further encroachment of woody AIP species

EWR QUANTIFICATION REQUIREMENTS

WRU Number	Require EWR quantification
WRU 02	No
WRU 03	No
WRU 04	No
WRU 05	Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised.
WRU 06	Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate.
WRU 10	No
WRU 11	Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate.
WRU 12	No
WRU 13	Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate.
WRU 15	No
WRU 16	No
WRU 17	No

WETLAND SUMARY

WRU Number	HGM Unit	PES	EIS	REC
WRU 02	Floodplain	C	B	C
WRU 03	Depression (Soutpan)	C	C	C
	Depression	B	C	B
WRU 04	Depression	A	C	A
	Unchannelled VB	C	C	A
WRU 05	Unchannelled VB	C	B	C
	Seep	C	C	C
WRU 06	Channeled VB	D	C	D
	Seep	D	C	C
WRU 10	Depression	B	C	B
WRU 11	Channeled VB	C	B	C
	Depression	C	C	C
WRU 12	Channeled VB	C	C	C
	Flat	C	B	C
WRU 13	Floodplain	D	C	C
	Channeled VB	C	C	C
	Unchannelled VB	D	B	C
WRU 15	Channeled VB	C	C	C
WRU 16	Channelled VB	A	B	A
	Seep	A	B	A
WRU 17	Seep	A	C	A

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GROUNDWATER RESERVE COMPONENT RESULTS AND FEEDBACK

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GROUNDWATER: APPROACH

- Available groundwater and other relevant data from DWS
  - Time series groundwater levels (Hydstra)
  - Time series groundwater quality (mainly WMS)
  - Groundwater Abstraction (mainly WARMS)
  - Flow data (WR, 2012)
- Execution of GRDM determinations for the set of groundwater resource units, including groundwater dependent ecosystems (GDEs), identified in the study;
  - Although, the current GRDM is currently under review. An update of the GRDM methodology and software is expected in 2024.
- Address both the quantity/quality of the EWR and BHN components;
- Determination of the EWR and BHN component; and
- Infield verification for GW Reserve determination (single hydrocensus survey in April 2022.

GROUNDWATER: RESERVE

- Water Balance Approach Adopted to determine the Reserve and Stress Index (WRC, 2012)

Reserve (%) = $EWR_{gw} + BHN_{gw}/Re \times 100$

Where:

Re = *Recharge*

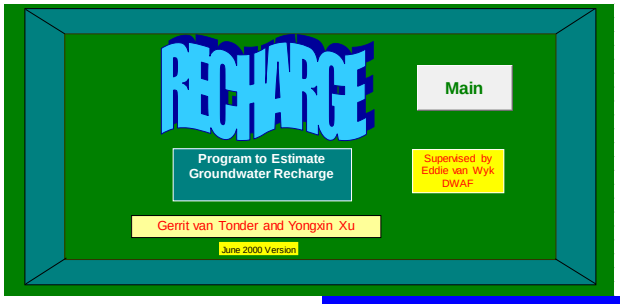
BHN_{gw} = *Basic human needs derived from groundwater*

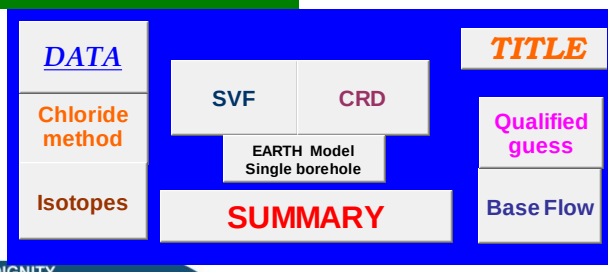
EWR_{gw} = *Groundwater contribution to EWR*

- Stress Index expressed as either a Surplus or Deficit in the catchment

- **Stress Index (SI) =** $Re - (GW_{use} + EWR_{gw} + BHN_{gw})$

GROUNDWATER: RECHARGE





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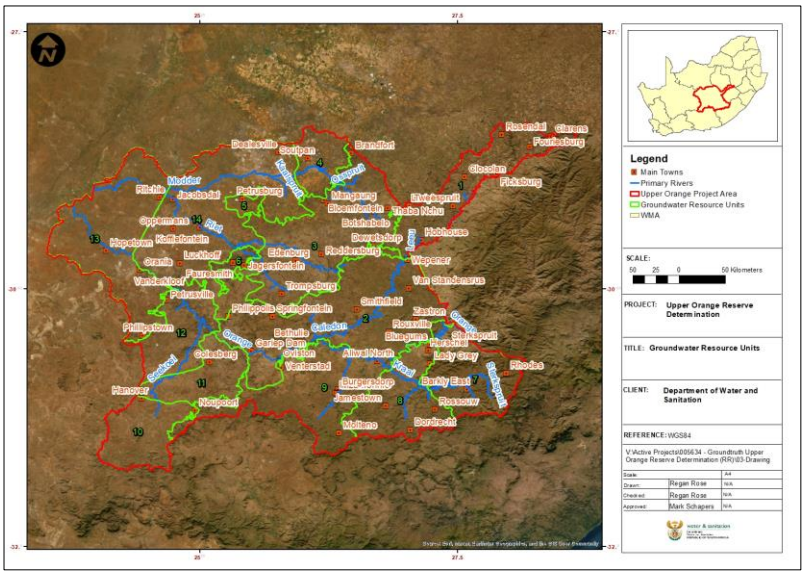
GROUNDWATER: LOCATION



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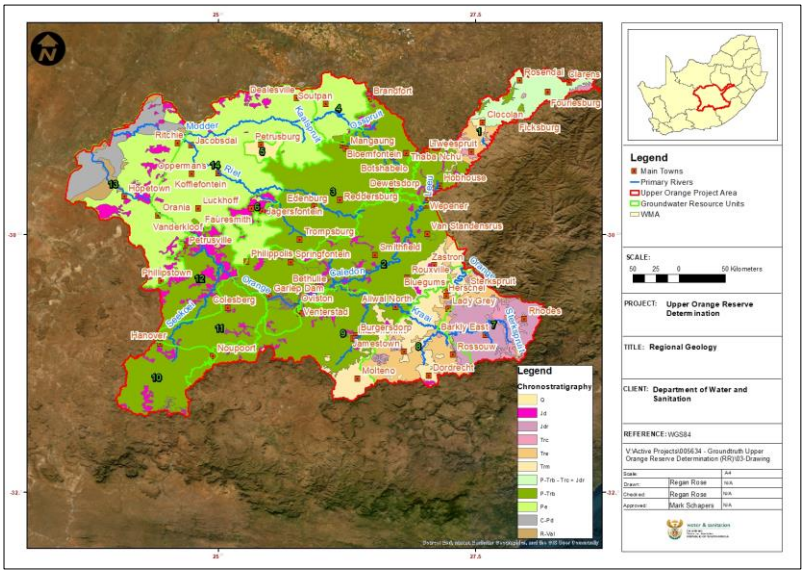
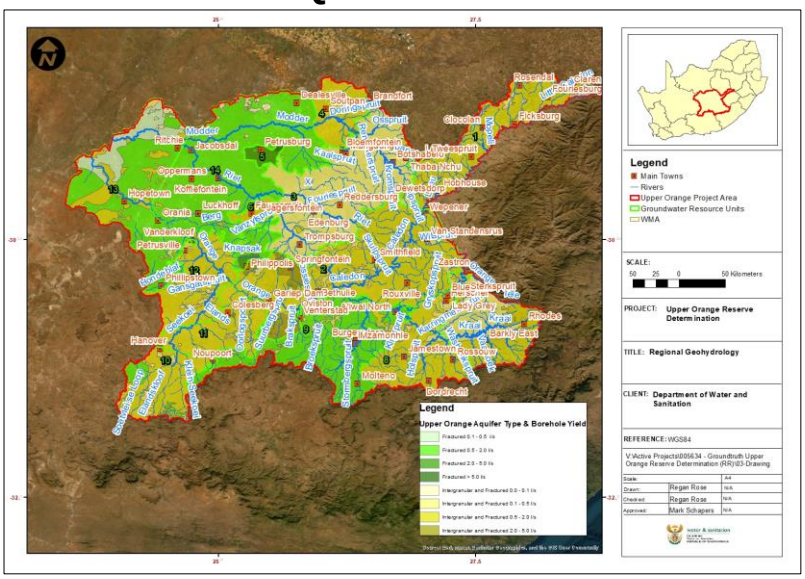
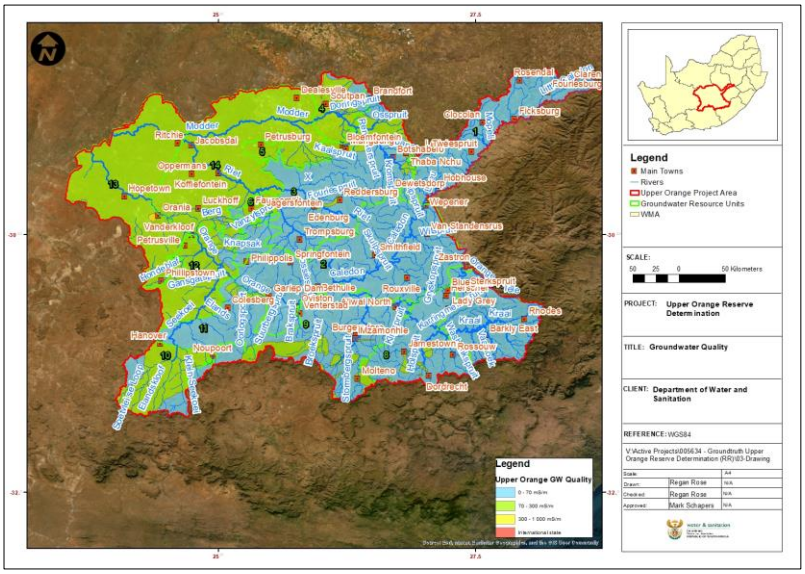
GROUNDWATER: GEOLOGY



GROUNDWATER: AQUIFER TYPES



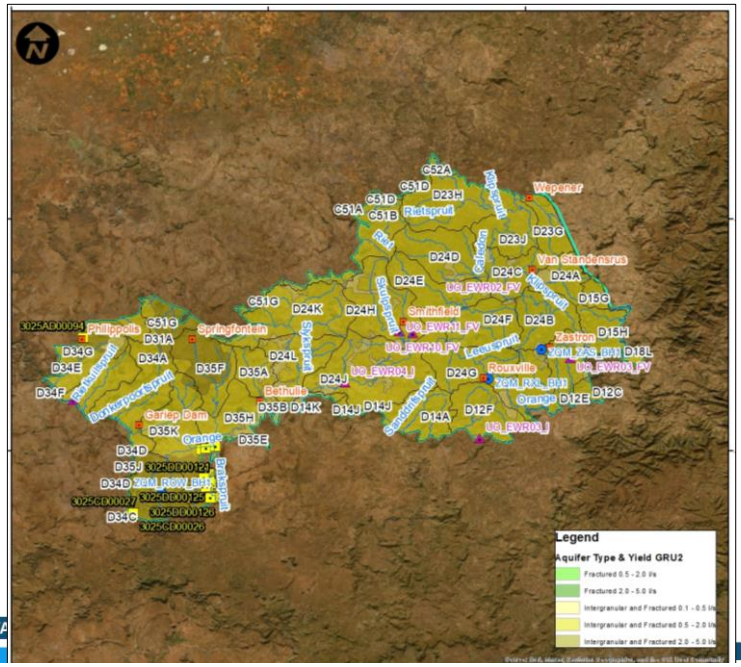
GROUNDWATER: GW QUALITY



GROUNDWATER RESERVE

- A total of 14 groundwater RU were identified; and
- A subset of GW RU's will be presented here, with a focus on the stress, recharge and Reserve.

GROUNDWATER: GRU2



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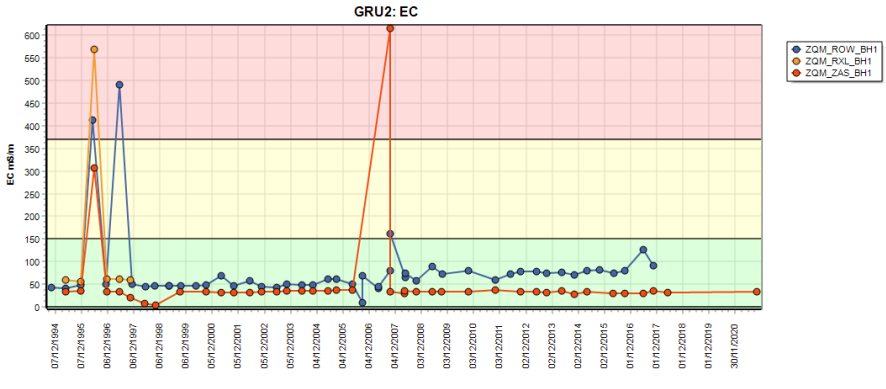
GROUNDWATER: GRU2



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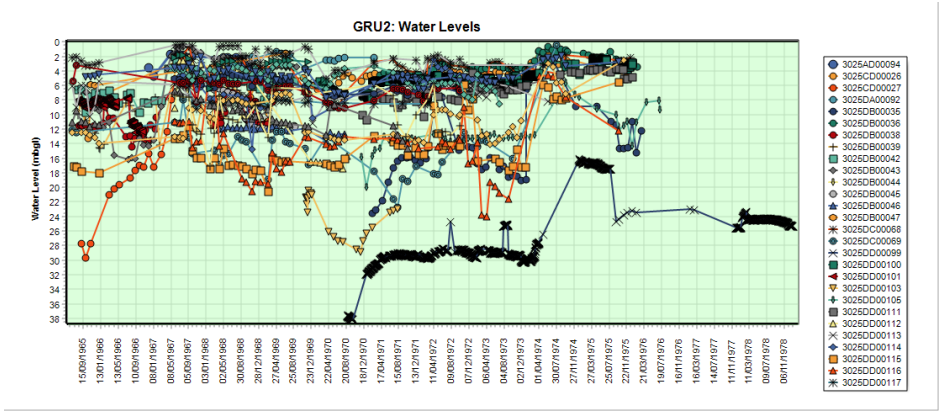
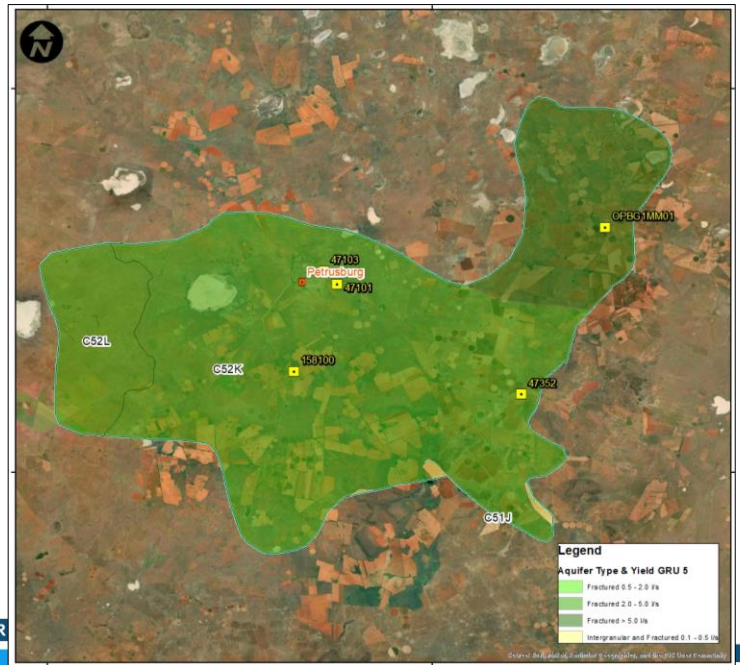
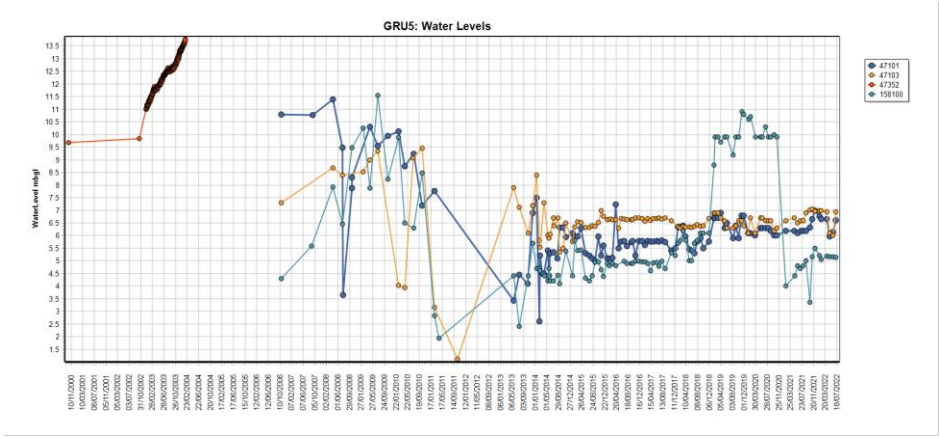
GROUNDWATER: GRU2



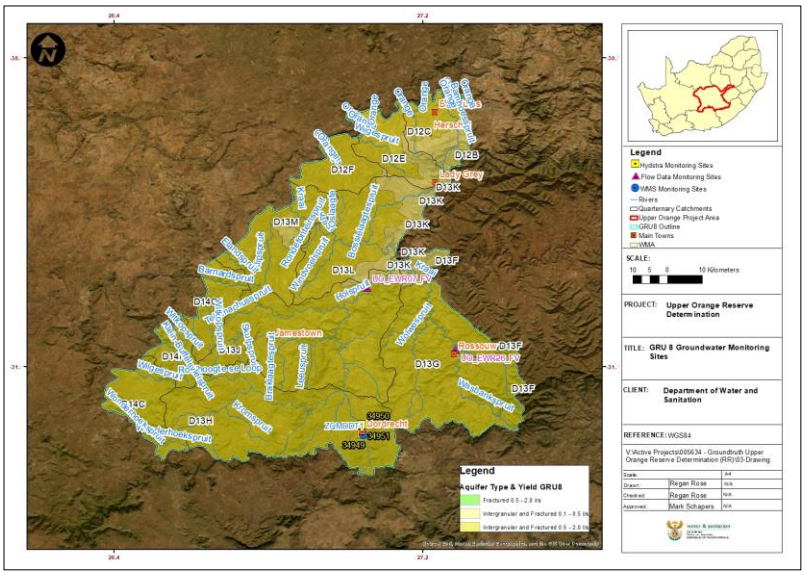
GROUNDWATER: GRU5



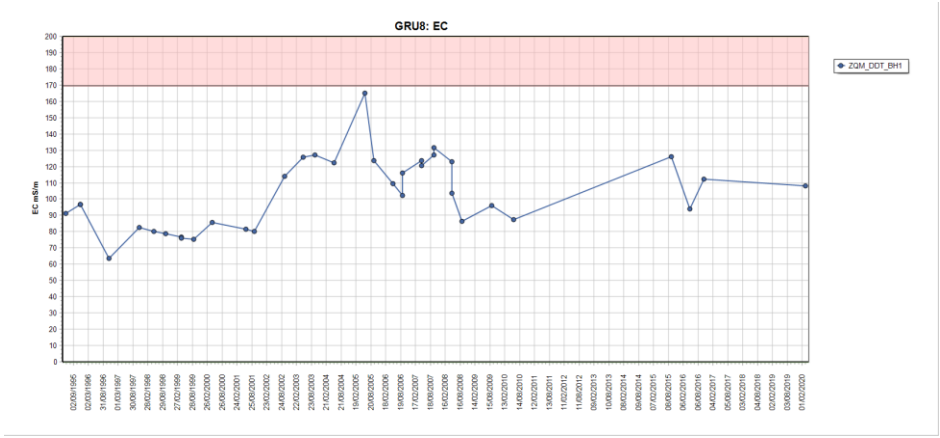
GROUNDWATER: GRU5



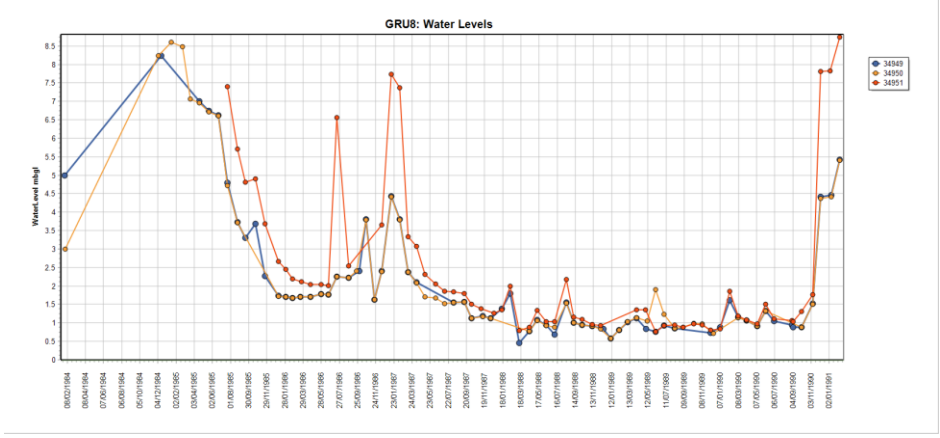
GROUNDWATER: GRU8



GROUNDWATER: GRU8



GROUNDWATER: GRU8



GROUNDWATER: RECHARGE

- Based on the available data, the Recharge toolkit was used to determine recharge per quaternary catchment. Due to the lack of sufficient monthly water level data, recharge estimation was mainly limited to the CMB method and qualified guesses.

Quaternary Catchment	Recharge Method	Average Annual Recharge (mm)	% Recharge	Recharge (Mm3/a)
C51A	CMB+Qualified Guess	16.6	3.5	11.205
C51B	Qualified Guess	14.5	3.1	24.548
C51C	Qualified Guess	16.8	4	10.508
C51D	Qualified Guess	17.1	3.5	15.796
C51E	Qualified Guess	17	4	13.681
C51F	Qualified Guess	15.8	4.3	13.880
C51G	CMB+Qualified Guess	14.8	3.7	27.112

GROUNDWATER: CONTRIBUTION TO BASEFLOW

- Consultation with the civil engineering department at the University of Pretoria, a simplistic technique of baseflow separation was devised that could provide reasonable results based on the limited available data.
- The technique considers the monthly flow during dry months, specifically extracting the lowest average monthly flows during dry months.
- A desktop analysis was conducted using these lowest monthly flows as a proxy for baseflow.
- Various options exist including using the single lowest, two lowest or three lowest monthly flows. In this assessment, we considered all three options and conducted a sensitivity analysis to determine the significance of the differences between the three options.
- The results indicated an insignificant difference, and therefore an average of the results from the three options were used to determine the baseflow.

GROUNDWATER: CONTRIBUTION TO BASEFLOW

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm^3/a)	Lowest average monthly flow (Mm^3/m)	2nd Lowest average monthly flow (Mm^3/m)	3rd Lowest average monthly flow (Mm^3/m)	Average of two lowest monthly flows (Mm^3/m)	Average of three lowest monthly flows (Mm^3/m)	Lowest average monthly flow/average annual total flow (Mm^3/m)	Average of two lowest monthly flows/average annual total flow (Mm^3/m)	Average of three lowest monthly flows/average annual total flow (Mm^3/m)	Average Baseflow (%)	Baseflow (Mm^3/m)	Baseflow (Mm^3/a)
C51A	15.03	0.14	0.18	0.19	0.16	0.17	0.93	1.06	1.13	1.04	0.16	1.92
C51B	20.07	0.23	0.27	0.3	0.25	0.27	1.15	1.25	1.33	1.24	0.25	3
C51C	9.39	0.07	0.09	0.14	0.08	0.1	0.75	0.85	1.06	0.89	0.08	0.96
C51D	16.18	0.15	0.16	0.2	0.16	0.17	0.93	0.96	1.05	0.98	0.16	1.92
C51E	18.69	0.15	0.19	0.2	0.17	0.18	0.8	0.91	0.96	0.89	0.17	2.04
C51F	12.12	0.08	0.11	0.12	0.1	0.1	0.66	0.78	0.85	0.77	0.09	1.08
C51G	42.74	0.35	0.44	0.49	0.4	0.43	0.82	0.92	1	0.91	0.39	4.68

Maximum Baseflow (Mm^3/year)	64.68
Minimum Baseflow (Mm^3/year)	0.12

GROUNDWATER: QUALITY RESERVE

- Available chemical parameters are:
  - EC, calcium, magnesium, sodium, potassium, total alkalinity, chloride, sulphate, nitrate/nitrite and fluoride
- Median concentrations of each chemical parameter were determined to characterise the dominant groundwater quality
- Groundwater Quality Reserve was set at median concentrations plus 10% for each chemical parameter

GROUNDWATER: QUALITY RESERVE

Chemical Parameter	Unit	Quaternary D22G			
		No. of Samples	Ambient GW quality or median[1]	BHN Reserve[2]	Groundwater Quality Reserve[3]
pH	–	46	8.10	5.0 – 9.5	8.91
Electrical Conductivity	mS/m	46	44.60	<150	49.06
Calcium as Ca	mg/l	46	26.39	<150	29.03
Magnesium as Mg	mg/l	46	8.60	<100	9.46
Sodium as Na	mg/l	46	62.11	<200	68.32
Potassium as K	mg/l	46	3.42	<50	3.76
Total Alkalinity as $CaCO_3$	mg/l	46	189.07	<330	207.98
Chloride as Cl	mg/l	46	19.60	<200	21.56
Sulphate as SO_4	mg/l	46	18.50	<400	20.35
Nitrate and Nitrite as N	mg/l	46	1.77	<1.0	1.95
Fluoride as F	mg/l	46	0.83	<1.0	0.91
				Water quality class	Class 1

[1] Median value (calculated from population of samples in QC).

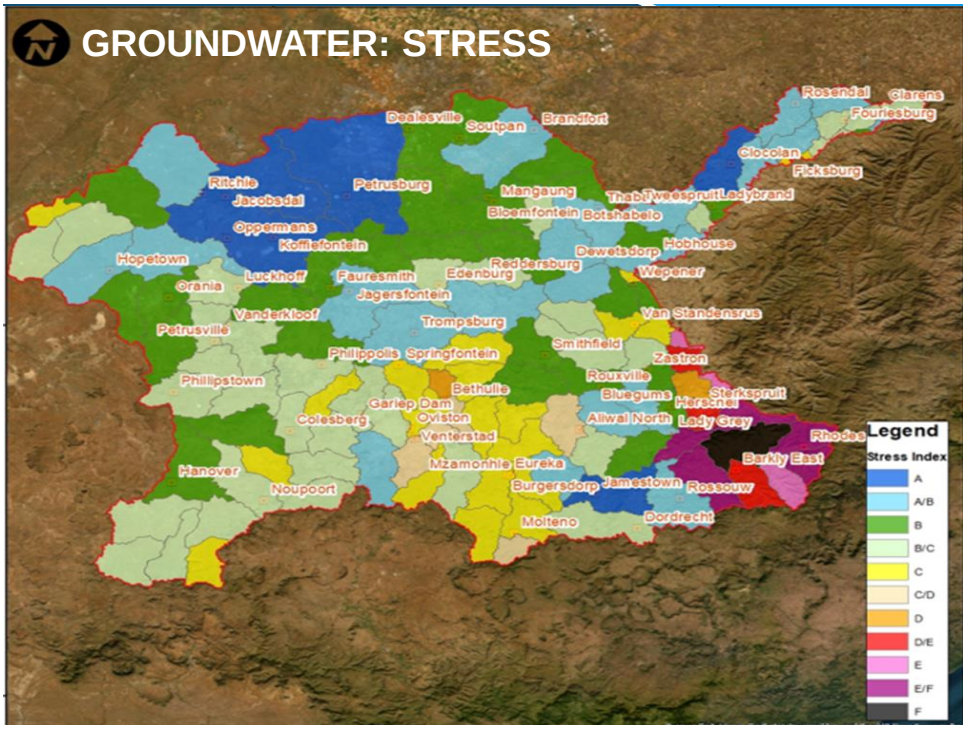
[2] Upper limit of Class I water quality (DWAF et al 1998).

[3] The median plus 10% for the Groundwater Quality Reserve.

GROUNDWATER: QUANTITY RESERVE, INCLUDING STRESS INDEX

- In accordance with WRC (2012), components of the Groundwater Reserve include groundwater recharge, BHN for groundwater, as well as groundwater contribution to baseflow.
- Using the available data, the latter components were estimated to determine the Groundwater Reserve as a percentage of Recharge.
- Results:
  - The Groundwater Reserve varies from 0.01 – 18.66%.

Quaternary Catchment	Recharge (Mm3/a)	Basic Human Needs Groundwater Reserve (Mm3/a)	Groundwater Baseflow (Mm3/a)	Groundwater Reserve (Mm3/a)	Groundwater Reserve (% of Recharge)	Current Groundwater Use (Mm3/a)	Surplus / Available Groundwater (Mm3/a)	Stress Index
C51A	11.205	0.004	0.16	0.164	1.43	1.821	9.220	B/C
C51B	24.548	0.007	0.25	0.257	1.04	1.221	23.070	A/B
C51C	10.508	0.003	0.08	0.083	0.82	0.983	9.442	B/C
C51D	15.796	0.017	0.16	0.177	1.11	0.574	15.045	B
C51E	13.681	0.01	0.17	0.18	1.29	1.247	12.254	B/C
C51F	13.88	0.005	0.09	0.095	0.7	0.869	12.916	B/C
C51G	27.112	0.007	0.39	0.397	1.47	1.992	24.723	A/B
C51H	27.668	0.01	0.29	0.3	1.08	3.602	23.766	A/B


GROUNDWATER: STRESS
Rosendal
Clarens
Fouriesburg
Bealesville
Soutpan
Brandfort
Clocolan
Ficksburg
Ritchie
Petrusburg
Mangaung
Thaba'Nchu
Tweespruit
Ladybrand
Jacobsdal
Bloemfontein
Botshabelo
Oppermans
Koffiefontein
Dewetsdorp
Hobhouse
Hopetown
Redbersburg
Wepener
Luckhoff
Fauresmith
Edenburg
Orania
Jagersfontein
Vanderkloof
Van Standensrus
Trompsburg
Petrusville
Smithfield
Philippolis
Springfontein
Zastron
Rouxville
Phillipstown
Bethulie
Bluegums
Sterkspruit
Herschel
Garlep Dam
Oviston
Colesberg
Aliwal North
Lady Grey
Venterstad
Rhodes
Barkly East
Mzamonhle
Eureka
Hanover
Burgersdorp
Jamestown
Rossouw
Noupoort
Molteno
Dordrecht
Legend
Stress Index
A
A/B
B
B/C
C
C/D
D
D/E
E
E/F
F

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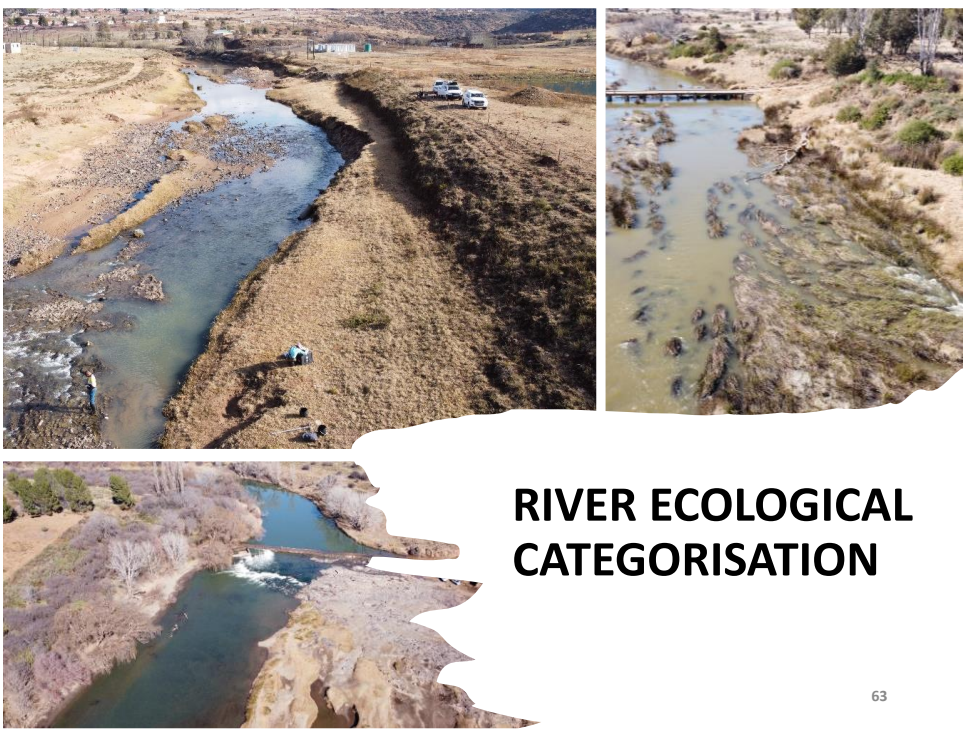
RIVER ECOLOGICAL CATEGORISATION
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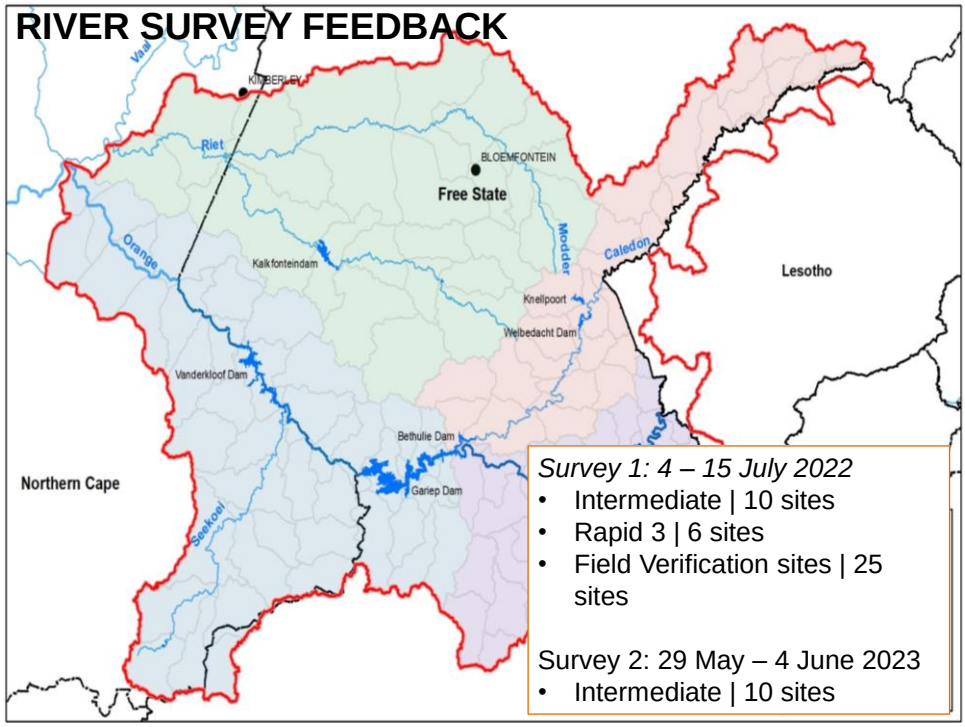
RIVER SURVEY FEEDBACK
Vaal
KIMBERLEY
Riet
BLOEMFONTEIN
Free State
Orange
Modder
Caledon
Kalkfonteindam
Lesotho
Knellpoort
Welbedacht Dam
Vanderkloof Dam
Bethulie Dam
Northern Cape
Gariep Dam
Seekoei
Survey 1: 4 – 15 July 2022
• Intermediate | 10 sites
• Rapid 3 | 6 sites
• Field Verification sites | 25 sites
Survey 2: 29 May – 4 June 2023
• Intermediate | 10 sites

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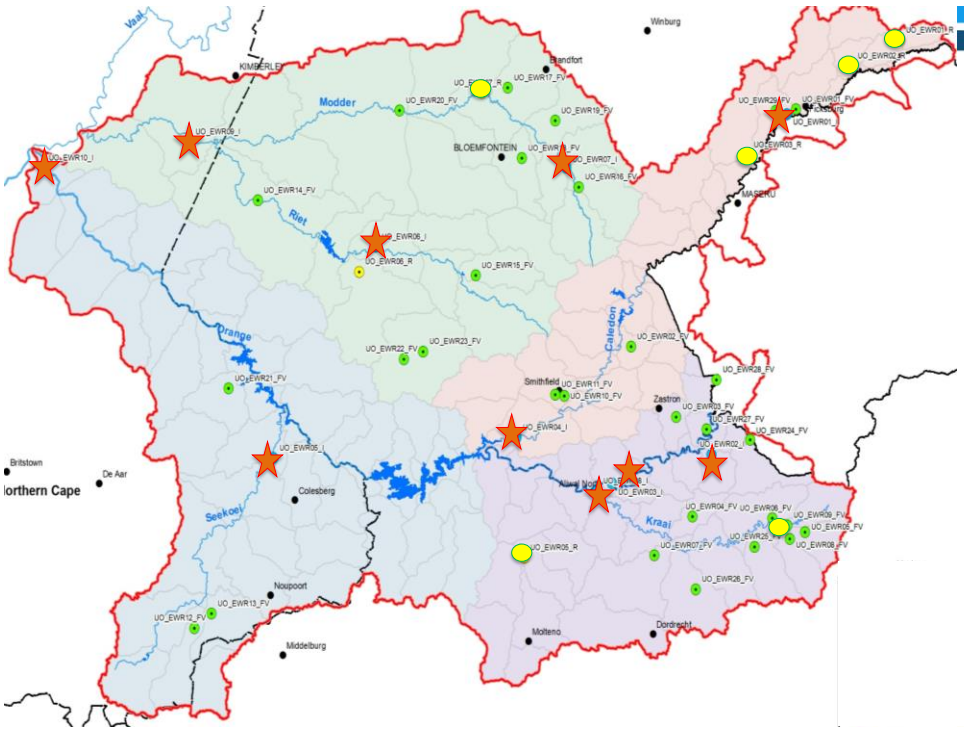
Vaal
Winburg
KIMBERLEY
Brandfort
Modder
BLOEMFONTEIN
Riet
Orange
Caledon
Smithfield
Zastron
Britstown
De Aar
Colesberg
Seekoei
Kraai
Noupoort
Middelburg
Molteno
Dordrecht

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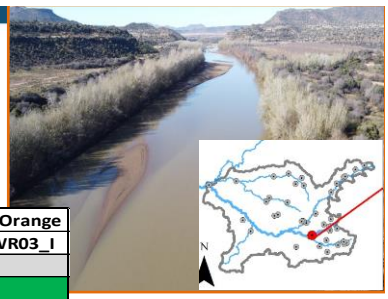
RIVERS ECO-CATEGORISATION

- The Eco-categorisation process was followed according to the methods of Kleynhans and Louw (2007);
- Eco-categorisation is the determination and categorisation of the PES (health and/or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition;
- These results then provide the information needed to derive desirable and attainable future ecological objectives for the rivers;
- Starts with assessing existing/available data at all identified EWR sites; and
- The following models were subsequently run using the data gathered during the river surveys (Sep'22 and May'23):
  - Hydrological Driver Assessment Index (HAI);
  - Geomorphology Driver Assessment Index (GAI);
  - WQ: Diatoms used to infer the present physical-chemical state of the system;
  - Macroinvertebrate Response Assessment Index (MIRAI);
  - Fish Response Assessment Index (FRAI);
  - Riparian Vegetation Response Assessment Index (VEGRAI);
  - Index of Habitat Integrity (IHI) – instream and riparian; and
  - EcoStatus Model

ECO-CATEGORISATION

UO_EWR03_I



Hydrological modification due to upstream impoundments within Lesotho

Diatoms: elevated nutrient concentrations prevalent at the site because of the Sterkspruit discharging untreated sewage upstream. Other contaminants and toxins were also picked up given the untreated effluent discharged upstream.

River	Upper Orange
EWR Site Code	UO_EWR03_I
Driver component	PES
HAI	D
Diatoms	C
GAI	C
Response component	PES
FRAI	D
MIRAI	C/D
VEGRAI	D
Ecostatus	D
EI	Moderate
ES	Moderate
REC	D
AEC	C/D

Poor habitat availability for both fish and aquatic macroinvertebrates

Extensive alien invasive plants

Widespread overgrazing and soil erosion in the catchment (largely Lesotho and communal land) elevating fine sediment loads)

(High)-Moderate (riparian-wetland zone habitat integrity class / instream habitat integrity class)

(High)-Moderate (reduced macroinvertebrate sensitivity / riparian-wetland vegetation intolerance to water level changes)

AEC ↑ Reach is not driven by water quality, but from sediment loads (upstream activities). Catchment/land management improvement (sand mining, upstream practices within Lesotho – also to consider implementation of environmental flows. EWR quantification for a D REC.

ECO-CATEGORISATION

UO_EWR08_I

Limited hydrological modification – free flowing river

Diatoms: indicated elevated electrolyte concentrations and pollutants. Algae content over the stones biotope.

Widespread overgrazing and soil erosion in the catchment elevating fine sediment loads

River	Lower Kraai
EWR Site Code	UO_EWR08_I
Driver component	PES
HAI	B
Diatoms	C
GAI	C
Response component	PES
FRAI	C
MIRAI	C
VEGRAI	D/E
Ecostatus	C
EI	High
ES	High
REC	B/C
AEC	B

Good habitat availability for macroinvertebrates, although some algae smothering the biotopes. Presence of non-native fish species

Extensive alien invasive plants

Both remain High

AEC ↑ Removal of alien vegetation along the riparian zone and continual management and catchment management (implement buffer zones for irrigation, overgrazing, trampling).

REC ↑ WQ improvements through land use activities (irrigation, abstraction, return flows). Alien invasive vegetation to be managed. EWR quantification for a B/C REC.

WATER IS LIFE - SANITATION IS DIGNITY

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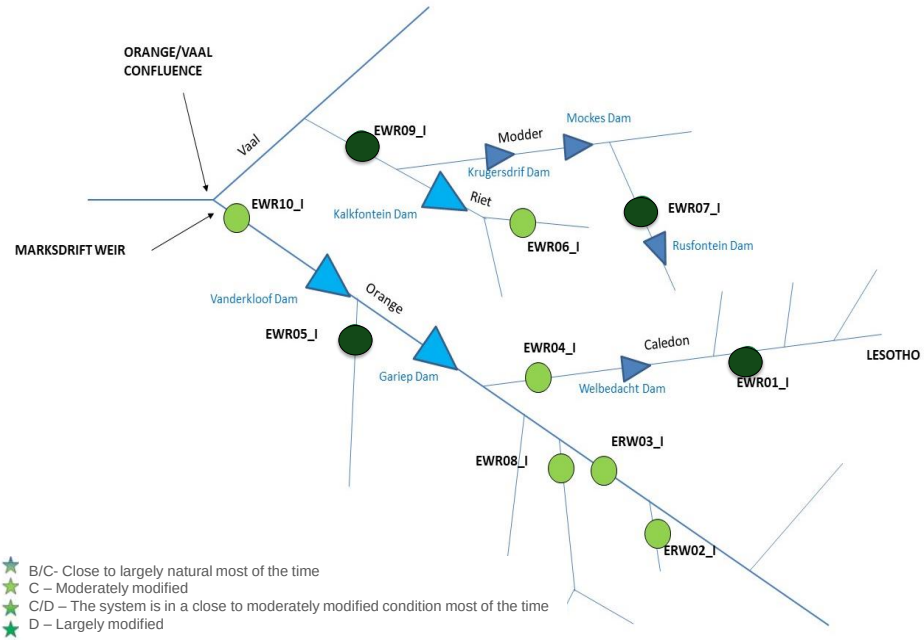
INTERMEDIATE EWR SITES: PES SUMMARY



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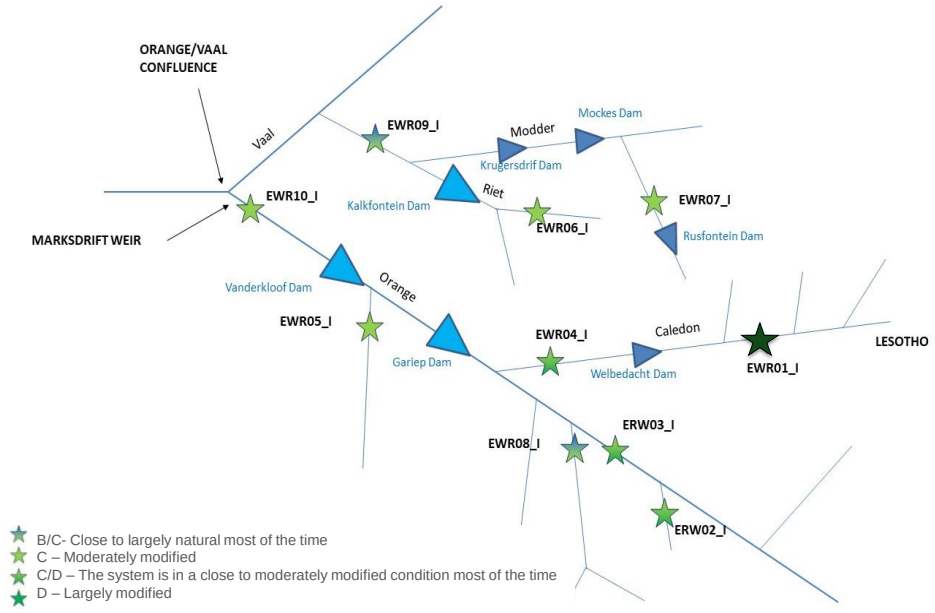
INTERMEDIATE EWR SITES: REC SUMMARY



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RIVERS EWR QUANTIFICATION

- EWR quantification is based on the REC;
- The Habitat Flow Stressor Response method (HFSR)
  - Low or baseflows for the intermediate sites;
- Floods/ freshets were also defined;
  - using a combination of the downstream Response to Imposed Flow Transformation (DRIFT)
  - Building Block Method (BBM) approach
- For all Rapid 3 level EWR sites
  - the Desktop Reserve Model (DRM) within SPATSIM
- Results from the hydraulic modelling - cross-sectional profile, discharge, Habflo model
- The EWR Quantification results have just been approved by DWS and will be shared on the website for stakeholders.

FLOW MANAGEMENT PLAN AND INTEGRATION BETWEEN COMPONENTS: DISCUSSIONS AND APPROVALS

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FLOW MANAGEMENT PLAN

WATER IS LIFE - SANITATION IS DIGNITY

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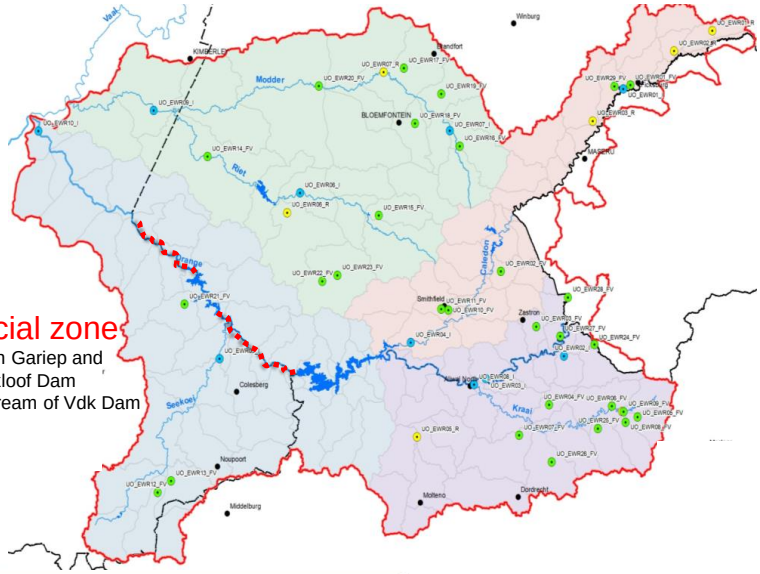
FLOW MANAGEMENT PLAN



Sacrificial zone

- Between Gariep and Vanderkloof Dam
- Downstream of Vdk Dam

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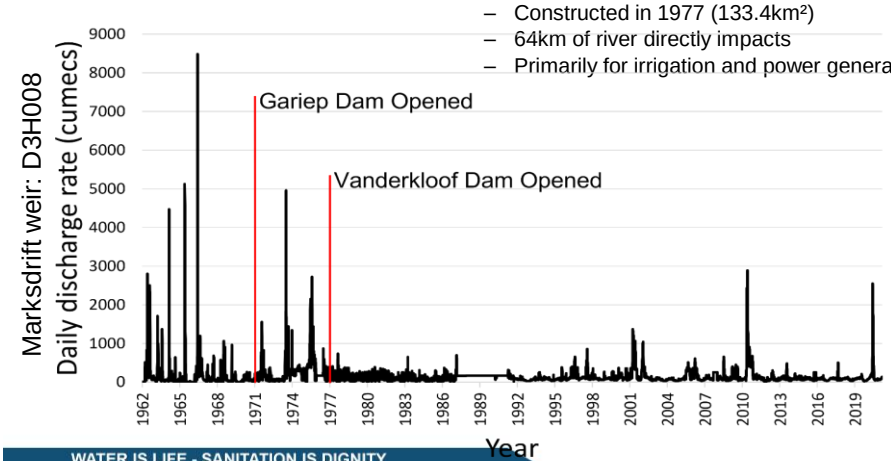
HISTORY OF FLOW ALTERATION

- **Gariep Dam**
  - Constructed in 1971 (352.2km²)
  - 113.3km of river directly impacts
  - Primarily for irrigation, domestic industrial and power generation
- **Vanderkloof Dam**
  - Constructed in 1977 (133.4km²)
  - 64km of river directly impacts
  - Primarily for irrigation and power generation



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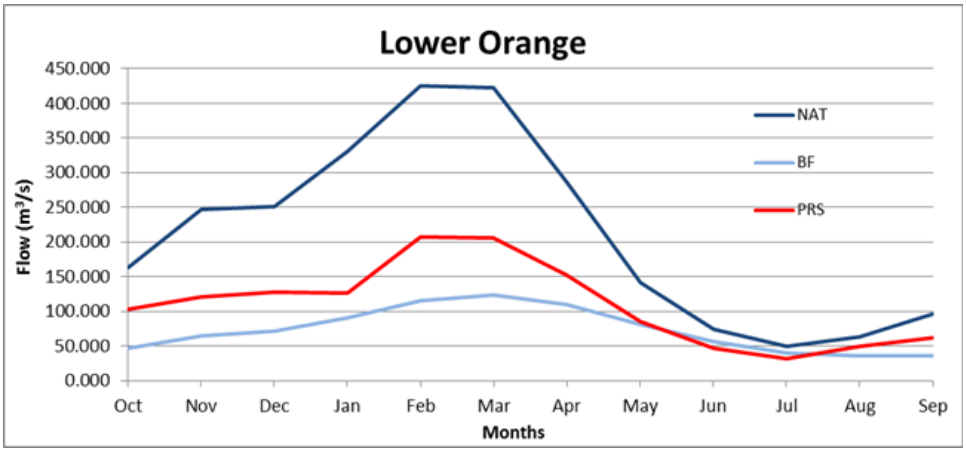
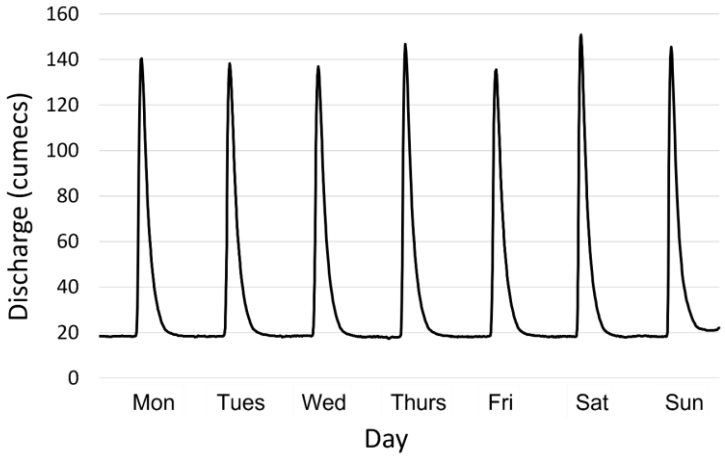
NATURAL FLOWS VS BASEFLOWS VS PRESENT DAY FLOWS

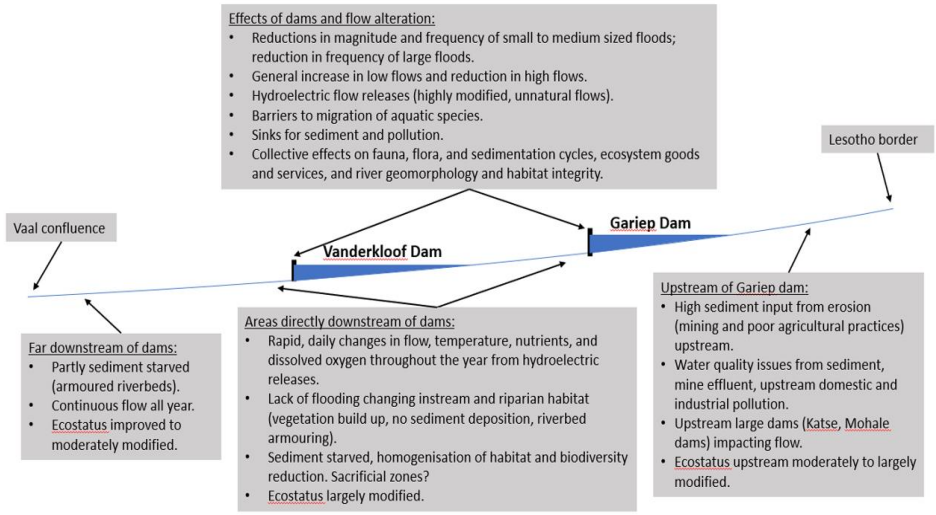


DAILY FLOW VARIATON



Discharge recorded from Vanderkloof Dam at gauging station (station D3R003) over a one-week period (01/01/2020 – 08/01/2020). Pattern shows the daily hydropeaking resulting from hydroelectric power generation releases.

LONGITUDINAL PROFILE OF THE UPPER ORANGE RIVER: LESOTHO – VAAL CONFLUENCE



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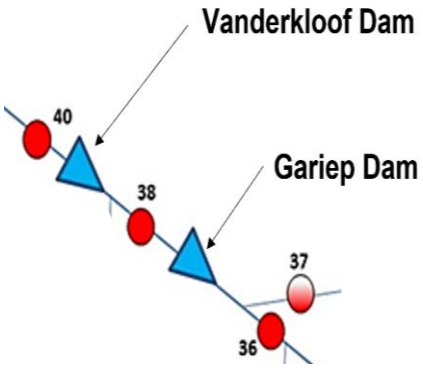
ECOLOGICAL STATUS



D – Largely modified

Overall ecological status (JBS3 – for AEH by the Orange-Senqu River Commission (ORASECOM 2022)

JBS assessments have indicated a steady decline in river health over the last 15 years in the Upper Orange River catchment

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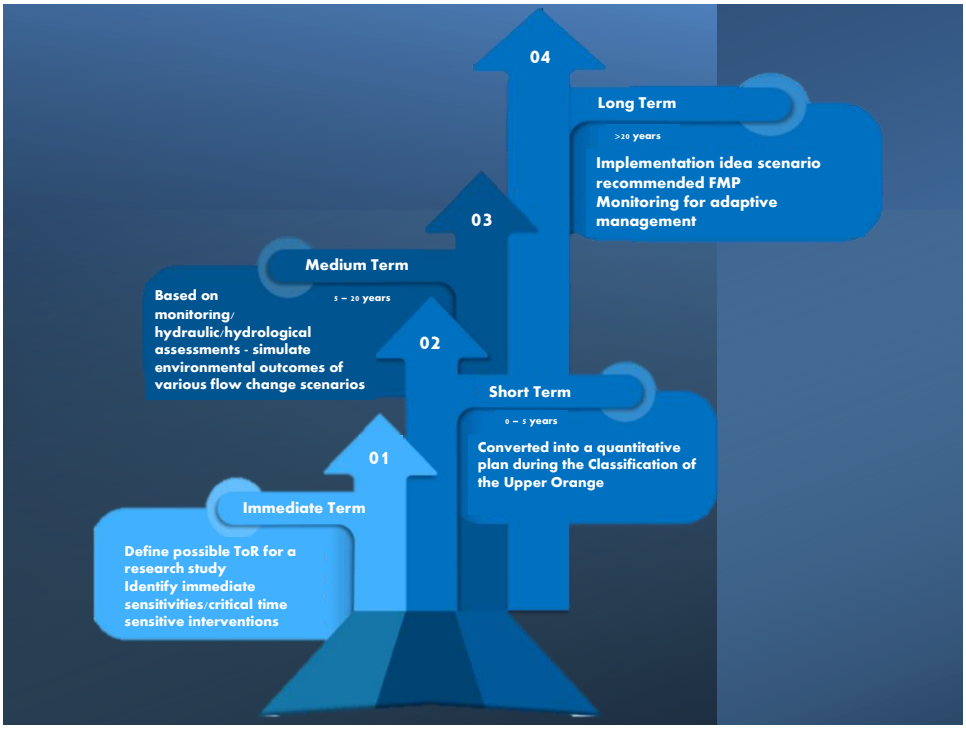
CONCEPTUAL FLOW MANAGEMENT PLAN

- Meeting with DWS, PSP and Eskom in February 2023;
- Outcome to develop a ***conceptual FMP*** *(initially suppose to conduct 2 intermediate sites below the dams, however due to altered flows and operation, we elected a conceptual FMP)*;
- Based on the current social/economic climate of SA:
  - Dams fulfil a critical role in providing water/power generation
  - Thus, cannot be avoided or flows altered
  - EWRs cannot be set for the sacrificial zone
  - Instead - recommendations / action plans have been proposed *(upcoming slides)*
- The conceptual FMP will form a chapter within the EWR Quantification Report deliverable.

CONCEPTUAL FLOW MANAGEMENT PLAN

- We understand the significant negative environmental/social/ economic consequences of the current flow regimes;
- Thus, this conceptual FMP should be considered and taken forward into the Classification of the Upper Orange catchment area (subsequent study) with possible socio-economic trade-offs;
- Overall, several avenues however do remain to be investigated to work towards:
  - Development of optimum environmental flows
  - Ecological Reserve
  - EWRs that maintains some of the core functionality of the dams – allowing to improve the aquatic ecosystem health and boost ecological goods and services; and
- For now, the conceptual FMP has suggested immediate, short term (0-5 years), medium term (5-20 years) and long term (>20 years) recommendations….


04
Long Term
>20 years
Implementation idea scenario
recommended FMP
Monitoring for adaptive
management
03
Medium Term
5 – 20 years
Based on
monitoring/
hydraulic/hydrological
assessments - simulate
environmental outcomes of
various flow change scenarios
02
Short Term
0 – 5 years
Converted into a quantitative
plan during the Classification of
the Upper Orange
01
Immediate Term
Define possible ToR for a
research study
Identify immediate
sensitivities/critical time
sensitive interventions

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INTEGRATION BETWEEN
COMPONENTS APPROACH
AND PRELIMINARY
RESULTS

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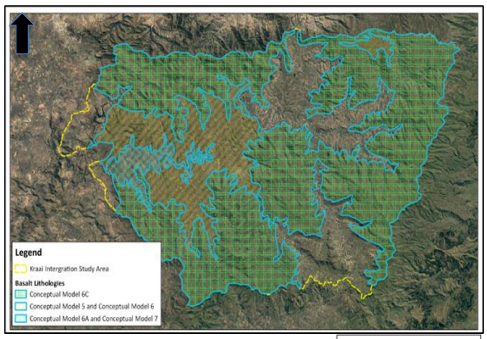
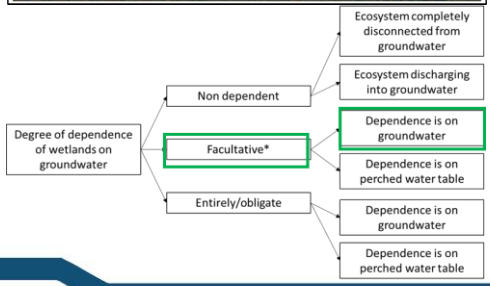
WHY INTEGRATE DIFFERENCE COMPONENTS OF THE STUDY?

- Assess the probability of hydrological dependence between:
  - Groundwater and surface water resources
  - Discrete surface water resources
- Assessment developed where multiple resource units overlap to estimate the hydrological dependency on one another
- Environmental authorisations that result in the degradation of one suite of resources may have additional indirect impacts on other resources
- Integrated assessment of these resources is necessary

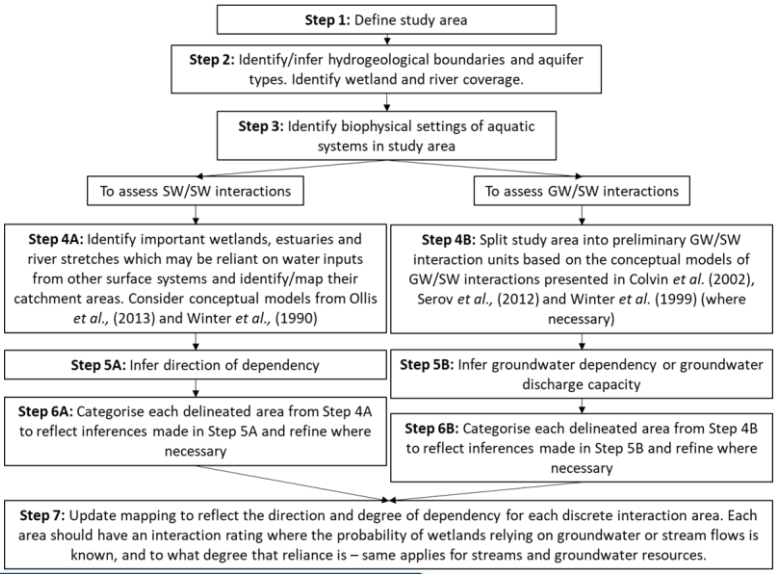
WHAT ARE THE OUTPUTS?

- Broad spatial data where the direction (i.e., which water resource is dependent on other water resources) and degree (i.e., whether one water resource is partially or completely hydrologically dependent on another) of dependency is shown
- Conceptual understanding of how groundwater and surface water systems interact, and how different surface water systems interact





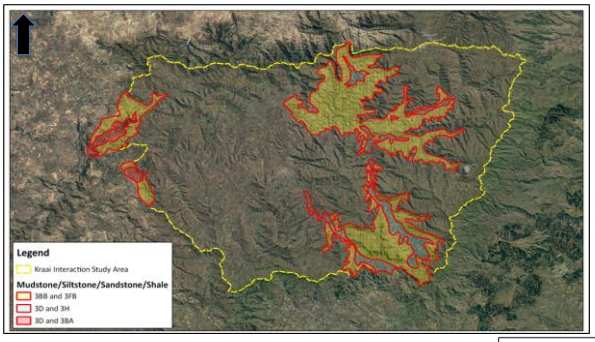
STEP-WISE METHOD

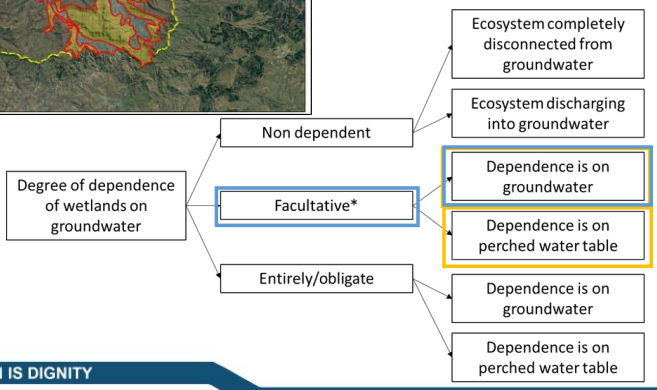


DATA CONSIDERED FOR INTEGRATION

- Water resource coverage (wetland, river, groundwater GIS layers);
- Geological information;
- Vegetation types;
- Slope and elevation data;
- Aquifer transmissivity data;
- Borehole density and depth to ground water;
- Flow data in rivers;
- Wetland typologies; and
- The more data made available, the more confident and robust the outputs are.

RESULTS FROM THE KRAAI INTEGRATION STUDY





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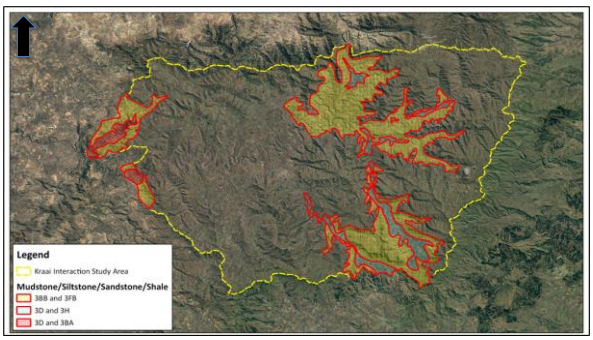
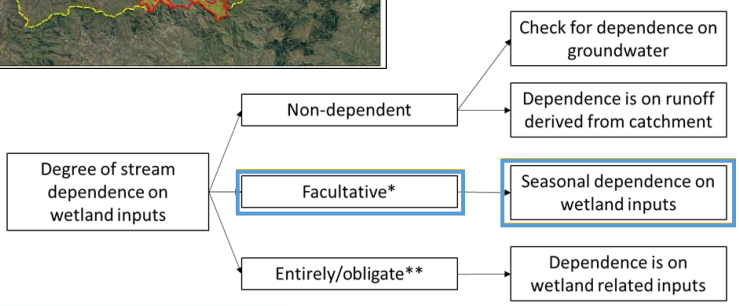
RESULTS FROM THE KRAAI INTEGRATION STUDY





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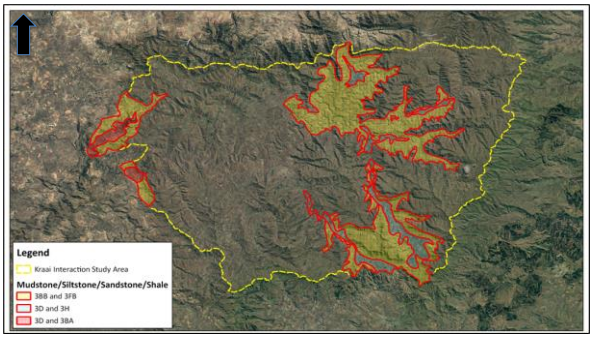
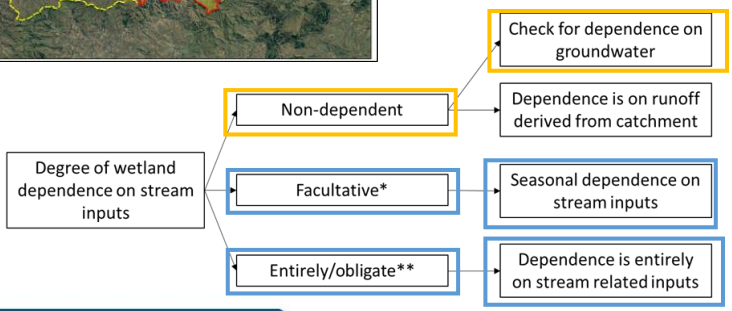
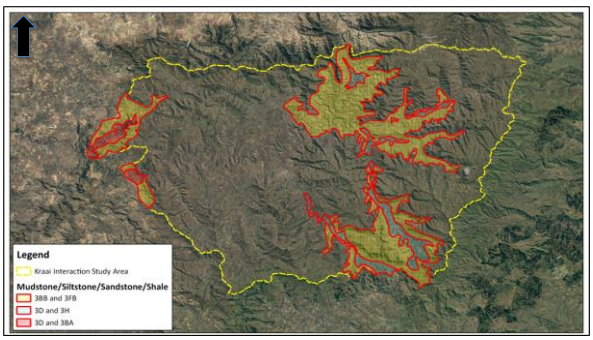
RESULTS FROM THE KRAAI INTEGRATION STUDY





CONTEXT OF THE RESERVES



- Surface water systems rely on groundwater/perched aquifers – therefore groundwater abstraction may have an impact on groundwater fed wetlands and baseflow dependent streams

- Surface water systems less dependent on groundwater, but wetlands have higher dependence on streams – therefore streamflow modifying activities should be considered in terms of wetlands as well as streams

CONCLUSION

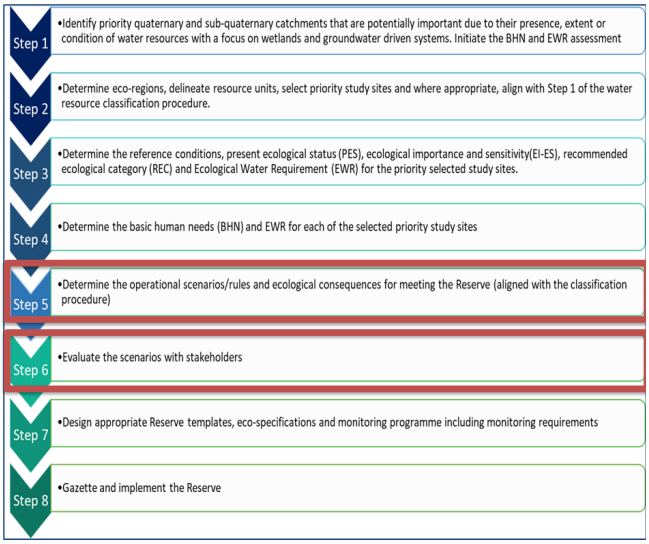
- A new approach yet to be finalised
- May yield important cross-discipline and cross water resource information for future authorisations
- The quality of data drastically impacts the confidence of these models
- Stakeholders can be involved by sharing any streamflow or borehole depth data

PROPOSED SCENARIOS

Number	Code	Description
Sc1	PRS1	Present day without EWR
Sc2	PRS2	Present day with EWR for REC
Sc3	FUT1	**2040**: Polihali, Makhaleng (pipeline to Botswana), Pipeline from Gariep to Bloemfontein, Caledon weirs with EWR for REC, estuarine requirements
Sc4	FUT2	**2040**: Polihali, Makhaleng (pipeline to Botswana), Pipeline from Gariep to Bloemfontein, Caledon weirs without EWR
Sc5	FUT3	**2060:** Polihali, Makhaleng (pipeline to Botswana), Pipeline from Gariep, Caledon weirs, Verbeeldingskraal on upper Orange, Boskraai on lower Kraai, EWR for REC, estuarine requirements
Sc6	FUT4	**2060**: Polihali, Makhaleng (pipeline to Botswana), Pipeline from Gariep, Caledon weirs, Verbeeldingskraal on upper Orange, Boskraai on lower Kraai, without EWR
Sc7	WQ	Present day flows with EWR for REC (Sc2) with progressive water quality decline

NEXT STEPS…

- ***Step 5***
  - Evaluate the consequences of management scenarios /rules
- ***Step 6***
  - Discussing/ presenting of the consequences for the management scenarios with the stakeholders



THANK YOU!

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https://www.dws.gov.za/rdm/currentstudies/default.aspx

WATER IS LIFE - SANITATION IS DIGNITY

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