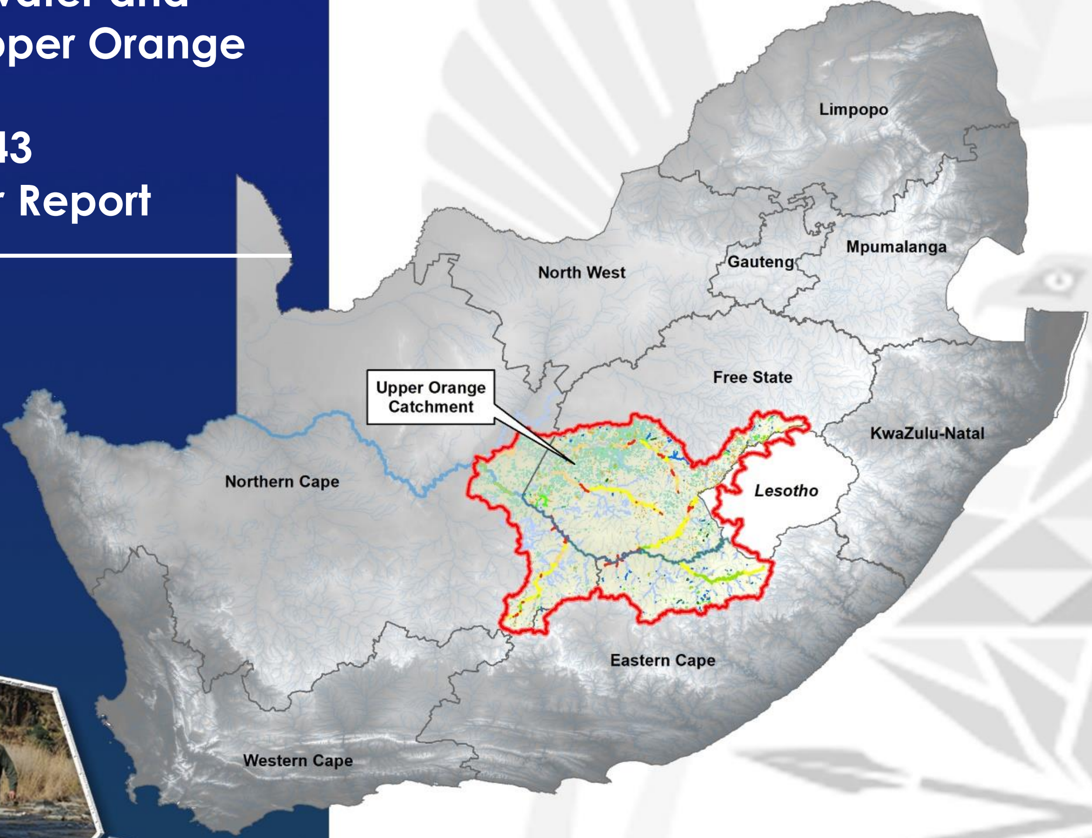
DEPARTMENT OF WATER AND SANITATION

A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange

WP11343
Groundwater Report



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GroundTruth
Environment & Engineering

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Reports as part of this project:

Bold type indicates this report

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LIST OF ACRONYMS

BHN	Basic Human Needs
CMB	Chloride Mass Balance
CRD	Cumulative Rainfall Departure
DEDTEA	Department of Economic Development, Tourism and Environ Affairs
DWS	Department of Water and Sanitation
EC	Electric Conductivity
EWR	Ecological Water Requirements
GDES	Groundwater Dependant Ecosystems
GPS	Global Positioning System
GRDM	Groundwater Resource Directed Measures
GRU	Groundwater Resource Unit
MAP	Mean Annual Precipitation
ORP	Oxygen Reduction Potential
SVF	Saturated Volume Fluctuation
TDS	Total Dissolved Solid
WARMS	Water Authorisation and Registration Management System
WMS	Water Management System
WSP	Water Services Provider

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1. INTRODUCTION

1.1 Introduction & Scope of Works

As part of the GroundTruth project team, JG Afrika's Groundwater Division was tasked to conduct the groundwater component of a High Confidence Reserve Determination Study for the Upper Orange Catchment. Following previous contributions to the Inception Report, Gaps Analysis Report, Resource Units Report and Groundwater Survey Report, respectively, a Groundwater Report is required for the catchment as part of broader Terms of Reference of the study.

To date the current methodology has aligned with previous Groundwater Resource Directed Measures (GRDM) methodology, i.e. WRC (2007) and WRC (2012), respectively. These are currently being updated by the Water Research Commission. An update of the GRDM methodology and software is expected in 2024.

In accordance with WRC (2012), the procedure for determining the groundwater component of the Reserve involves an eight-step process as follows:

- Step 1 is to "Initiate the basic human needs (BHN) and ecological water requirements (EWR) assessment". This involves quantification of the volume of groundwater needed for BHN and contributing to EWR. This report represents the Groundwater Report and is a 1st attempt at quantifying the groundwater component of the Reserve.
- Step 2 is to "Determine eco-regions, delineate resource units, select study sites and, where appropriate, align with the water resource classification procedure set out in Regulation 2(4)."
- Step 3 is to "Determine the reference conditions, resent ecological status and the ecological importance and sensitivity of each of the selected study sites".
- Step 4 is to "Determine the basic human needs and ecological water requirements for each of the selected study sites and, where appropriate, align with Step 3 of the water resource classification procedure set out in Regulation 2(4)."
- Step 5 is to "Determine operation scenarios and its socio-economic and ecological consequences."
- Step 6 is to "Evaluate the scenarios with stakeholders and align with Step 6 of the water resource classification procedure set out in Regulation 2(4)."
- Step 7 is to "Design an appropriate monitoring programme."
- Step 8 is to "Gazette and implement the reserve."

The scope of works for the Groundwater Report is as follows:

- Defining the present status – The present status of monitoring data is to be assessed for each Groundwater Resource Unit (GRU) to determine data availability and potential use for subsequent detailed assessments.
- Assessment of the Reserve, though Groundwater Quantification and Qualitative approach – This activity will seek to establish the volume of groundwater that contributes to sustaining the EWR and BHN and to establish groundwater quality at GRU aspect to Quaternary based level. This is a necessary pre-requisite to determining the quantity and quality of groundwater potentially available for allocation to users and potential users.

1.2 Information Used

The following information has been used in the preparation of this report:

Reports

- WRC (2012). Groundwater Resource Directed Measures (2012 Edition). Ingrid Dennis, Kai Witthüsser, Koos Vivier, Rainer Dennis & Andrew Mavurayi. WRC Report No TT 506/12.
- WRC (2007). Groundwater Resource Directed Measures – Setting Resource Directed Measures (RDM) for Groundwater: A Pilot Study. Roger Parsons & Johan Wentzel. WRC Report No TT 299/07

Maps

- Map Sheets titled, "3126 Queenstown", "2722 Kimberley", "2726 Kroonstad","2924 Bloemfontein","3122 Beaufort West" at a scale of 1:500 000, first editions of the Hydrogeological Map Series of the Republic of South Africa, supplied by the Directorate: Geohydrology, of the Department of Water Affairs and Forestry
- WR (2012) shapefile of 1:1 000 000 geological map
- WR (2012) shapefiles of 1:500 000 geohydrology map

Data

- Water Authorisation and Registration Management System (WARMS) by the Department of Water and Sanitation.
- Water Management System (WMS) digital information, as supplied by the Department of Water and Sanitation as at February 2022.
- Hydstra digital information, as supplied by the Department of Water and Sanitation as at February 2022.
- WR 2012, shapefiles of geohydrological parameters, as supplied by the Department of Water and Sanitation

Software

- ArcGIS Desktop 10.5
- Aquiworx Version 2.5.3.0 of 2016

2. *PROJECT AREA DESCRIPTION*

The catchment spans over 102 840 km^2 west of Lesotho and includes portions of three provinces namely, Free State, Northern Cape, and Eastern Cape provinces. The topography of the study area is dominated by generally flat pans and plains, with grassland biomes mainly towards the west and the mountainous regions of the southern Drakensberg along the east. As per the Department of Economic

Development, Tourism and Environmental Affairs (DEDTEA) (2014), the rainfall in the catchment is influenced by topography along the eastern highlands, which is greater than the western parts of the catchments.

The catchment has an elevation range of approximately 1038 mamsl to 2410 mamsl and drains in a north-westerly direction via four main river systems. These include the Caledon, Riet, Modder and Orange Rivers.

Based on a variety of geohydrological, management and geo-political criteria, the catchment was subdivided into fourteen (14) Groundwater Resource Units (GRUs) as shown in **Figure 1**. The GRUs and quaternary catchments within the Upper Orange Catchment are listed in **Table 1** and shown in Figure 2.

Table 1: Upper Orange Catchment GRU's and Quaternary Catchments

GRU	Quaternary Catchments
GRU1	D21F, D22A, D21D, D21E, D21G, D21A, D22B, D22G, D21H, D21C, D22D, D22C, C52C, D22F, D23C, D22H, C52B, D22L, C52A, D23D, D23A, D23E, D23H, D23J, D23F, D23G
GRU2	C52A, C51D, C51A, D23H, D23J, D23F, C51B, D23G, D24D, C51G, D24C, D31A, D24C, D31A, D24E, D24A, D15G, D24H, D18L, D24K, D24B, D24F, D15H, D34G, D24G, D35F, D24J, D12D, D24L, D34A, D34E, D35A, D12A, D12E, D35K, D12C, D35H, D12F, D34F, D14A, D35B, D14K, D14J, D12B, D34D, D35E, D35J, D35G, D34C
GRU3	C52H, C52G, C52K, C52E, C52J, C52C, C52F, C51K, C52D, C52B, C52A, C51J, C51D, C51E, C51F, D23E, C51A, C51C, C51H, D23H, D23J, D23F, C51B, C51G, D24K
GRU4	C52H, C52G, C52E, C52F
GRU5	C52K, C52L, C51J
GRU6	C51K, C51J, C51F, C51H, D31D, D31A
GRU7	D18L, D15H, D12D, D12A, D12E, D18K, D12C, D18G, D12B, D13B, D13E, D13K, D13L, D13F, D13A, D13C, D13G, D13D, D13J
GRU8	D12E, D12C, D12F, D12B, D13M, D13K, D13L, D13F, D14G, D14F, D13G, D13J, D14C, D13H
GRU9	D24J, D35K, D35H, D12F, D14A, D35B, D14K, D14J, D34D, D14H, D35E, D13M, D35J, D35G, D35C, D32G, D35D, D32H, D34C, D14G, D14F, D14E, D34B, D14C, D32C, D14D, D14B, D23B
GRU10	D32F, D32G, D32E, D32C, D32A, D32D, D32B
GRU11	D34G, D34A, D34E, D32K, D34F, D32J, D34D, D32F, D35J, D32G, D32H, D34C, D34B
GRU12	D31D, D33A, D33B, D31A, D31E, D31C, D34G, D32K, D31B, D34F, D32J, D32F, D32G, D32H
GRU13	C92C, C92B, C51L, C52L, C51M, C51K, D33K, D33H, D33J, D33E, D33G, D33C, D33D, D33F, D33A, D33B, D31E, D31C, D31B
GRU14	C52H, C52G, C52K, C52L, C52J, C51K, C51J, D33E, C51E, C51F, D33C, C51H, D33D, D31D, C51G, D33A, D33B, D31A, D31E, D34G

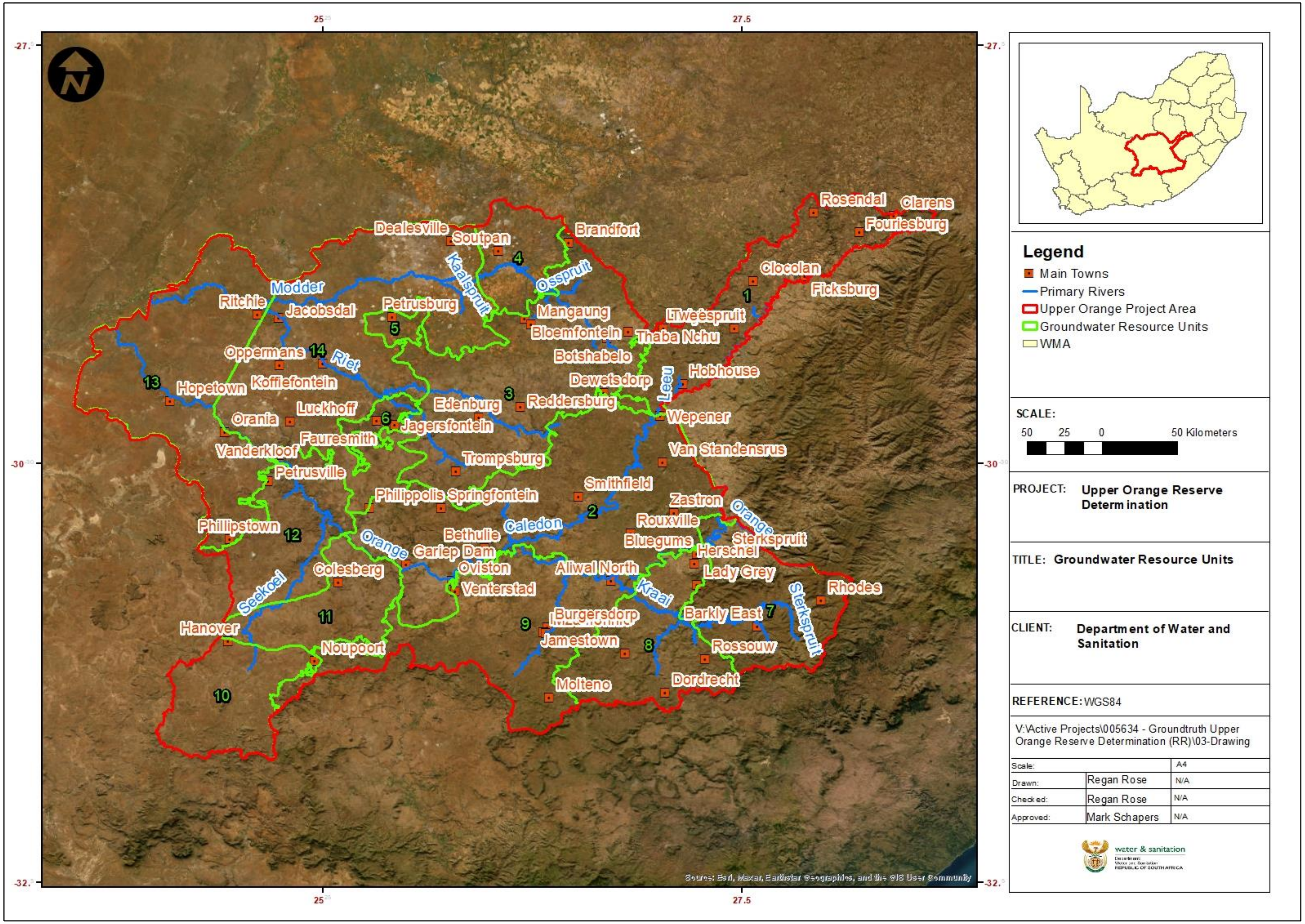

Figure 1: Upper Orange catchment indicating the Groundwater Resource Units

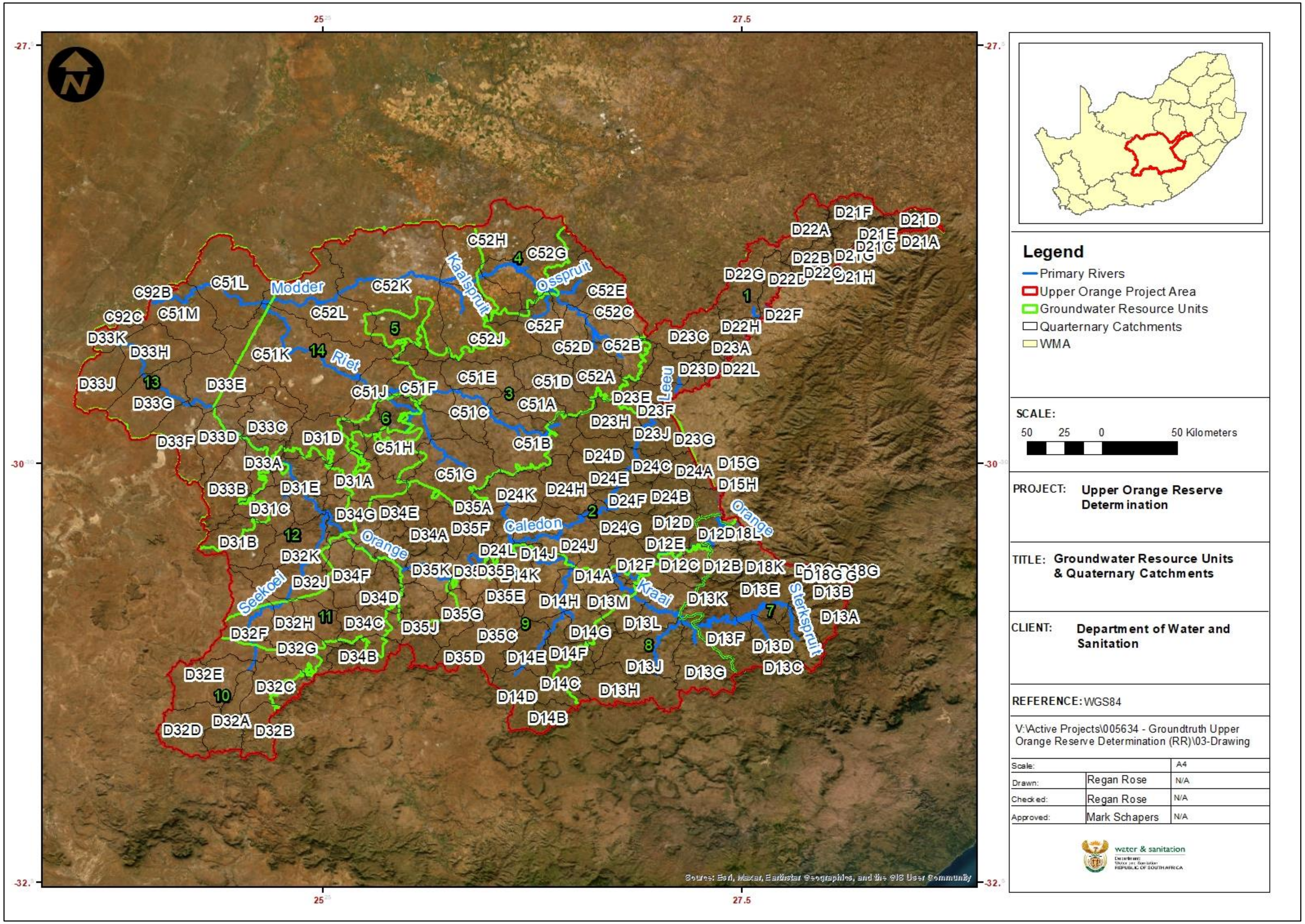

Figure 2: Upper Orange catchment indicating the Groundwater Resource Units and Quaternary Catchments

3. DESKTOP REVIEW

3.1 Regional Geology

The surface geology is dominated by the Karoo Supergroup overlying relatively small outcrops of the basement Ventersdorp Supergroup in the northwest. The Karoo Supergroup comprises of sedimentary deposits of alternating sandstone, shale, mudstone, and siltstone, which was intruded by post karoo dolerite dykes and sills in the west and capped by volcanic rocks in the east.

The oldest rocks in the catchment are represented by Randian aged volcanic rocks of the Allanridge Formation, which consists of andesite and basaltic andesite.

The Karoo Supergroup comprises the following lithostratigraphic units in order of decreasing age:

- Dwyka Formation which consists of tillite, mudstone and shale.
- Ecca Formation which consists of shale and mudstone.
- The Permian age Adelaide Formation of the Beaufort Group which consists of mudstone and subordinate sandstone.
- Triassic age Katberg Formation of the Beaufort Group which consists of fine-grained sandstone and red and green-grey mudstone.
- Mid to late Triassic sedimentary deposits occur along the eastern and south-eastern parts of the catchment comprise of three sedimentary formations namely:
    - The Molteno Formation, which consists of sandstone, mudstone, shale and occasional coal seams, which is overlain by,
    - Brownish-red and grey mudstone and sandstone of the Elliot Formation and,
    - Fine-grained sandstone of the Clarens Formation

The Jurassic age Drakensberg Formation, which consists of basaltic lava, tuff, and agglomerate, provides the capping material, whilst widespread dolerite sill and dykes intruded the sedimentary cover rocks.

Quaternary age calcrete and alluvium occupy surface depressions and main drainage regions.

The regional geology is presented in **Table 2** and shown in **Figure 3**.

Table 2: Upper Orange Catchment Regional Geological Succession

Symbol `on Map	Geological Time Scale (Period)	Lithological Unit		Description
		Sedimentary & Volcanic Rocks	Intrusive Rocks	
Q	Quaternary	Alluvium		Unconsolidated sediments
Jdr Jd	Jurassic	Drakensberg Formation	Dolerite	Dolerite dyke and Sills-
				Basaltic lava, tuff, and agglomerate
Trc	Triassic	Clarens Formation		Yellowish-grey, pale-orange, or pink, very fine-grained sandstone
Tre		Elliot Formation		Brownish-red and grey mudstone, sandstone
Trm		Molteno Formation		Gritty sandstone, grey mudstone, shale, and occasional coal seams
P-Trb		Beaufort Group: Katberg Formation		fine-grained sandstone and red and green-grey mudstone
	Permian	Beaufort Group: Adelaide Formation		Red, purple, grey, and blue green mudstone subordinate sandstone
Pe		Ecca Group		Alternating succession of Sandstone, siltstone and mudstone
C-Pd	Carboniferous	Dwyka Formation		Tillite
R-Val	Randian		Allanridge Formation	Tholeiitic, and andesite; tuff and pyroclastic, Braccia

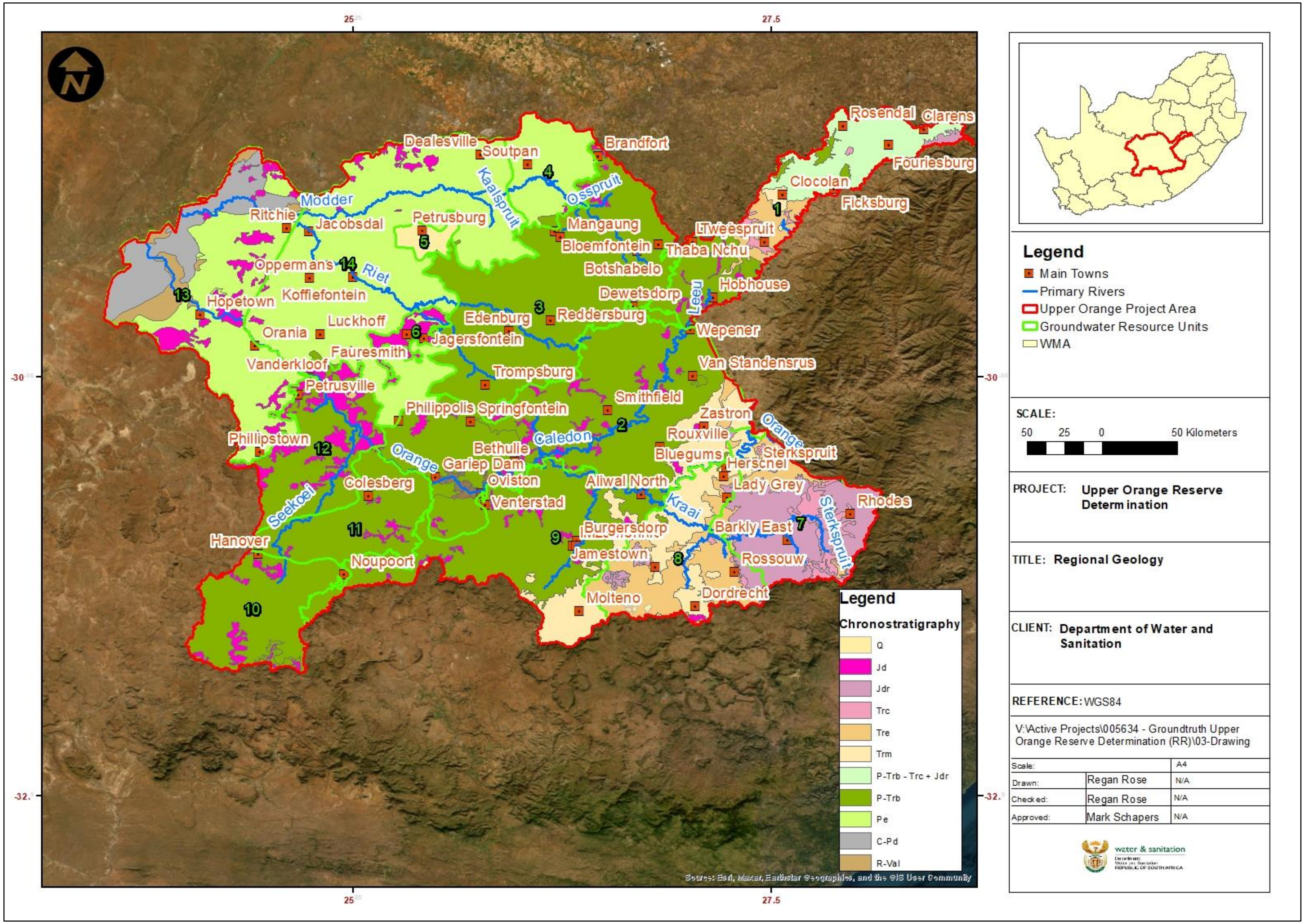

Figure 3: Regional Geology of the Upper Orange catchment

3.2 Regional Geohydrology

The regional geohydrology of the catchment is dominated by fractured aquifers, as well as fractured and intergranular aquifers.

The occurrence of groundwater in fractured aquifers is due to fracturing, faulting, jointing and bedding planes within predominantly arenaceous units in hard rock formations. The geohydrology according to the DWS geohydrological map series infer the principal groundwater occurrences associated with fractured aquifers to be “b3” and “b4”, with median borehole yields in the range of 0.5 to 2.0l/s and 2.0 to 5.0l/s, respectively.

The occurrence of groundwater in intergranular and fractured aquifers is a result of dual porosity properties exhibited by the Drakensberg lavas and dolerite intrusions (sills and dykes), i.e., upper weathered zone and a deeper fractured zone. The geohydrology according to the DWS geohydrological map series infer the principal groundwater occurrences associated with fractured and intergranular aquifers to be “d2” to “d4”, with median borehole yields in the range of 0.1 to 0.5l/s to 2.0 to 5.0l/s.

Elevated borehole yields can occur especially adjacent to defined valleys and near to river channels within the area due to favourable recharge conditions. The regional geohydrology of the catchment is presented in **Figure 4.**

Groundwater quality, as contoured in the DWS geohydrological map series, indicates Electrical Conductivity (EC) to be in the range of 0-70mS/m for the majority of the eastern parts of the catchment, whilst the western parts of the catchment 33have EC ranging between 70-300mS/m. The regional groundwater quality of the catchment is presented in **Figure 5.** The improved groundwater quality along the eastern parts of the catchment reflects higher rainfall and elevated groundwater recharge conditions.

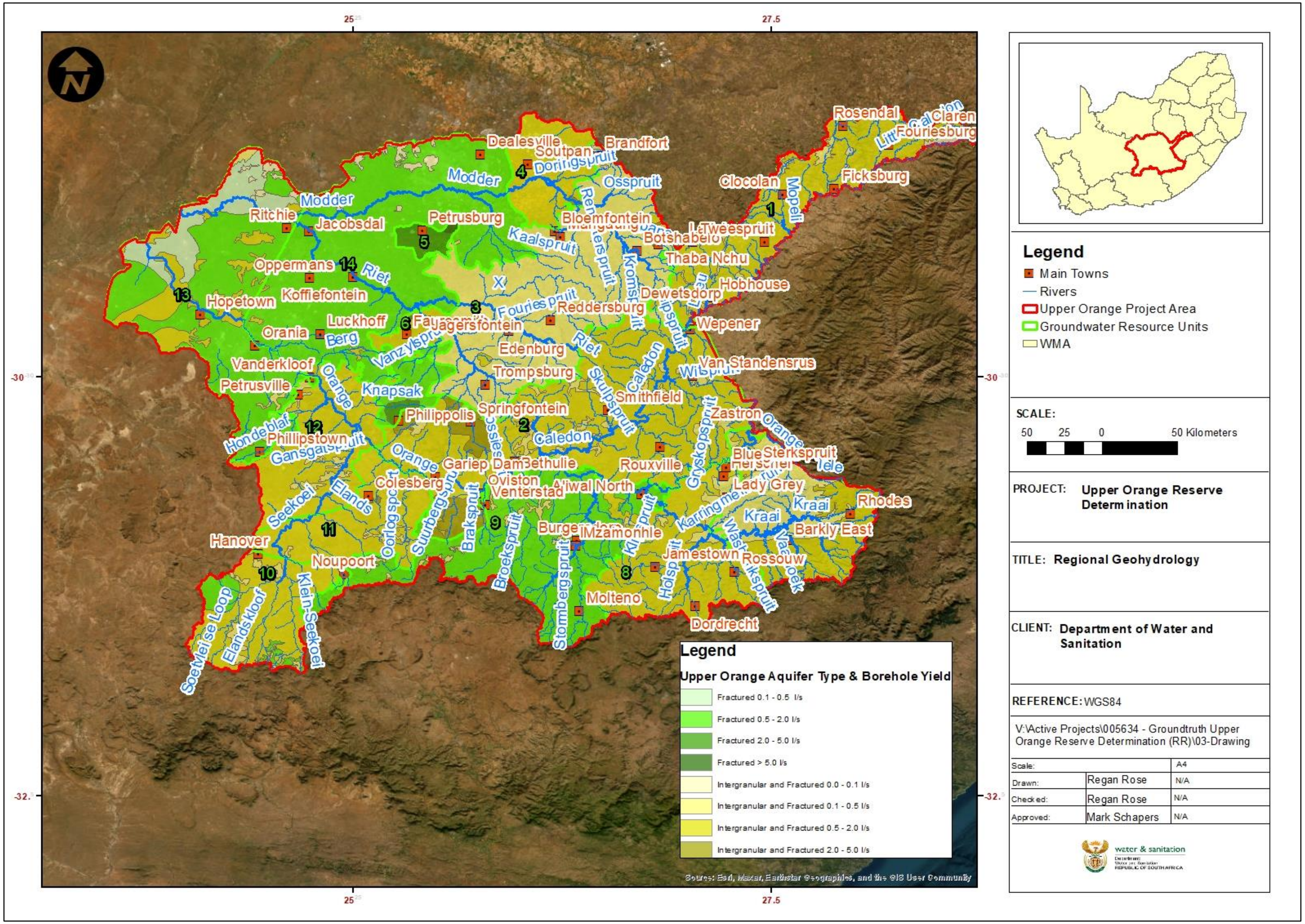

Figure 4: Aquifer type and borehole yield

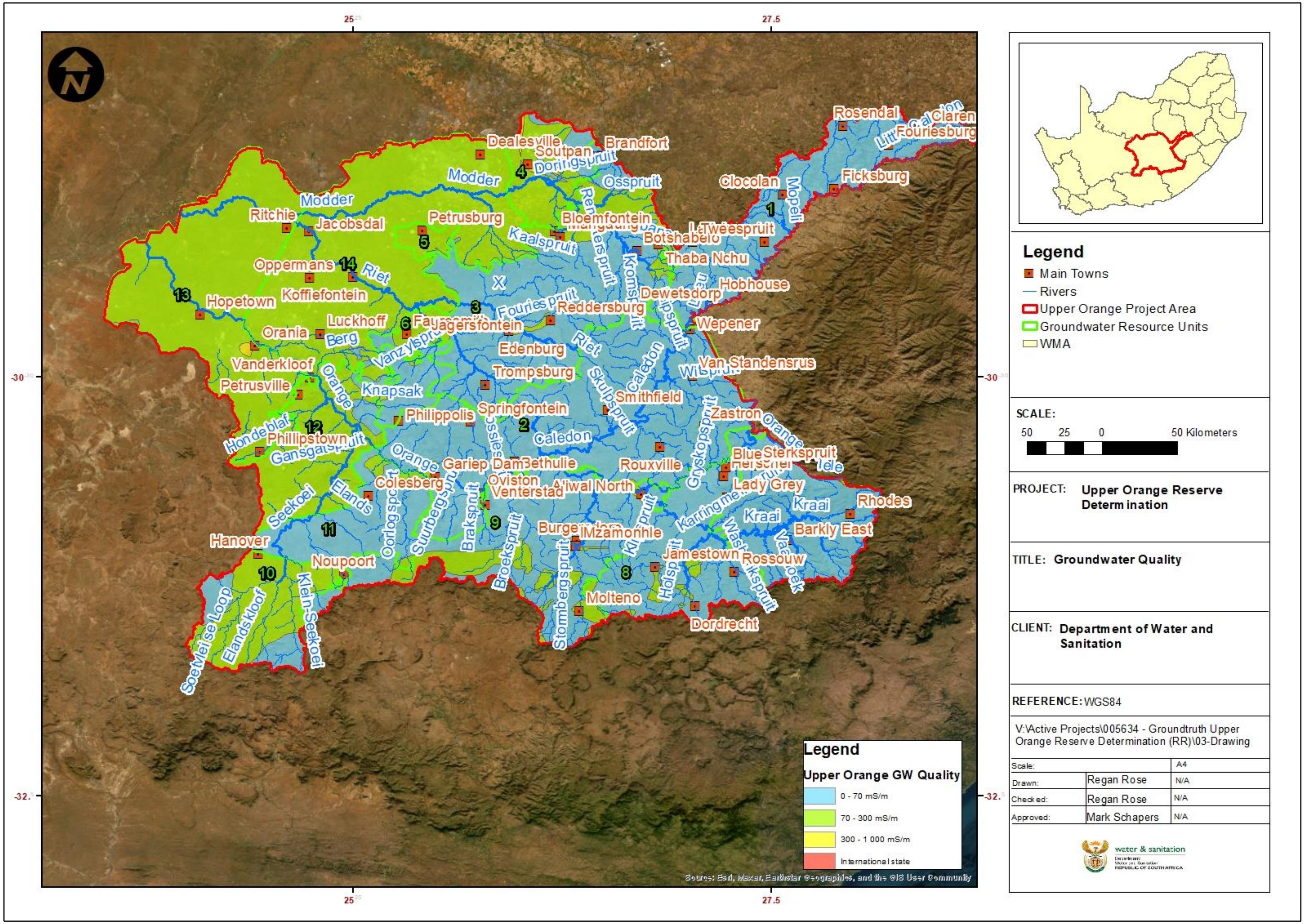

Figure 5: Groundwater Quality

4. OVERVIEW OF METHODOLOGY FOR RESERVE DETERMINATION

The methodology for the groundwater component of the Reserve is well documented in WRC (2007) and later updated in WRC (2012). The Reserve is defined as the water that is set aside to 1) provide for basic human needs (BHN), and 2) protect water ecosystems (sustain healthy ecosystems). The procedure for determining the Reserve involves an eight- step process. Step 1 is to "Initiate the basic human needs and ecological water requirements (EWR) assessment". This involves quantification of the volume of groundwater needed for BHN and contributing to EWR.

The current GRDM is currently under review. An update of the GRDM methodology and software is expected in 2024.

According to WRC (2012), the groundwater component of the Reserve is defined by the following equation:

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

Where:

Re	=	Recharge
BHN_{gw}	=	Basic human needs derived from groundwater
EWR_{gw}	=	Groundwater contribution to EWR

Whilst the BHN derived from groundwater are set at 25l/p/day, recharge and groundwater contribution to EWR require additional care. Chapter 8 of the WRC (2012) provides estimation tools for both recharge and groundwater contribution to EWR. The appropriate selection of tools depends on availability of data.

5. PRESENT STATUS OF GROUNDWATER RESOURCE UNITS

Existing monitoring data was assessed for each GRU. The data includes WMS, Hydstra and EWR surface flow data. The data provides insight regarding historical information, length of monitoring record, and whether the sites are active or non-active. Graphs have been compiled for EC, groundwater levels and surface flow and are provided in **Annexure A**. Note that the surface flows, as acquired from WR (2012), was mainly used for the determination of the groundwater contribution to baseflow component and not for the assessment of present status.

5.1 GRU1

The monitoring sites in GRU1 include water levels, WMS water quality and flow monitoring sites. These monitoring sites are summarised in **Table 3** and provided in **Figure 6.**

Water level time series data at Golden Gate Highlands National Park (as monitored by SANParks) indicates very stable water levels. Time series ECs from WMS indicate that the groundwater quality within GRU1 is relatively good (**Annexure A)**. ECs at all monitoring sites are generally below 100mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a “Class I” or “Good Water Quality” type water.

Table 3: Summary of Monitoring sites in GRU1

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
MBH-1	-28.52873	28.58463	Borehole, water level	D21D
MBH-2	-28.50451	28.58330	Borehole, water level	D21D
MBH-3	-28.50086	28.58012	Borehole, water level	D21D
MBH-4	-28.50012	28.58034	Borehole, water level	D21D
MBH-5	-28.50011	28.58036	Borehole, water level	D21D
MBH-6	-28.50013	28.58035	Borehole, water level	D21D
ZQM_CCN_BH1	-28.92056	27.57000	Borehole, water quality	D22G
ZQM_CCN_BH2	-28.92056	27.57000	Borehole, water quality	D22G
ZQM_CCN_BH3	-28.91194	27.56750	Borehole, water quality	D22G
ZQM_CDP_BH1	-28.69306	28.23639	Borehole, water quality	D21E
ZQM_CDT_BH1	-28.69222	28.23639	Borehole, water quality	D21E
ZQM_CPT_BH1	-28.69306	28.23639	Borehole, water quality	D21E
UO_EWR01_I	-28.90890	27.78500	Surface water, flow	D22D
UO_EWR01_R	-28.55780	28.40571	Surface water, flow	D21D
UO_EWR02_R	-28.68034	28.13993	Surface water, flow	D21G
UO_EWR03_R	-29.10121	27.57075	Surface water, flow	D22G
UO_EWR01_FV	-28.88573	27.83494	Surface water, flow	D22B
UO_EWR29_FV	-28.89253	27.72235	Surface water, flow	D22D
JBS3 - 29	-29.52020	27.12940	Surface water, flow	D23D
EFR-C5	-28.65080	28.38750	Surface water, flow	D21A
JBS3 - 28 (15_6)	-29.37161	27.40573	Surface water, flow	D23A

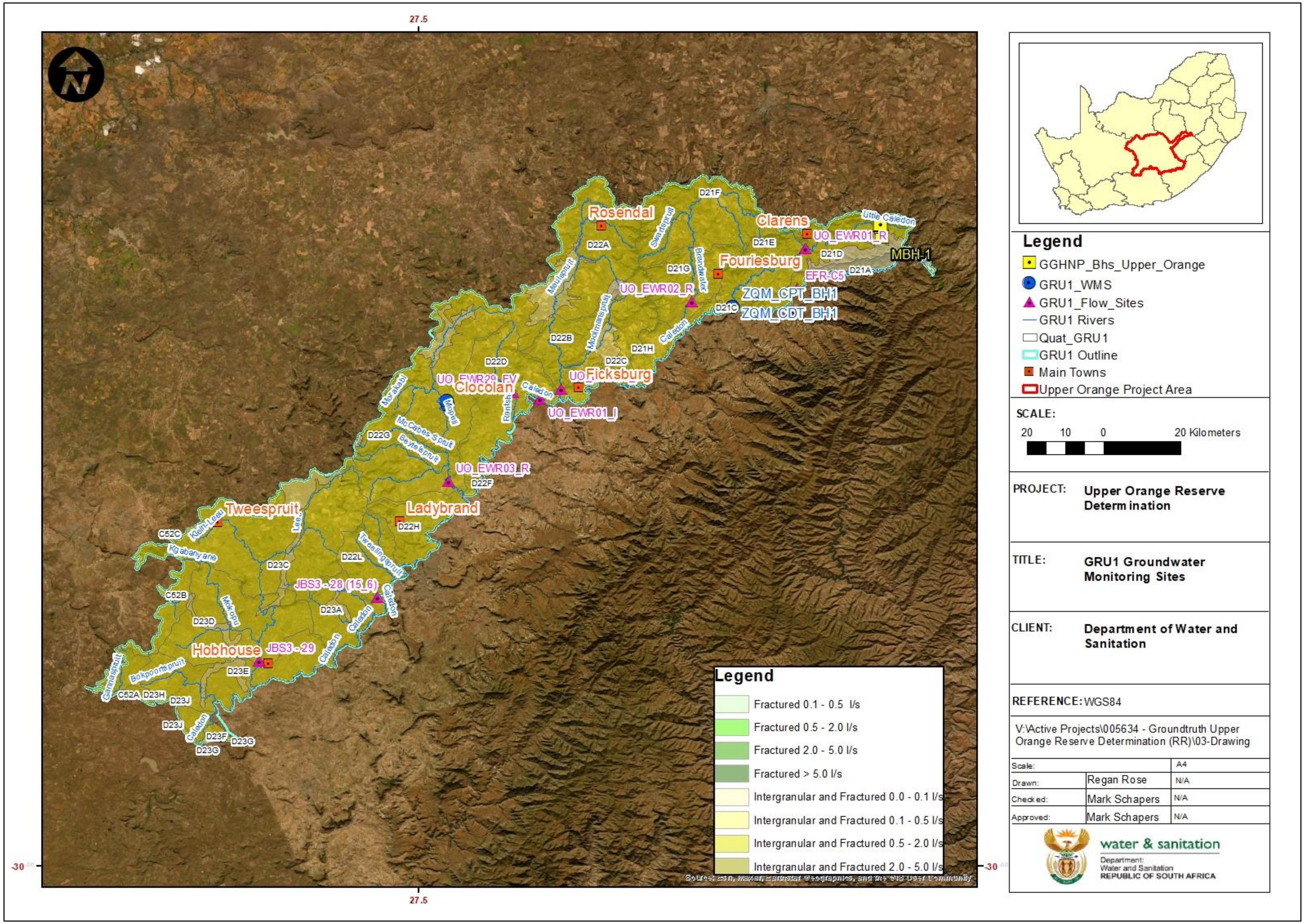

Figure 6: GRU 1 Monitoring Sites

5.2 GRU2

The monitoring sites in GRU2 include Hydstra, WMS and flow monitoring sites. These monitoring sites are summarised in **Table 4** and provided in **Figure 7.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU2 is relatively good (**Annexure A**). ECs at all monitoring sites are generally below 100mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a “Class I” or “Good Water Quality” type water. Outliers in the data set were identified during 1995 to 1996 and 2007 however, these are likely to be a result of erroneous measurements or data capturing.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of between 0 - 38mbgl were obtained and include mainly historical monitoring sites last monitored in 1978. There is no significant variation in groundwater level data throughout the trend analysis period within this GRU with the anticipated seasonal variations in groundwater levels observed.

Table 4: Summary of Monitoring sites in GRU2

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
3025AD00094	-30.25862	25.28010	Borehole, water level	D34G
3025CD00026	-30.94084	25.47427	Borehole, water level	D35K
3025CD00027	-30.94084	25.47428	Borehole, water level	
3025DA00092	-30.69612	25.74121	Borehole, water level	D35K
3025DB00035	-30.68928	25.75732	Borehole, water level	
3025DB00036	-30.68928	25.75733	Borehole, water level	
3025DB00038	-30.69084	25.76288	Borehole, water level	
3025DB00039	-30.69084	25.76289	Borehole, water level	
3025DB00042	-30.69085	25.76287	Borehole, water level	
3025DB00043	-30.69084	25.76289	Borehole, water level	
3025DB00044	-30.69086	25.76287	Borehole, water level	
3025DB00045	-30.69084	25.76290	Borehole, water level	
3025DB00046	-30.69196	25.75787	Borehole, water level	
3025DB00047	-30.68362	25.79537	Borehole, water level	D35H
3025DC00068	-30.82307	25.74232	Borehole, water level	D35G
3025DC00069	-30.88362	25.70787	Borehole, water level	
3025DD00099	-30.88362	25.78317	Borehole, water level	
3025DD00100	-30.88393	25.78287	Borehole, water level	
3025DD00101	-30.88362	25.78318	Borehole, water level	
3025DD00103	-30.87863	25.78649	Borehole, water level	
3025DD00105	-30.87863	25.78651	Borehole, water level	
3025DD00111	-30.87863	25.78650	Borehole, water level	
3025DD00112	-30.78946	25.77176	Borehole, water level	
3025DD00113	-30.78696	25.76898	Borehole, water level	
3025DD00114	-30.78862	25.76676	Borehole, water level	
3025DD00115	-30.78918	25.76148	Borehole, water level	
3025DD00116	-30.77585	25.75093	Borehole, water level	
3025DD00117	-30.82807	25.77648	Borehole, water level	

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
3025DD00118	-30.81696	25.76482	Borehole, water level	
3025DD00119	-30.81668	25.77232	Borehole, water level	
3025DD00120	-30.82223	25.75732	Borehole, water level	
3025DD00121	-30.80585	25.75093	Borehole, water level	
3025DD00122	-30.85029	25.76621	Borehole, water level	
3025DD00123	-30.86279	25.75787	Borehole, water level	
3025DD00124	-30.87946	25.77454	Borehole, water level	
3025DD00125	-30.88362	25.77871	Borehole, water level	
3025DD00126	-30.88362	25.77454	Borehole, water level	
UO_EWR04_I	-30.43614	26.29926	Surface water, flow	D24G
UO_EWR03_I	-30.65279	26.82321	Surface water, flow	D12F
UO_EWR02_FV	-30.00826	26.92832	Surface water, flow	D24C
UO_EWR03_FV	-30.33963	27.17688	Surface water, flow	D12D
UO_EWR10_FV	-30.24119	26.56130	Surface water, flow	D24H
UO_EWR11_FV	-30.23444	26.51134	Surface water, flow	D24H
JBS3 - 38 (26_15)	-30.50378	25.24003	Surface water, flow	D34E
ZQM_ROW_BH1	-30.86667	25.58694	Borehole, water quality	D35J
ZQM_RXL_BH1	-30.41944	26.85639	Borehole, water quality	D24G
ZQM_ZAS_BH1	-30.30500	27.06444	Borehole, water quality	D12D

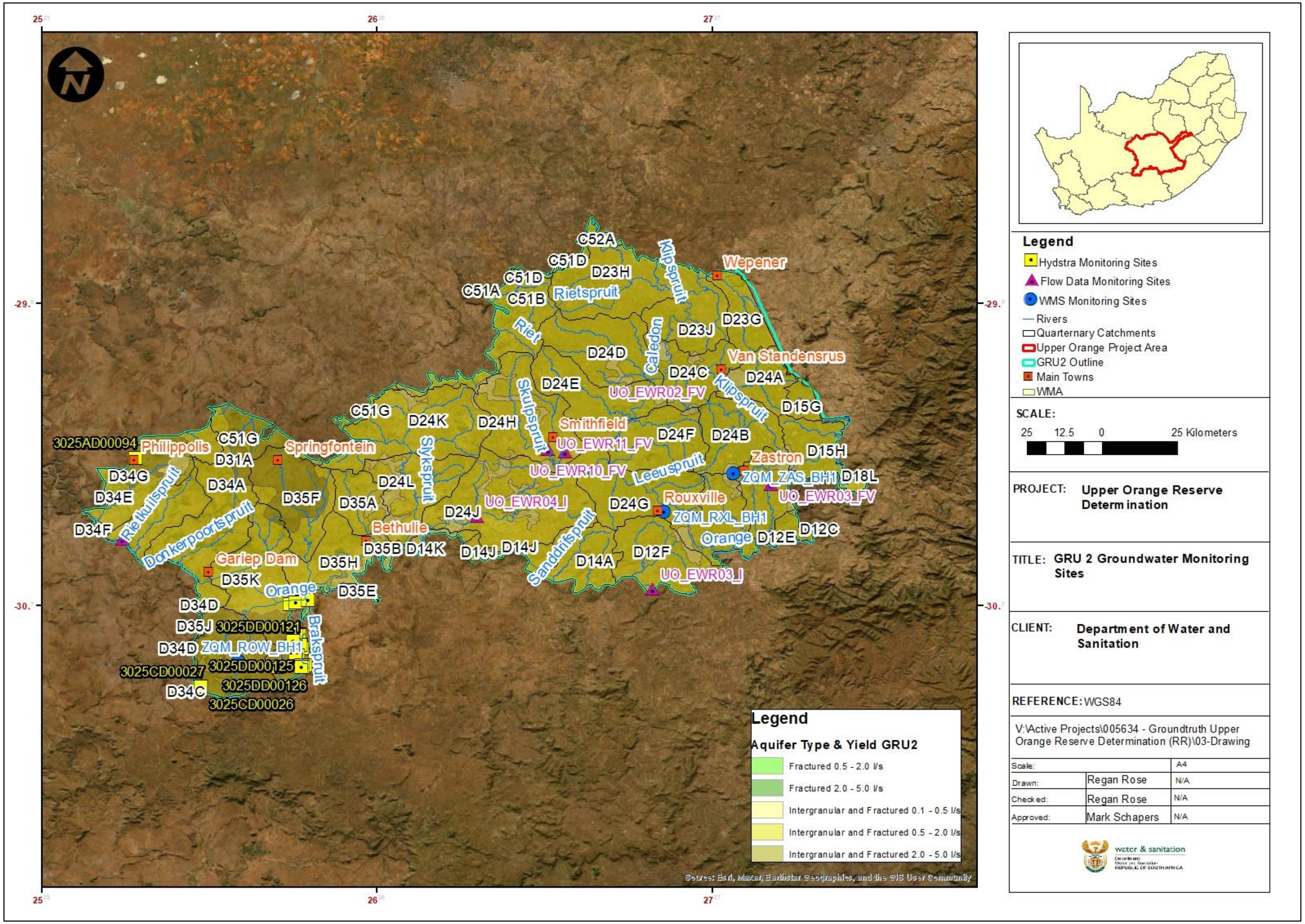

Figure 7: GRU2 Monitoring sites

5.3 GRU3

The monitoring sites in GRU3 include Hydstra, WMS and flow monitoring sites. These monitoring sites are summarised in **Table 5** and provided in **Figure 8.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU3 is relatively good (**Annexure A**). With the exclusion of a few outliers, ECs at all monitoring sites are generally below 100mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a “Class I” or “Good Water Quality” type water. A gradual declining trend in EC is visible.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of between 0 - 50mbgl were obtained and include mainly historical monitoring sites last monitored in 1992. There is no significant variation in groundwater level data throughout the trend analysis period with the anticipated seasonal variations in groundwater levels observed.

Table 5: Summary of Monitoring sites in GRU3

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
2926AA00045	-29.11146	26.13292	Borehole, water level	C52H
2926AB00006	-29.16702	26.33292	Borehole, water level	C52F
2926AB00053	-29.13924	26.28570	Borehole, water level	
2926AB00054	-29.10452	26.27043	Borehole, water level	
2926AB00063	-29.10341	26.27626	Borehole, water level	
2926AB00064	-29.19868	26.27654	Borehole, water level	
2926BA00016	-29.11980	26.51626	Borehole, water level	C52D
2926CA00008	-29.65452	26.18292	Borehole, water level	C51A
2926CA00009	-29.65453	26.18292	Borehole, water level	
2926CA00010	-29.65452	26.16626	Borehole, water level	
2926CA00011	-29.65452	26.17459	Borehole, water level	
2926CA00339	-29.65452	26.18681	Borehole, water level	
2926CA00342	-29.65453	26.18681	Borehole, water level	
2926CA00343	-29.65452	26.18682	Borehole, water level	
2926CA00356	-29.65454	26.18681	Borehole, water level	
2926CA00357	-29.65452	26.18683	Borehole, water level	
2926CA00361	-29.65455	26.18681	Borehole, water level	
2926CA00364	-29.65456	26.18681	Borehole, water level	
2926DA00235	-29.57387	26.67930	Borehole, water level	C52A
2926DA00289	-29.57761	26.67558	Borehole, water level	
3025BB00314	-30.03362	25.76621	Borehole, water level	C51G
3025BB00339	-30.03362	25.78287	Borehole, water level	
3025BB00407	-30.03057	25.79204	Borehole, water level	
3025BB00505	-30.03057	25.79205	Borehole, water level	
3025BB00506	-30.03058	25.79204	Borehole, water level	
UO_EWR07_I	-29.16002	26.57249	Surface water, flow	C52B
UO_EWR15_FV	-29.67121	26.07439	Surface water, flow	C51A
UO_EWR16_FV	-29.25322	26.64220	Surface water, flow	D52B
UO_EWR18_FV	-29.11632	26.32870	Surface water, flow	C52F

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
UO_EWR19_FV	-28.93917	26.51141	Surface water, flow	C52E
UO_EWR22_FV	-30.06628	25.68106	Surface water, flow	C51G
UO_EWR23_FV	-30.03120	25.78646	Surface water, flow	C51G
ZQMRDG1 2926CA00002 REDDERSBURG	-29.66472	26.18444	Borehole, water quality	C51A
ZQMTMG1 3025BB00508 TROMPSBURG ALLOTMENT	-30.04000	25.78028	Borehole, water quality	C51G
ZQMDWP1 DEWETSDORP	-29.56278	26.68028	Borehole, water quality	C52A

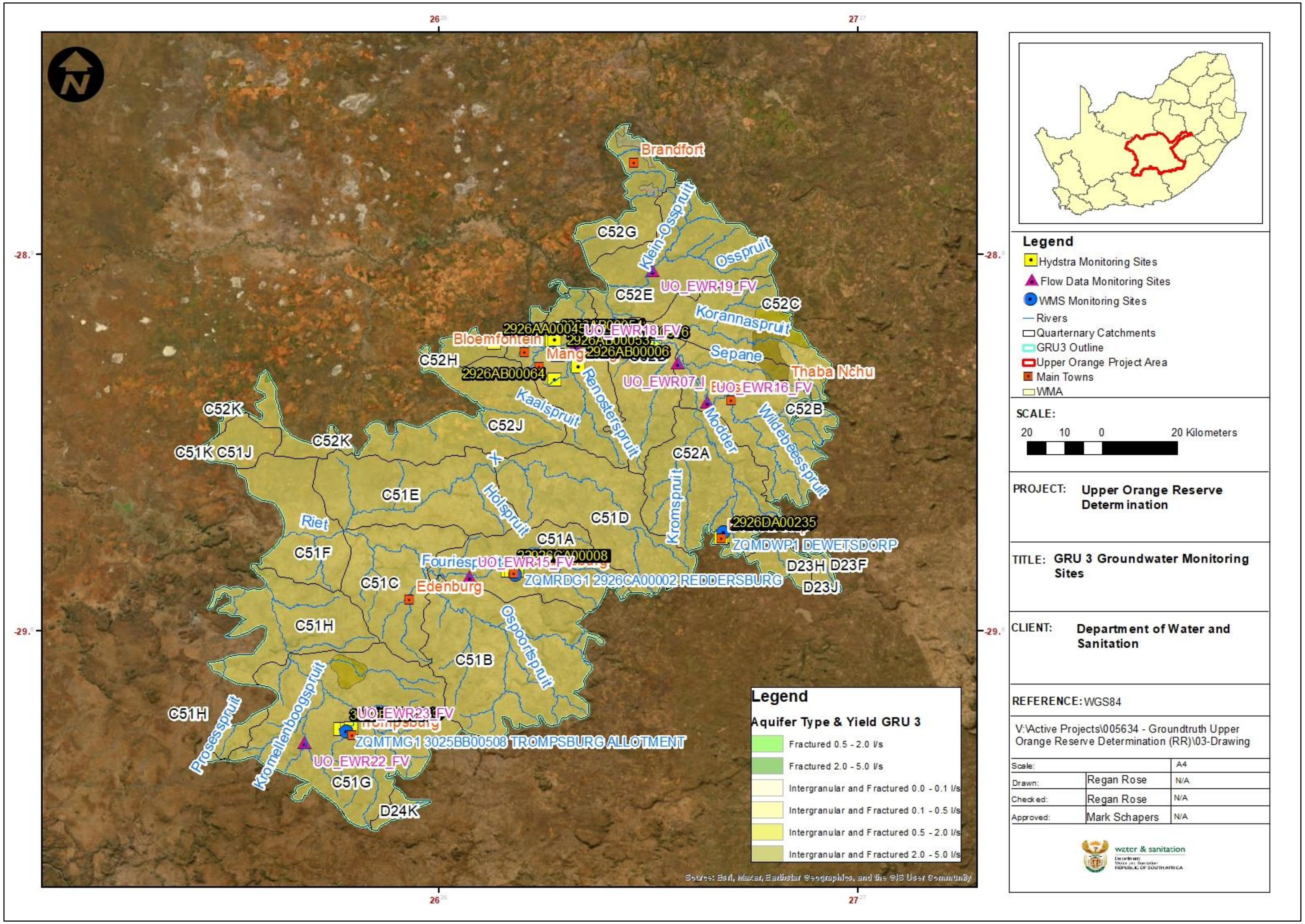

Figure 8: GRU3 Monitoring sites

5.4 GRU4

The monitoring sites in GRU4 include Hydstra, WMS and flow monitoring sites. These monitoring sites are summarised in **Table 6** and provided in **Figure 9.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU4 is variable (**Annexure A**). ECs were only obtained for one (1 No.) water quality monitoring site and vary between 50 - 260mS/m. In terms of the DWAF Water Classification System the groundwater in this GRU can be classified as a “Class I – Class II” or “Good to Marginal Water Quality” type water.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of between 0 - 56mbgl were obtained and include mainly historical monitoring sites last monitored in 1972. There is no significant variation in groundwater level data throughout the trend analysis period within this GRU with the anticipated seasonal variations in groundwater levels observed.

Table 6: Summary of Monitoring sites in GRU4

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
2825DD00021	-28.86399	25.96624	Borehole, water level	C52G
2826CC00025	-28.85457	26.03850	Borehole, water level	
2926AA00071	-29.00680	26.22130	Borehole, water level	
2926AA00083	-29.00674	26.05403	Borehole, water level	C52H
2926AA00084	-29.06202	26.05403	Borehole, water level	
2926AA00085	-29.06229	26.09903	Borehole, water level	
2926AA00086	-29.07480	26.12182	Borehole, water level	
2926AA00087	-29.03535	26.07098	Borehole, water level	
2926AA00089	-29.05813	26.13709	Borehole, water level	
2926AA00090	-29.05729	26.12459	Borehole, water level	
UO_EWR07_R	-28.80719	26.10969	Surface water, flow	C52G
UO_EWR17_FV	-28.78348	26.25112	Surface water, flow	
ZQMSPN1 SOUTPAN	-28.72472	26.03250	Borehole, water quality	C52H

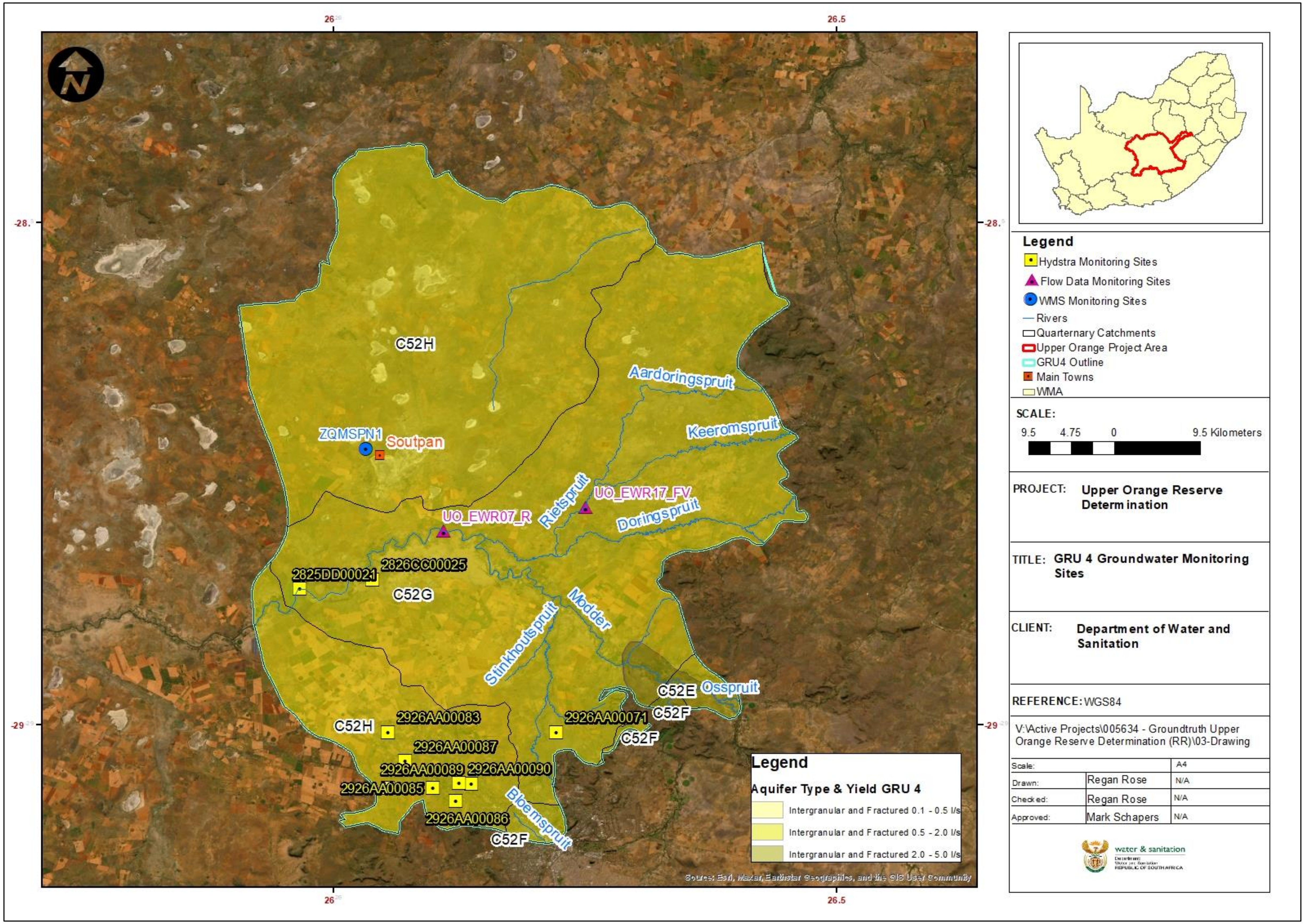

Figure 9: GRU4 Monitoring sites

5.5 GRU5

The monitoring sites in GRU5 include only Hydstra monitoring sites. These monitoring sites are summarised in **Table 7** and provided in **Figure 10.**

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data (**Annexure A**). Groundwater levels of between 0 - 14mbgl were obtained. Although recent groundwater levels in this GRU are relatively stable, historic groundwater levels are erratic during certain intervals. The anticipated seasonal variation in groundwater levels can also be observed.

Table 7: Summary of Monitoring sites in GRU5

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
47101	-29.12720	25.43850	Borehole, water level	C52K
47103	-29.11840	25.42980	Borehole, water level	
47352	-29.19867	25.55816	Borehole, water level	
158100	-29.18390	25.41050	Borehole, water level	
OPBG1MM01	-29.09000	25.61260	Borehole, water level	

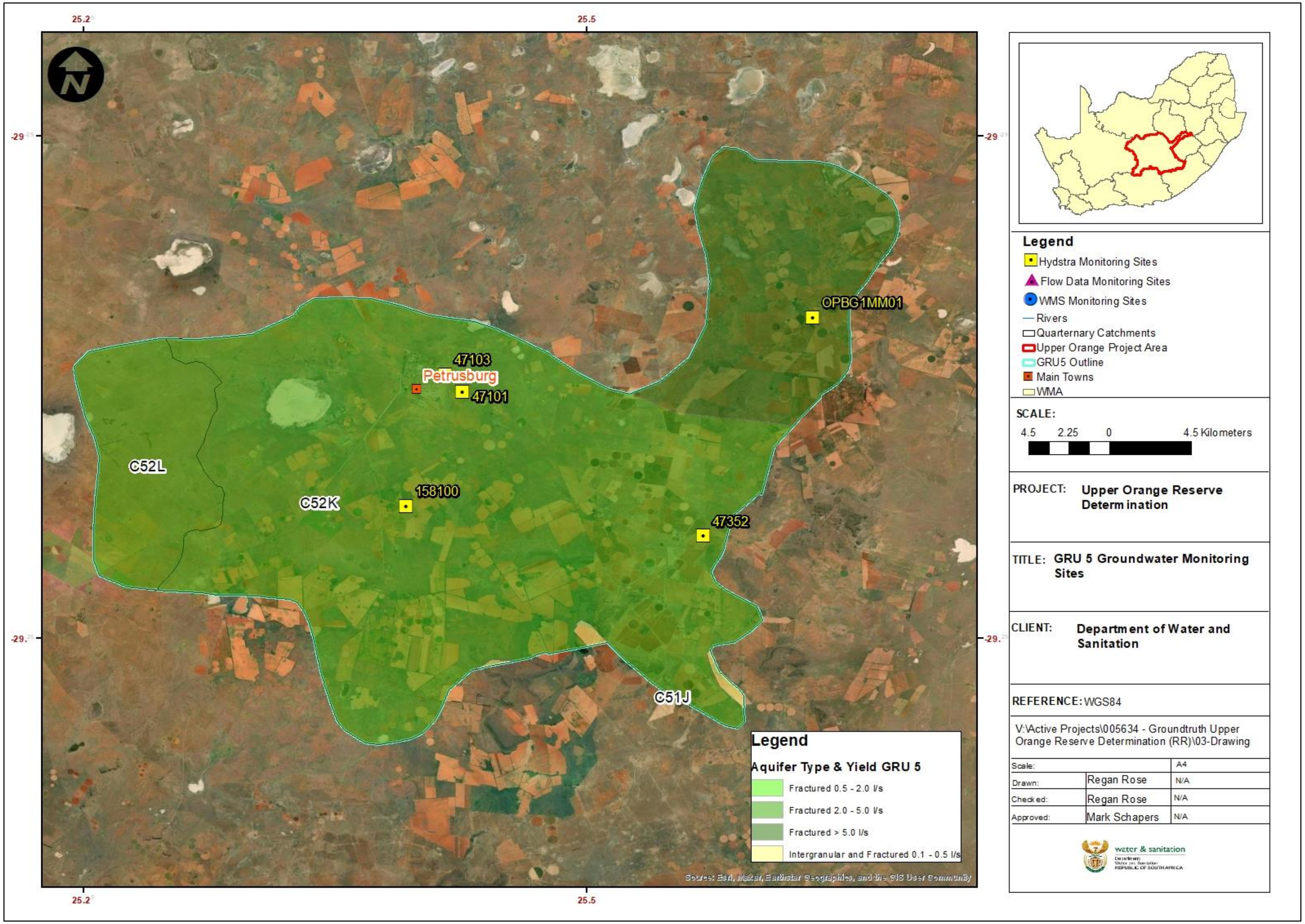

Figure 10: GRU5 Monitoring sites

5.6 GRU6

The monitoring sites in GRU6 include Hydstra and flow monitoring sites. These monitoring sites are summarised in **Table 8** and provided in **Figure 11.**

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data (**Annexure A**). Groundwater levels of between 0 - 20mbgl were obtained with one borehole returning groundwater levels in excess of 180mbgl[1]. The groundwater level data include mainly historical monitoring sites last monitored in 1995. There is no significant variation in groundwater level data throughout the trend analysis period within this GRU with the anticipated seasonal variations in groundwater levels observed.

Table 8: Summary of Monitoring sites in GRU6

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
2925CB00069	-29.74978	25.31622	Borehole, water level	C51J
2925CB00070	-29.74867	25.32678	Borehole, water level	
2925CD00009	-29.75034	25.31622	Borehole, water level	
2925CD00010	-29.75867	25.42872	Borehole, water level	C51H
UO_EWR06_R	-29.65360	25.43507	Surface water, flow	

[1] Possible error with field measurement or data capturing

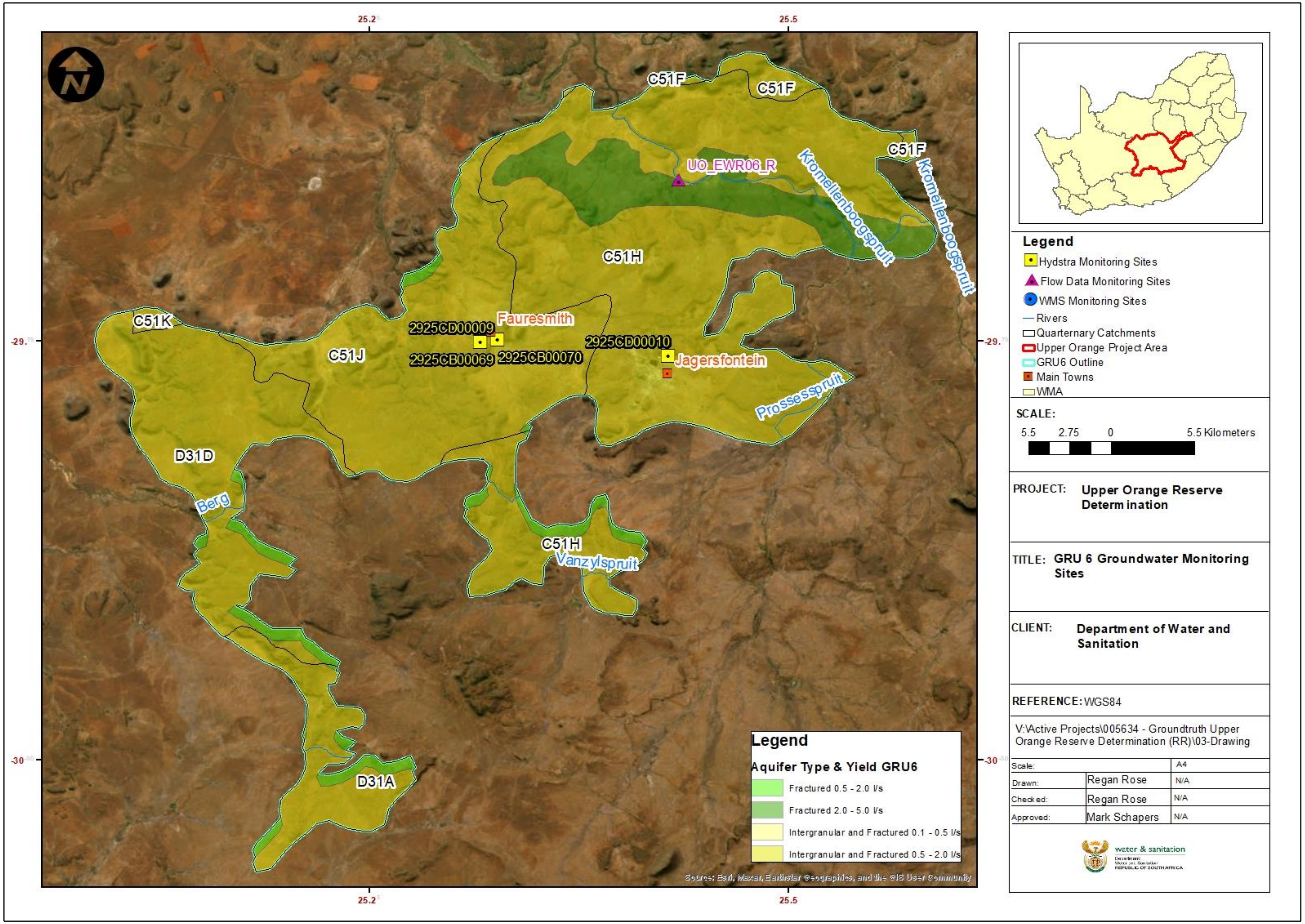

Figure 11: GRU6 Monitoring sites

5.7 GRU7

The monitoring sites in GRU7 include WMS and flow monitoring sites. These monitoring sites are summarised in **Table 9** and provided in **Figure 12**.

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU7 is of a good quality **(Annexure A)**. ECs at the identified monitoring site is generally below 80mS/m, and, in terms of the DWAF Water Classification System the groundwater in this area can be classified as a “Class I” or “Good Water Quality” type water. An outlier in the data set was identified during 1996 however, this is likely to be a result of erroneous field data measurement or data capturing.

Table 9: Summary of Monitoring sites in GRU7

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
UO_EWR02_I	-30.51781	27.36906	Surface water, flow	D12B
UO_EWR04_R	-30.85179	27.77689	Surface water, flow	D13E
UO_EWR04_FV	-30.81177	27.26650	Surface water, flow	D13K
UO_EWR05_FV	-30.88469	27.88456	Surface water, flow	D13A
UO_EWR06_FV	-30.81948	27.70431	Surface water, flow	D13E
UO_EWR08_FV	-30.91762	27.80075	Surface water, flow	D13C
UO_EWR09_FV	-30.85260	27.78656	Surface water, flow	D13B
UO_EWR24_FV	-30.44859	27.58234	Surface water, flow	D18K
UO_EWR25_FV	-30.95413	27.60613	Surface water, flow	D13D
UO_EWR27_FV	-30.39876	27.34299	Surface water, flow	D12A
ZQMBYS1 3027DC00040 BARKLEY EAST TOWN	-30.97111	27.59389	Borehole, water quality	D13D

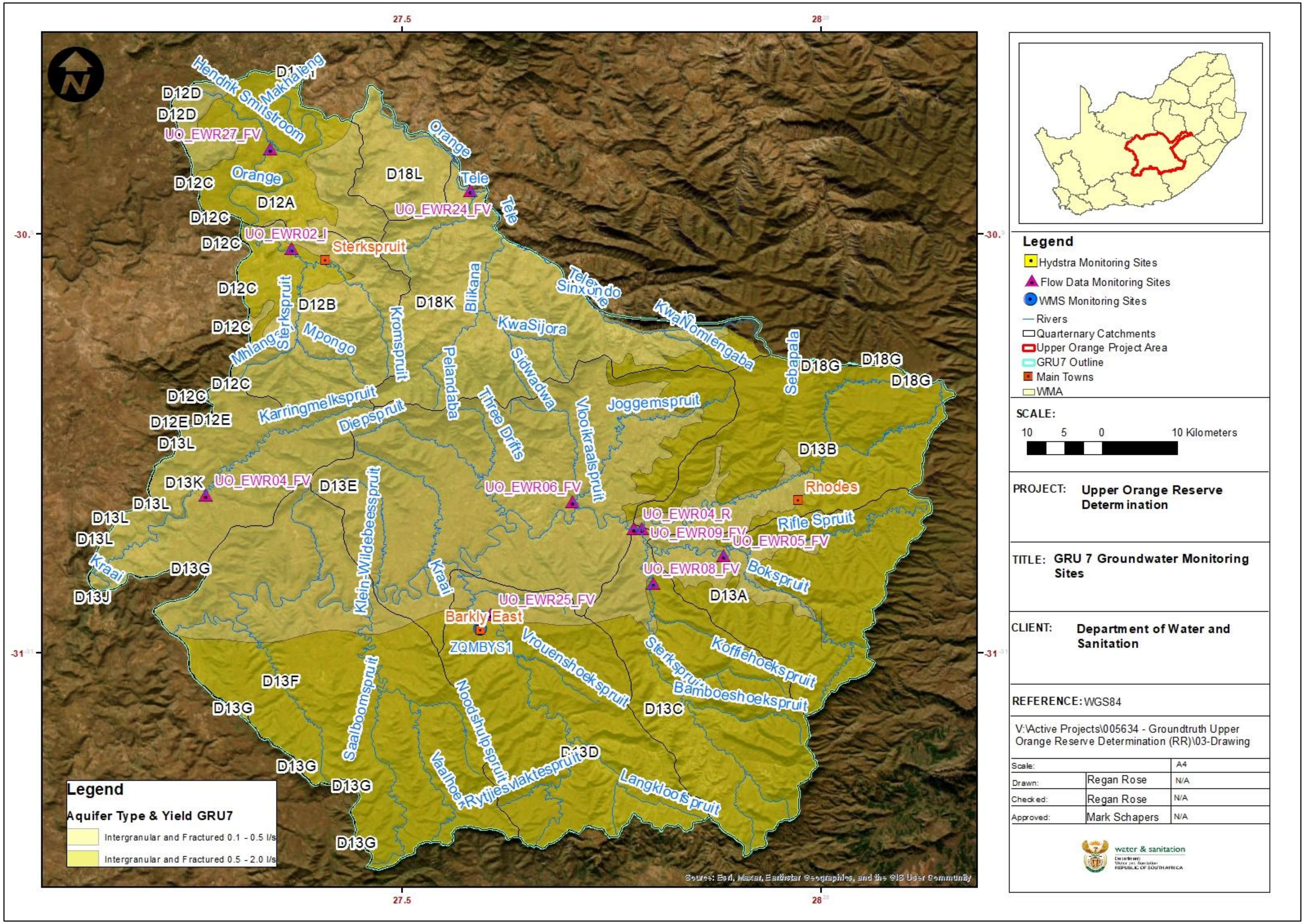

Figure 12: GRU7 Monitoring sites

5.8 GRU8

The monitoring sites in GRU8 include Hydstra and WMS monitoring sites. These monitoring sites are summarised in **Table 10** and provided in **Figure 13.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU8 is of a relatively good quality (**Annexure A**). ECs at the water quality monitoring site identified were generally below 170mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a "Class I" or "Good Water Quality" type water.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of <10mbgl are observed. Periodic variations in groundwater level data throughout the trend analysis period within this GRU may be related to periods of resting and pumping at nearby production boreholes. Recent water level data indicates relatively stable water levels with seasonal variations.

Table 10: Summary of Monitoring sites in GRU8

Site Name	Longitude	Latitude	Monitoring Site Type	Quaternary Catchment
34949	27.04127	-31.37359	Borehole, water level	D13H
34950	27.04093	-31.34962	Borehole, water level	
34951	27.04182	-31.37470	Borehole, water level	
EC/D13/0082	27.04626	-31.38807	Borehole, water level	
ZQMDDT1 3127AC00153 DORDRECHT	27.04472	-31.37556	Borehole, water quality	
UO_EWR07_FV	27.05664	-30.99532	Surface water, flow	D13J
UO_EWR26_FV	27.28444	-31.15554	Surface water, flow	D13G

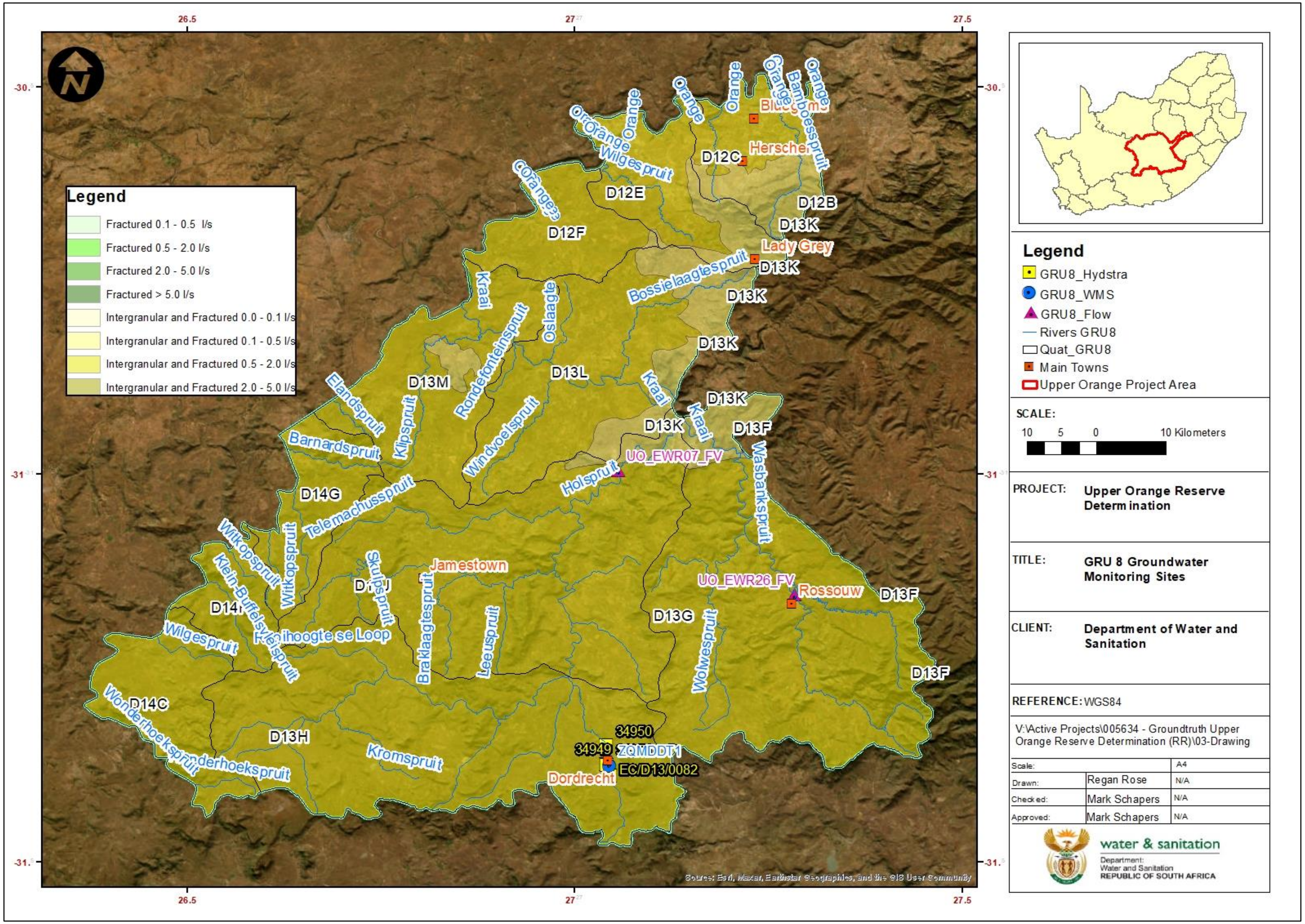

Figure 13: *GRU8 Monitoring sites*

5.9 GRU9

The monitoring sites in GRU9 include Hydstra, WMS and flow monitoring sites. These monitoring sites are summarised in **Table 11** and provided in **Figure 14.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU9 is of a relatively good quality (**Annexure A**). ECs at the monitoring site identified are generally below 170mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a "Class I" or "Good Water Quality" type water.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels are between 1 - 32mbgl and include mainly historical monitoring sites last monitored in 1992. There are significant variations in groundwater level data, possible related to groundwater abstraction, throughout the trend analysis period within this GRU with the strong seasonal variations in groundwater levels being observed.

Table 11: Summary of Monitoring sites in GRU9

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
3025DB00015	-30.69612	25.77315	Borehole, water level	D35H
3025DC00070	-30.97946	25.74121	Borehole, water level	D35G
3025DC00071	-30.97529	25.74121	Borehole, water level	
3025DC00072	-30.98362	25.74121	Borehole, water level	
3025DD00127	-30.90862	25.77037	Borehole, water level	
3025DD00128	-30.97529	25.75371	Borehole, water level	
3025DD00129	-30.98362	25.75371	Borehole, water level	
3025DD00130	-30.98779	25.74954	Borehole, water level	
3124BB00048	-31.20717	24.97418	Borehole, water level	D32G
3124BB00050	-31.22330	24.97909	Borehole, water level	
3124BB00051	-31.21743	24.97754	Borehole, water level	
3124BB00055	-31.22029	24.97940	Borehole, water level	
3124BB00056	-31.20775	24.97700	Borehole, water level	
3124BB00057	-31.20303	24.97561	Borehole, water level	
3124BB00062	-31.22803	24.98006	Borehole, water level	
3124BB00064	-31.20219	24.97450	Borehole, water level	
3124BB00065	-31.20303	24.97450	Borehole, water level	
3124BB00066	-31.20331	24.97450	Borehole, water level	
3124BB00067	-31.20664	24.97561	Borehole, water level	
3124BB00068	-31.20414	24.97756	Borehole, water level	
3124BB00069	-31.20581	24.97672	Borehole, water level	
3124BB00070	-31.20303	24.97589	Borehole, water level	
3125BA00003	-31.08414	25.73121	Borehole, water level	D35G
3125BA00005	-31.12275	25.73732	Borehole, water level	D35D
3125BA00006	-31.06303	25.73260	Borehole, water level	D35G
3125BA00007	-31.05442	25.73565	Borehole, water level	
3125BA00008	-31.04525	25.73204	Borehole, water level	
3125BA00009	-31.03497	25.72537	Borehole, water level	
3125BA00010	-31.08275	25.72871	Borehole, water level	
3125BA00011	-31.04608	25.72454	Borehole, water level	

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
3125BA00012	-31.04192	25.70676	Borehole, water level	D35D
3125BA00013	-31.06969	25.70982	Borehole, water level	
3125BA00014	-31.08636	25.73065	Borehole, water level	
3125BA00015	-31.07803	25.71343	Borehole, water level	
3125BA00016	-31.07358	25.70982	Borehole, water level	
3125BA00017	-31.08414	25.71954	Borehole, water level	
3125BA00018	-31.08636	25.72148	Borehole, water level	
3125BA00019	-31.07803	25.71621	Borehole, water level	
3125BA00020	-31.16692	25.71287	Borehole, water level	
3125BA00021	-31.13219	25.70676	Borehole, water level	
3125BA00022	-31.18358	25.69593	Borehole, water level	
3125BA00023	-31.18359	25.70843	Borehole, water level	
3125BA00024	-31.18358	25.70398	Borehole, water level	
3125BA00025	-31.18386	25.74482	Borehole, water level	
3125BA00026	-31.18025	25.74593	Borehole, water level	
3125BA00027	-31.19525	25.74121	Borehole, water level	
3125BA00030	-31.18358	25.71954	Borehole, water level	
3125BB00001	-31.19192	25.76899	Borehole, water level	
3125BB00002	-31.19194	25.76901	Borehole, water level	
3225DD00002	-30.77252	25.83565	Borehole, water level	D35G
3225DD00003	-30.77251	25.83426	Borehole, water level	
3225DD00006	-30.77723	25.82510	Borehole, water level	
3225DD00007	-30.77254	25.81621	Borehole, water level	
UO_EWR08_I	-30.69007	26.74157	Surface water, flow	D13M
UO_EWR05_R	-31.00526	26.34194	Surface water, flow	D14E
JBS3 - 35	-30.65495	26.46614	Surface water, flow	D14H
JBS3 - 36 (26_14)	-30.57142	26.45166	Surface water, flow	D14J
ZQMALI1 3026DA00035 ALIWAL NORTH	-30.71556	26.71472	Borehole, water quality	D14A
ZQMBUP1 3026CD00013 BURGERSDORP	-30.99361	26.32444	Borehole, water quality	D14E

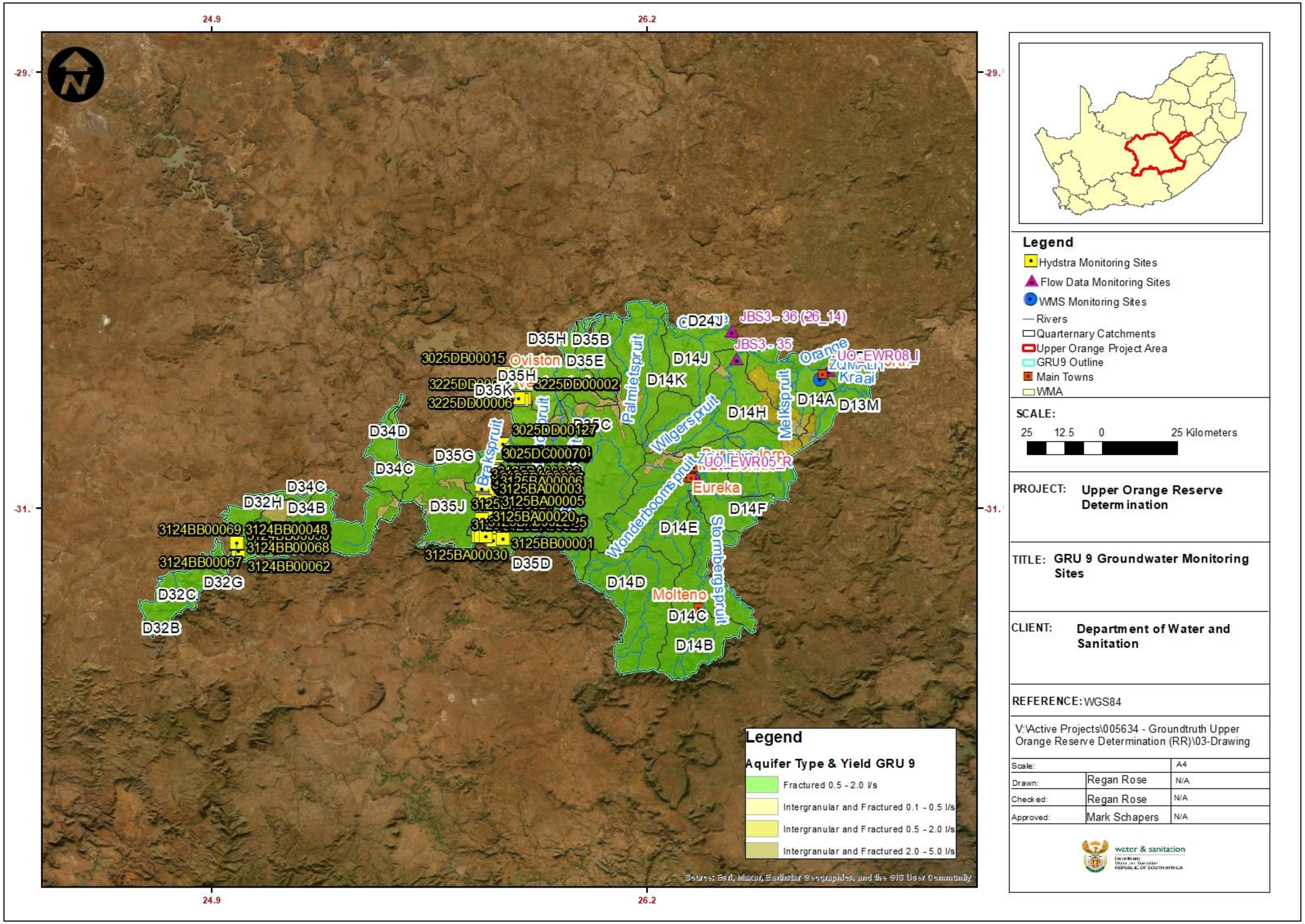

Figure 14: GRU9 Monitoring sites

5.10 GRU10

The monitoring sites in GRU10 include Hydstra, WMS and flow monitoring sites. These monitoring sites are summarised in **Table 12** and provided in **Figure 15.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU10 is of a relatively good quality (**Annexure A**). ECs at all monitoring sites are generally below 100mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a "Class I" or "Good Water Quality" type water.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of between 0 - 19mbgl were obtained. There are significant variations in groundwater level data, possible related to groundwater abstraction, throughout the trend analysis period within this GRU. However, recent groundwater levels indicate very stable conditions.

Table 12: Summary of Monitoring sites in GRU10

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
6701	-31.18830	24.94144	Borehole, water level	D32G
3124AB00015	-31.07414	24.42394	Borehole, water level	D32F
3124BB00058	-31.18552	24.97673	Borehole, water level	D32G
3124BB00060	-31.18831	24.94144	Borehole, water level	
3124BB00063	-31.20164	24.97506	Borehole, water level	
3124BB00071	-31.20053	24.97644	Borehole, water level	
3124BB00080	-31.16273	24.92922	Borehole, water level	
3124DA00001	-31.55358	24.52311	Borehole, water level	D32B
ZQMHNR1 COMFYT KUIL	-31.21667	24.43222	Borehole, water quality	D32E
ZQMNOU1 3124BB00061 NOUPOORT TOEKENNINGSGEBIED	-31.22250	24.94500	Borehole, water quality	D32G
UO_EWR12_FV	-31.33905	24.53070	Surface water, flow	D32A
UO_EWR13_FV	-31.27024	24.62418	Surface water, flow	D32C

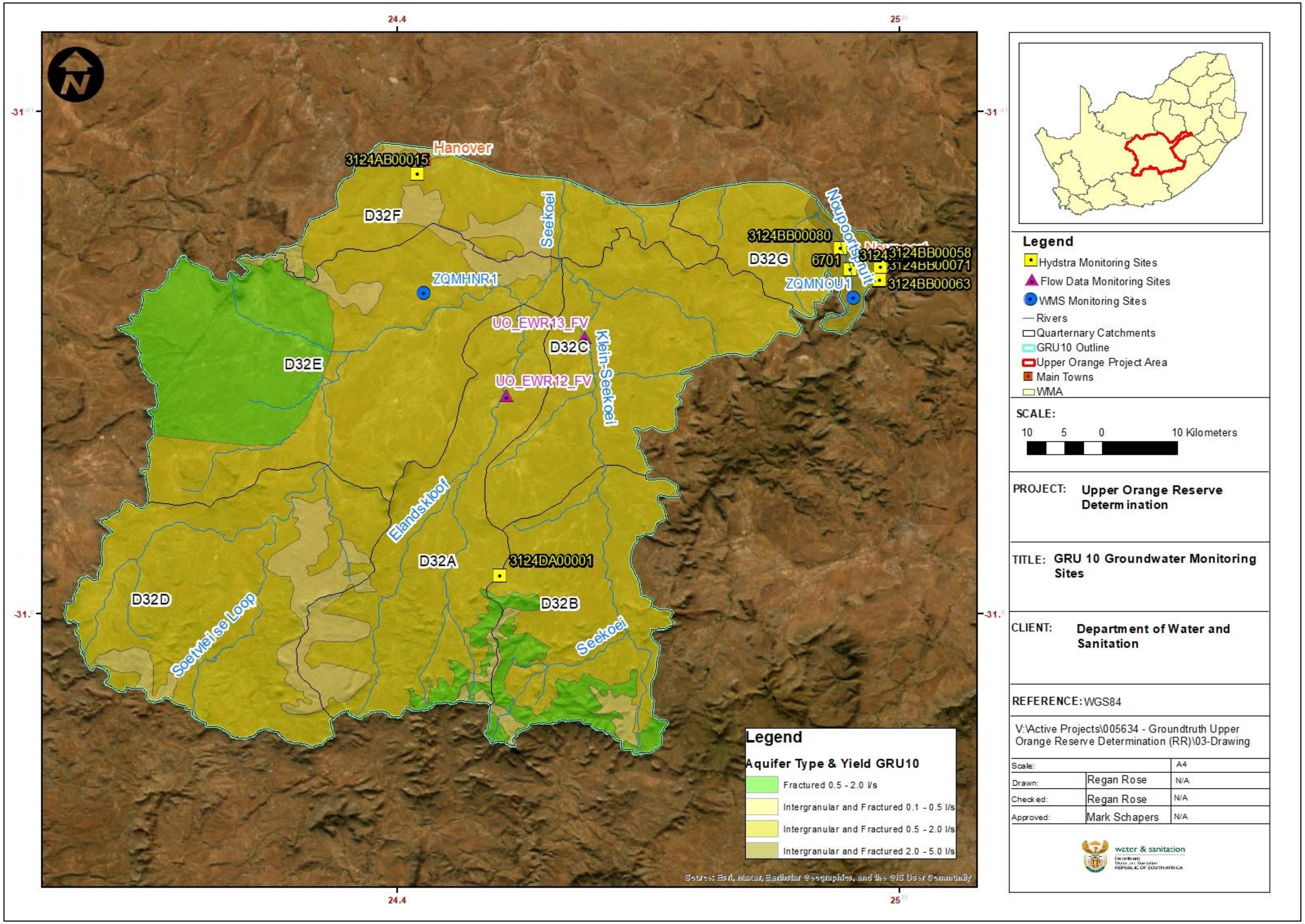

Figure 15: GRU10 Monitoring sites

5.11 GRU11

The monitoring sites in GRU11 include only Hydstra monitoring sites. These monitoring sites are summarised in **Table 13** and provided in **Figure 16**.

A time series trend analysis graph for water levels was produced based on Hydstra monitoring data (**Annexure A**). Groundwater levels of between 0 - 32mbgl were obtained and include mainly historical monitoring sites last monitored in 1992. There are significant variations in groundwater level data, possible related to groundwater abstraction, throughout the trend analysis period within this GRU with the strong seasonal variations in groundwater levels being observed.

Table 13: Summary of Monitoring sites in GRU11

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
3025CA00045	-30.71560	25.13868	Borehole, water level	D34F
3025CA00046	-30.72188	25.07823	Borehole, water level	
3025CA00047	-30.72807	25.09120	Borehole, water level	
3025CA00048	-30.72529	25.09398	Borehole, water level	
3025CA00054	-30.72724	25.10093	Borehole, water level	
3025CA00055	-30.72724	25.10094	Borehole, water level	
3025CA00056	-30.72724	25.10095	Borehole, water level	
3025CA00057	-30.72724	25.10096	Borehole, water level	
3025CA00058	-30.72724	25.10097	Borehole, water level	
3025CA00059	-30.72724	25.10098	Borehole, water level	
3025CA00060	-30.72724	25.10094	Borehole, water level	
3025CA00061	-30.72725	25.10093	Borehole, water level	
3025CA00062	-30.72724	25.10095	Borehole, water level	
3025CA00063	-30.72726	25.10093	Borehole, water level	
3025CA00064	-30.72724	25.10096	Borehole, water level	
3025CA00065	-30.72727	25.10093	Borehole, water level	
3025CC00032	-30.75816	25.14567	Borehole, water level	
3025CC00033	-30.75982	25.14206	Borehole, water level	
3025CC00034	-30.75117	25.13530	Borehole, water level	
3025CC00035	-30.75912	25.13309	Borehole, water level	

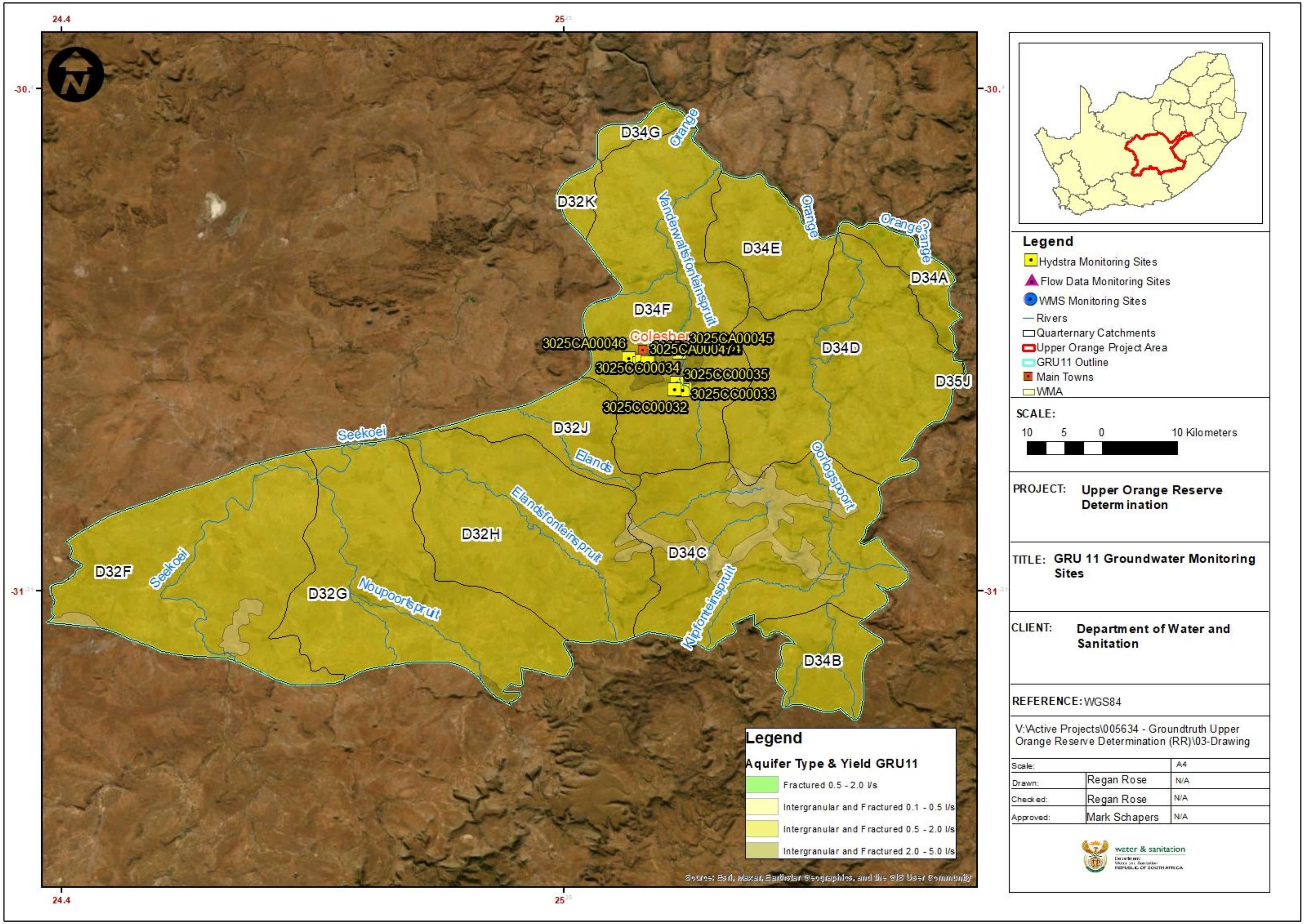

Figure 16: GRU11 Monitoring sites

5.12 GRU12

The monitoring sites in GRU12 include WMS and flow monitoring sites. These monitoring sites are summarised in **Table 14** and provided in **Figure 17**.

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU12 is of a moderate quality (**Annexure A**). ECs at the monitoring site identified are generally below 200mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a “Class II” or “Marginal Water Quality” type water. A steady increase in ECs can be observed throughout the monitoring period. An outlier in the data set was identified during 1996 however, this is likely to be a result of an erroneous field measurement or data capturing.

Table 14: Summary of Monitoring sites in GRU12

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
UO_EWR05_I	-30.53436	24.96290	Surface water, flow	D32J
UO_EWR21_FV	-30.20514	24.71803	Surface water, flow	D31C
ZQMMDG1 3024BD00005 HAMELFONTEIN/UITSIG	-30.42556	24.84222	Borehole, water quality	D32K

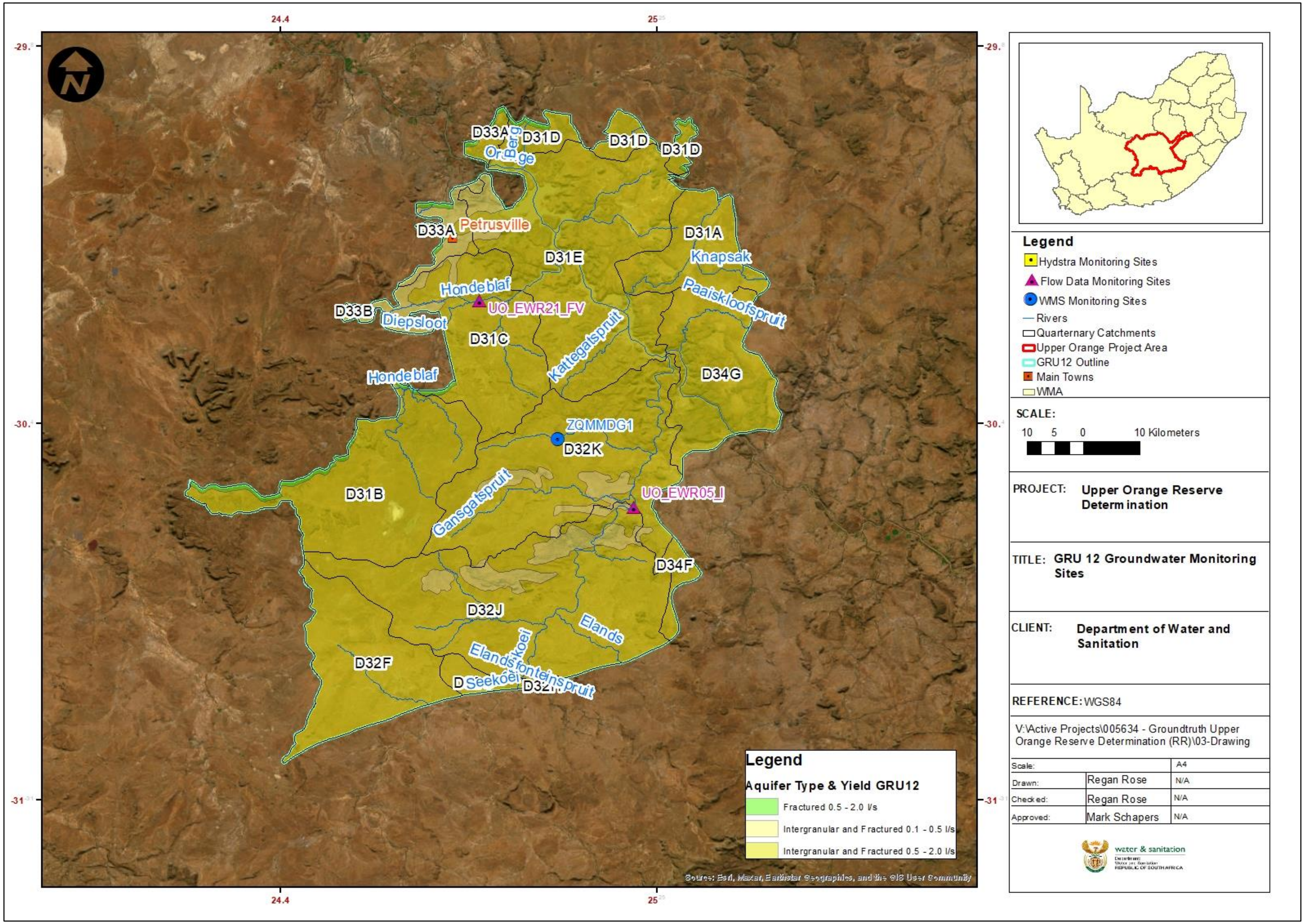

Figure 17: GRU12 Monitoring sites

5.13 GRU13

The monitoring sites in GRU13 include water levels, WMS water quality and flow monitoring sites. These monitoring sites are summarised in **Table 15** and provided in **Figure 18.**

Water level data is limited to only a few manual measurements at Mokala National Park by SANParks. No clear trend in water levels is visible as yet. A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU13 is of a marginal to good quality (**Annexure A**). ECs at the monitoring site identified is generally below 500mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a "Class II – Class I" or "Marginal to Good Water Quality" type water. ECs varied significantly throughout the monitoring period. Outliers in the data set were identified during 2011 and 2013 however, these are likely to be a result of erroneous field measurements or data capturing.

Table 15: Summary of Monitoring sites in GRU13

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
JBS3 - 40 (26_2)	-29.64356	24.21554	Surface water, flow	D33E
UO_EWR09_I	-29.03842	24.50283	Surface water, flow	C51L
ZQMSZS1 2924AC00053 SCHOLZFONTEIN-WES	-29.29250	24.23444	Borehole, water quality	C51M
MBH1	-29.17955	24.25815	Borehole, water level	C51M
MBH10	-29.07474	24.47920	Borehole, water level	C51L
MBH2	-29.17527	24.33267	Borehole, water level	C51M
MBH3	-29.15183	24.30913	Borehole, water level	C51M
MBH4	-29.17357	24.26479	Borehole, water level	C51M
MBH5	-29.17110	24.26233	Borehole, water level	C51M
MBH6	-29.11482	24.23995	Borehole, water level	C51M
MBH7	-29.13144	24.38661	Borehole, water level	C51L
MBH8	-29.12930	24.38647	Borehole, water level	C51L
MBH9	-29.07989	24.37193	Borehole, water level	C51L

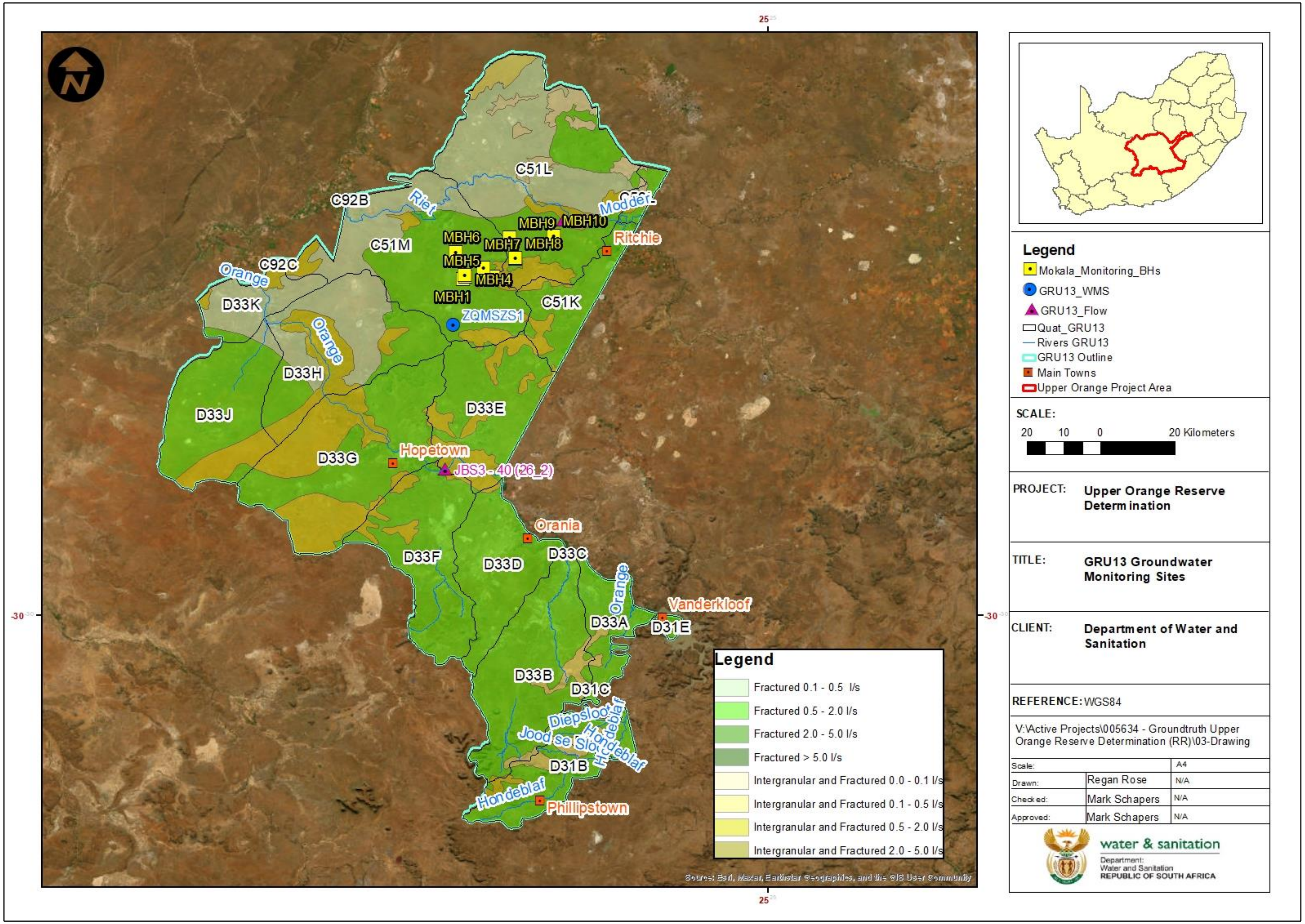

Figure 18: GRU13 Monitoring sites

5.14 GRU14

The monitoring sites in GRU14 include only Hydstra monitoring sites. These monitoring sites are summarised in **Table 16** and provided in **Figure 19.**

A time series trend analysis graph for EC was produced from WMS data and indicates that the groundwater quality within GRU14 is of a relatively good quality (**Annexure A**). ECs at the monitoring site identified are generally below 150mS/m, and, in terms of the DWAF Water Classification System the groundwater within this GRU can be classified as a "Class I" or "Good Water Quality" type water. An outlier in the data set was identified towards the end of 1995 however, this is likely to be a result of an erroneous field measurement of data capturing.

A time series trend analysis graph for groundwater levels was produced based on Hydstra monitoring data. Groundwater levels of between 0.5 - 14mbgl were obtained. Periodic variations in groundwater level data throughout the trend analysis period within this GRU may be related to periods of pumping at nearby production boreholes. Recent groundwater level data indicates relative stable groundwater levels.

Table 16: Summary of Monitoring sites in GRU14

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
43717	-29.16340	24.70738	Borehole, water level	C51K
43718	-29.16127	24.72024	Borehole, water level	
43720	-29.15706	24.69568	Borehole, water level	
43722	-29.16745	24.72136	Borehole, water level	
43723	-29.15245	24.71312	Borehole, water level	
44219	-29.16372	24.71046	Borehole, water level	
44221	-29.16007	24.71232	Borehole, water level	
44227	-29.16953	24.71990	Borehole, water level	
156857	-29.15690	25.69610	Borehole, water level	C52K
2825AD00015	-28.68590	25.75310	Borehole, water level	C52H
2825AD00016	-28.68210	25.46630	Borehole, water level	C52K
2825CA00136	-28.71780	25.36970	Borehole, water level	
2825CB00022	-28.87450	25.66700	Borehole, water level	
2825CB00023	-28.90990	25.66130	Borehole, water level	
2825DB00005	-28.67261	25.76763	Borehole, water level	C52H
2925BA00038	-29.28125	25.99330	Borehole, water level	C52J
2925BA00039	-29.17430	25.12310	Borehole, water level	
2925BB00017	-29.14478	25.80788	Borehole, water level	
2925BB00018	-29.14478	25.80789	Borehole, water level	
2925BB00019	-29.14479	25.80788	Borehole, water level	
2925BB00022	-29.14534	25.81122	Borehole, water level	
2925BB00023	-29.14534	25.81123	Borehole, water level	
2925BD00005	-29.29770	25.77050	Borehole, water level	
ZQMJBL1 2924BB00002 JACOBSDAL ALLOTMENT AREA	-29.12556	24.77861	Borehole, water quality	C51K
ZQMLCF2 LUCKHOFF ALLOTMENT - PALMFONTEIN	-29.11917	24.73222	Borehole, water quality	
UO_EWR06_I	-29.53506	25.52457	Surface water, flow	C51F
UO_EWR14_FV	-29.31554	24.87825	Surface water, flow	C51K

Site Name	Latitude	Longitude	Monitoring Site Type	Quaternary Catchment
UO_EWR20_FV	-28.89166	25.65645	Surface water, flow	

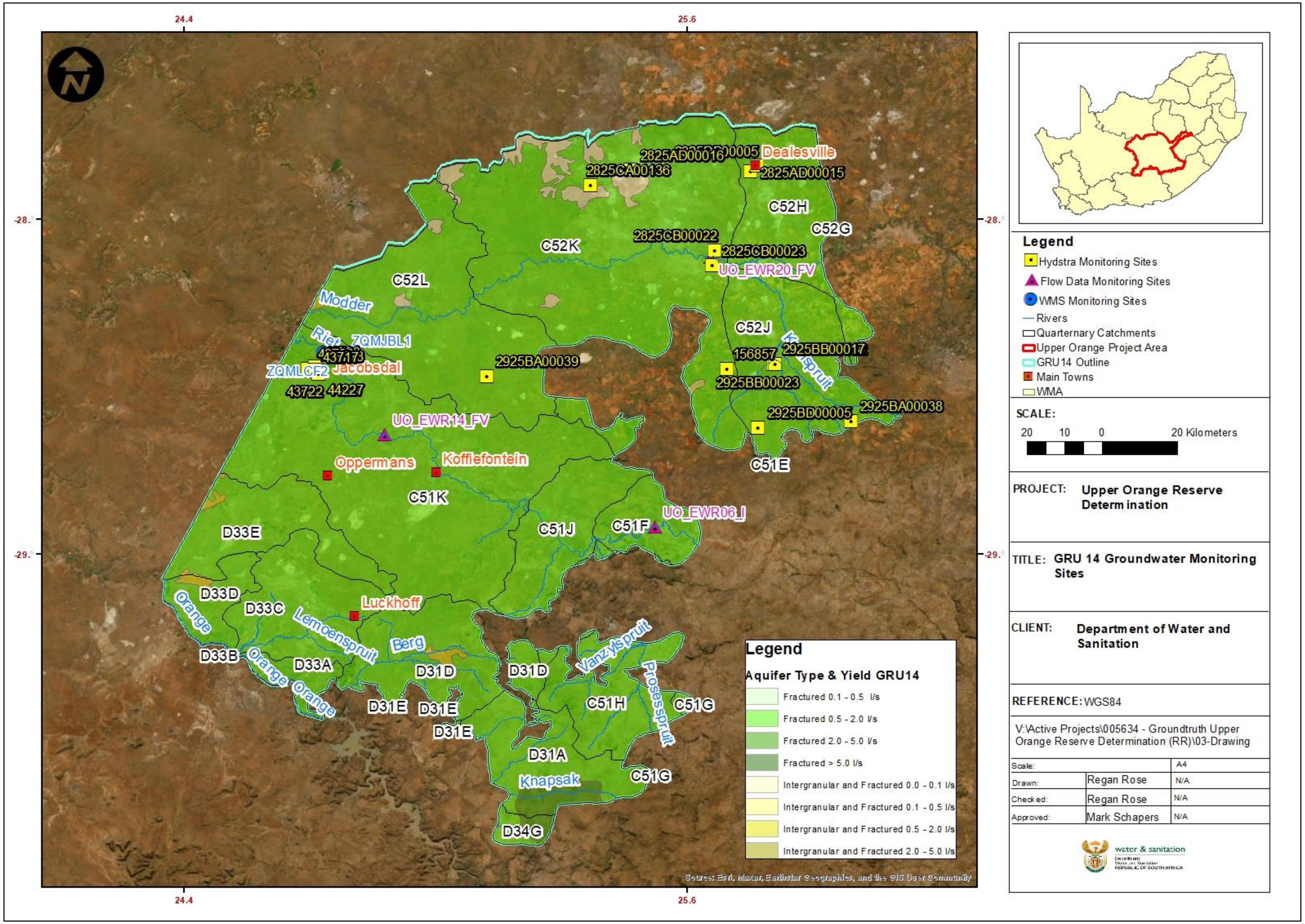

Figure 19: GRU14 Monitoring sites

6. *RESERVE COMPONENTS*

6.1 Recharge

WRC (2012) provides several tools for the determination of groundwater recharge. These tools include the following:

- National scale Maps
- Chloride mass balance method
- Earth Model
- Cumulative rainfall departure method
- Saturated volume fluctuation method
- Isotopes

The above tools have been packaged into a comprehensive Excel-based Recharge toolkit produced by DWS in 2000. Depending on data availability, several methods can be employed simultaneously to produce recharge estimations of specific areas as defined by the user. The Chloride Mass Balance (CMB), Saturated Volume Fluctuation (SVF) and Cumulative Rainfall Departure (CRD) methods generally produce the highest confidence levels (weighting of 4) with recharge estimations. However, the SVF and CRD methods require very detailed data relating to monthly water levels, rainfall and abstraction, which is not always available on larger catchment scale assessments.

The next level of recharge estimation is through qualified guesses using national scale maps of soil, geology, Vegter Groundwater Recharge, Agricultural Catchments Research Unit (ACRU), Harvest Potential and expert guesses (where available through specialist studies and research). These methods generally produce a slightly lower confidence (weighting of 3) compared to the methods described in the previous paragraph.

The final level of recharge estimation in accordance with the Recharge Toolkit is through additional methods such as Baseflow, Isotopes, Earth Model and Groundwater Flow Model. These methods, however, have the lowest confidence (weighting of 1).

Based on the available data, the Recharge toolkit was used to determine recharge per quaternary catchment. A summary of recharge for the quaternary catchments present within the Upper Orange Catchment is presented in **Annexure B.** Due to the lack of sufficient monthly water level data, recharge estimation was mainly limited to the CMB method and qualified guesses.

6.2 Basic Human Needs

A Basic Human Needs (BHN) assessment was recently conducted for the catchment for surface water and groundwater, respectively. The assessment relates specifically to the population not linked to a formal water supply system and directly dependent on rivers and groundwater abstraction to meet their basic needs. The BHN assessment was conducted at the quaternary catchment scale, with population information derived from ward-level census data. The relevant wards were identified by overlaying ward boundaries (2016 Municipal Demarcation Board boundaries) with the quaternary catchments to identify those that fall entirely or partially within the quaternary catchments of the study area. Once the wards were identified, the steps outlined below were followed.

The following steps were applied for the BHN assessment:

Step1: Obtain Census data at the most refined level available

Census data were sourced from Statistics South Africa (StatsSA). While the latest South African National Census was undertaken in 2022, the data will only be available after the completion of this study. Consequently, the data from the previous census (2011) were used and adjusted for population changes using the StatsSA Mid-year Population Estimates.

Census 2011 data on 'main source of water for household use' were extracted from the Community Profile Databases (using the StatsSA SuperWeb application) for the 176 wards of the study area. The data was used to distinguish the population directly reliant on river and groundwater resources for basic needs. The StatsSA census resources provide ward-level data and distinguish between 11 categories of household main water source including: 'borehole', 'spring' and 'river/stream'. The categories of 'borehole' and 'spring' were combined to reflect groundwater reliance.

The StatsSA Mid-year Population Estimates (MYPE, 2011 to 2022) were used to adjust the 2011 census data to account for population changes since 2011 and better reflect population sizes for the assessment year (2022).

Step 2: Match ward-level population data to quaternary catchments

Census water source data are seldom available at a quaternary catchment scale; the census wards and quaternary catchment boundaries do not directly align. As such, the water source population data has to be manipulated to align with the quaternary catchments. This was done through a GIS analysis (DWS, 2016) to overlay the wards with the quaternary catchments and establish the proportion of each ward falling within a particular quaternary catchment. The approach assumed an equal distribution of the population across the ward.

Step 3: Generate the quantum of water based on the defined daily allocation

The BHN volume was calculated based on the lifeline amount of 25 litres per person per day (DWS, 2016). The BHN requirement for river/stream sources was then expressed as a percent of natural mean annual runoff (NMAR) per quaternary; the BHN requirement for groundwater sources was expressed as an annual volume per quaternary.

A summary of the BHN assessment for groundwater per GRU is presented in **Table 17** with the full list for each quaternary catchment provided in **Annexure C**.

Table 17: Summary of BHN in the catchment (GRUs)[2]

GRU	BHN (Mm3/a)
1	0.175
2	0.306
3	0.328
4	0.097
5	0.044
6	0.044
7	0.26
8	0.136
9	0.087
10	0.016
11	0.036
12	0.037
13	0.086
14	0.222
Other	0.236
Total	**2.11**

6.3 Groundwater Contribution to Baseflow

WRC (2012) provides several tools for the determination of groundwater contribution to baseflow. These include the following:

- Herold method of baseflow separation, which is one of the most common methods used in South Africa to determine the groundwater contribution to flow in a river.
- Recession curve by Moore is the specific part of the hydrograph after the crest (and the rainfall event) where streamflow diminishes. The slope of the recession curve flattens over time from its initial steepness as the quickflow component passes and baseflow becomes dominant.
- Stang and Hunt's analytical solution for a homogeneous, isotropic aquifer of infinite lateral extent, with dominant lateral flow and constant T (Dupuit flow), overlain by an infinitely thin stream with a semi-pervious layer.
- The (Laplace-space) solution of Butler et al. (2001) considers, in addition to a partially penetrating stream underlain by a semi-pervious layer, an aquifer of finite lateral extent. Bounded or strip aquifers are frequently observed in valleys and for alluvial aquifers consisting of river sediments (river trains).
- The (semi-analytical) solution of Chen & Yin (2004) is a solution for a partially penetrating stream, adding a gradient between the aquifer and the gaining river.
- The Système Hydrologique Européen (SHE) is a physically-based distributed hydrological numerical modelling system that integrates surface and subsurface flow (including unsaturated vertical flow) on a catchment scale.
- MODFLOW – SFR1 (numerical model): The STREAMFLOW ROUTING, package SFR1, allows for water in-/outflows from run-off, precipitation and evapotranspiration within each reach. In

[2] "Other" refers to portions that overlap with 2 or more quaternary catchments

comparison to the RIVER or BRANCH packages, the hydraulic conductance of the riverbed is calculated from input data (hydraulic conductivity, thickness, stream length and stream width) or computed based on streamflow (conductance as a function of river width).

- MODFLOW – SFR2 (numerical model): An extension of the SFR2 package by Niswonger and Prudic (2005) allows modelling the unsaturated vertical flow between streams and aquifers, hence enabling the description of, for example, limited leakage due to the relative permeability of the unsaturated zone.
- The groundwater contribution to the wetland can be estimated using Darcy's Law, which states that the rate of flow through a porous medium is proportional to the loss of head, and inversely proportional to the length of the flow path.

Baseflow is the portion of streamflow that is not directly generated from the excess rainfall during a storm event. It is the flow that would exist in the stream without the contribution of direct runoff from the rainfall. Separation of baseflow and direct runoff is useful to understand the hydrology of a catchment, including the interaction of surface and sub-surface water[3]. Observed baseflows are rarely available and are limited to focused pilot studies. Fortunately, a plethora of simple to complex tools which are highlighted in **Table 18** exist to facilitate the separation of baseflow. The selection of which tool to use is often based on assumptions that may not be fully met depending on the catchment and availability of hydrological data. Ideally measured streamflow records of long duration, at shorter time intervals are required to properly characterize flow hydrographs as baseflow separation techniques are better suited to analyzing hydrographs for individual rainfall-runoff events. For this study, only monthly surface flow data was available for 129 quaternary catchments, and consequently traditional separation techniques could not be used.

Table 18: Traditional baseflow separation methods

Baseflow separation methods	Input data	Limitations
Graphical	Streamflow and experience	Application is time consuming and arbitrary
Hydrological simulation	Hydro-meteorological data	Model frequently needs numerous basic hydro-meteorological data, and the calibration of the model parameters is time consuming
Tracer-based	Streamflow and tracer v values	Laborious and expensive
Conductivity mass-balance	Streamflow and specific conductive	Obtaining conductive values of surface flow and baseflow is problematic
Automatic	Streamflow	Lacks rigorous physical meaning

In 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

[3] Baseflow Separation Using Straight Line Method (carleton.edu)

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. A summary of the data is presented in **Table 19**.

Table 19: Summary of baseflow results

Maximum Groundwater Baseflow (Mm^3/a)	64.68
Minimum Groundwater Baseflow (Mm^3/a)	0.12

The results in **Table 19** indicate that on average for all 132 quaternary catchments, the groundwater baseflow ranges from $0.12Mm^3/a$ to $64.68Mm^3/m$, averaging ~26% of the total flow. Baseflow results for all 132 quaternary catchments are provided in **Annexure D**.

6.4 Groundwater Quality Reserve

The DWS WMS data was interrogated to further assess groundwater quality (chemical) parameters in the catchment in more detail. From the data set, chemical parameters including pH, EC, Calcium, Magnesium, Potassium, Sodium. Chlorine, Fluorine, Total Alkalinity, Sulphate and Nitrates were available. The objective of this exercise was to assign groundwater quality class to the reserve by analyzing the chemicals trend over time. Median Concentrations for each chemical parameter were determined to characterise the prominent groundwater quality for each quaternary catchment, where available.

The catchment area constitutes of 129 quaternary catchments, of which 18 quaternary catchments have groundwater quality data. As a result of this Groundwater Quality Reserves were aggregated to GRU scale to represent quaternary catchments with no groundwater quality data as shown in Table 20. For GRU5, GRU6 and GRU11 no groundwater quality data is available for the relevant quaternary catchments. Groundwater quality is within the limits of a Class 1 water quality in terms of DWS Water quality guidelines (DWS 1998); however, for GRU4, GRU9, GRU10 and GRU13, the limits exceed DWS Class 1 Water quality guidelines. GRU 4 and GRU 9 have the worst groundwater quality of Class 3 and Class 4, respectively. Groundwater quality results are provided in **Annexure E** for quaternary catchments and **Annexure F** for GRUs.

Table 20: Quaternary catchments with no groundwater quality data

GRU	Quaternary Catchments
GRU1	C52B, C52C, D21A, D21C, D21D, D21F, D21G, D21H, D22A, D22B, D22C, D22D, D22H, D22L, D23A, D23C, D23D, D23E, D23F, D23G, D23H, D23J
GRU2	C51D, C51G, D12A, D12B, D12C, D12E, D12F, D14J, D14K, D15G, D15H, D18L, D23F, D23G, D23H, D23J, D24A, D24B, D24C, D24E, D24F, D24H, D24J, D24K, D24L, D31A, D34A, D34C, D34D, D34E, D34F, D34G, D35A, D35B, D35E, D35F, D35G, D35H, D35K
GRU3	C51B, C51C, C51D, C51E, C51F, C51G, C51H, C51J, C52B, C52C, C52D, C52E, C52F, C52G, C52J, C52K, D23E, D23F, D23H, D23J, D24K
GRU4	C52E, C52F, C52G
GRU5	C51J, C52K, C52L
GRU6	C51F, C51H, C51J, D31A, D31D
GRU7	D12A, D12B, D12C, D12E, D13A, D13B, D13C, D13E, D13F, D13G, D13J, D13K, D13L, D15H, D18K, D18L
GRU8	D12B, D12C, D12E, D12F, D13F, D13G, D13J, D13K, D13L, D13M, D14C, D14F, D14G
GRU9	D12F, D13M, D14B, D14C, D14D, D14F, D14G, D14H, D14J, D14K, D24J, D32C, D32H, D34B, D34C, D34D, D35B, D35C, D35D, D35E, D35G, D35H, D35K
GRU10	D32A, D32B, D32C, D32D, D32F
GRU11	D32F, D32H, D32J, D34A, D34B, D34C, D34D, D34E, D34F, D34G
GRU12	D31A, D31B, D31C, D31D, D31E, D32F, D32H, D32J, D33A, D33B, D34F, D34G
GRU13	C51L, C52L, D31B, D31C, D31E, D33A, D33B, D33C, D33D, D33E, D33F, D33G, D33H, D33J, D33K
GRU14	C51E, C51F, C51G, C51H, C51J, C52G, C52J, C52K, C52L, D31A, D31D, D31E, D33A, D33B, D33C, D33D, D33E, D34G

7. STRESS INDEX

The available Groundwater Recharge and Use data were used to quantify the Stress Index. In accordance with WRC (2012) the Stress Index is defined as follows:

Stress Index (SI) = $GW_{use}/Re \times 100$

Where:

Re = Recharge

GW_{use} = Groundwater Use

The SI results show that all quaternary catchments have surplus groundwater available, i.e. groundwater use is less than Recharge. The SI was divided into eleven (11 No.) categories as shown in Table 21, overleaf. The SI categories vary from “A” (Natural) to “F” (Critically Modified).

Table 21: Stress Index (SI) categories

Category	Stress Index (values)	Stress Index (%)	Description
A	0.05	5	Natural
A/B	0.10	10	Natural to good
B	0.20	20	Good
B/C	0.30	30	Good to Fair
C	0.40	40	Fair
C/D	0.50	50	Fair to Poor
D	0.60	60	Poor
D/E	0.70	70	Poor to Seriously Modified
E	0.80	80	Seriously Modified
E/F	0.90	90	Seriously Modified to Critically Modified
F	1.00	100	Critically modified

The spatial distribution of the SI categories is shown in Figure 20, overleaf. The SI per quaternary catchment is provided in **Annexure G**, Table 57. The majority of the quaternary catchments fall in the "A" (Natural) category (69%), followed by the "A/B" (Natural to Good) category (13%), "B" (Good) category (13%) and "D" (Poor) category (2%). The largest SI in the Catchment is a "D/E", i.e. Poor to Seriously Modified for C52H and C52J, respectively.

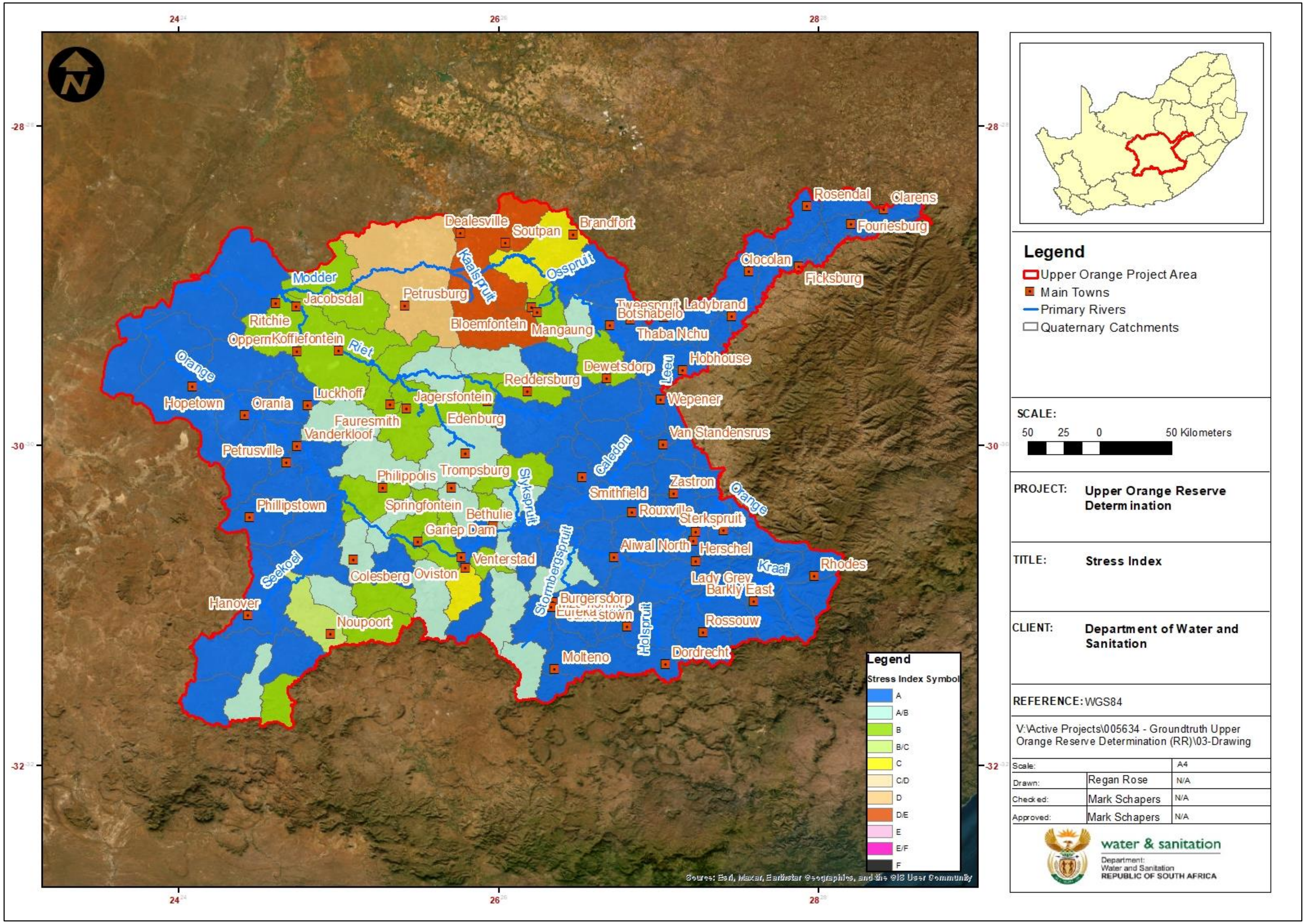

Figure 20: Stress Index

8. ALLOCABLE GROUNDWATER

A water balance approach was used to quantify allocable groundwater in the catchment. Groundwater Recharge is defined as the input into the catchment, whilst Groundwater Use and Groundwater Reserve collectively define the output. This was done on a quaternary catchment level. For the purpose of this assessment the Allocable Groundwater has been defined as follows:

Allocable Groundwater = $Re - (GW_{use} + EWR_{gw} + BHN_{gw})$

Where:

Re = Recharge

GW_{use} = Groundwater Use

BHN_{gw} = Basic human needs derived from groundwater

EWR_{gw} = Groundwater contribution to EWR

The Allocable Groundwater was divided into eleven (11 No.) geometric interval categories as shown in Table 22. The spatial distribution of Allocable Groundwater is shown in Figure 21, overleaf. The data per quaternary catchment is provided in **Annexure G**, Table 57. A large range in values can be observed from -35.897Mm^3/a to 42.076Mm^3/a. Negative values seems to indicate that there is no surplus groundwater available in the quaternaries after accounting for the Groundwater Reserve and vice versa.

Table 22: Allocable Groundwater Categories

Category	Allocable Groundwater Categories (Mm3/a)
A	25.78 – 42.08
A/B	15.96 - 25.77
B	9.81 - 15.95
B/C	5.96 - 9.80
C	3.54 - 5.95
C/D	2.03 - 3.53
D	-0.39 - 2.02
D/E	-4.24 - -0.40
E	-10.39 - -4.25
E/F	-20.21 - -10.40
F	-35.90 - -20.22

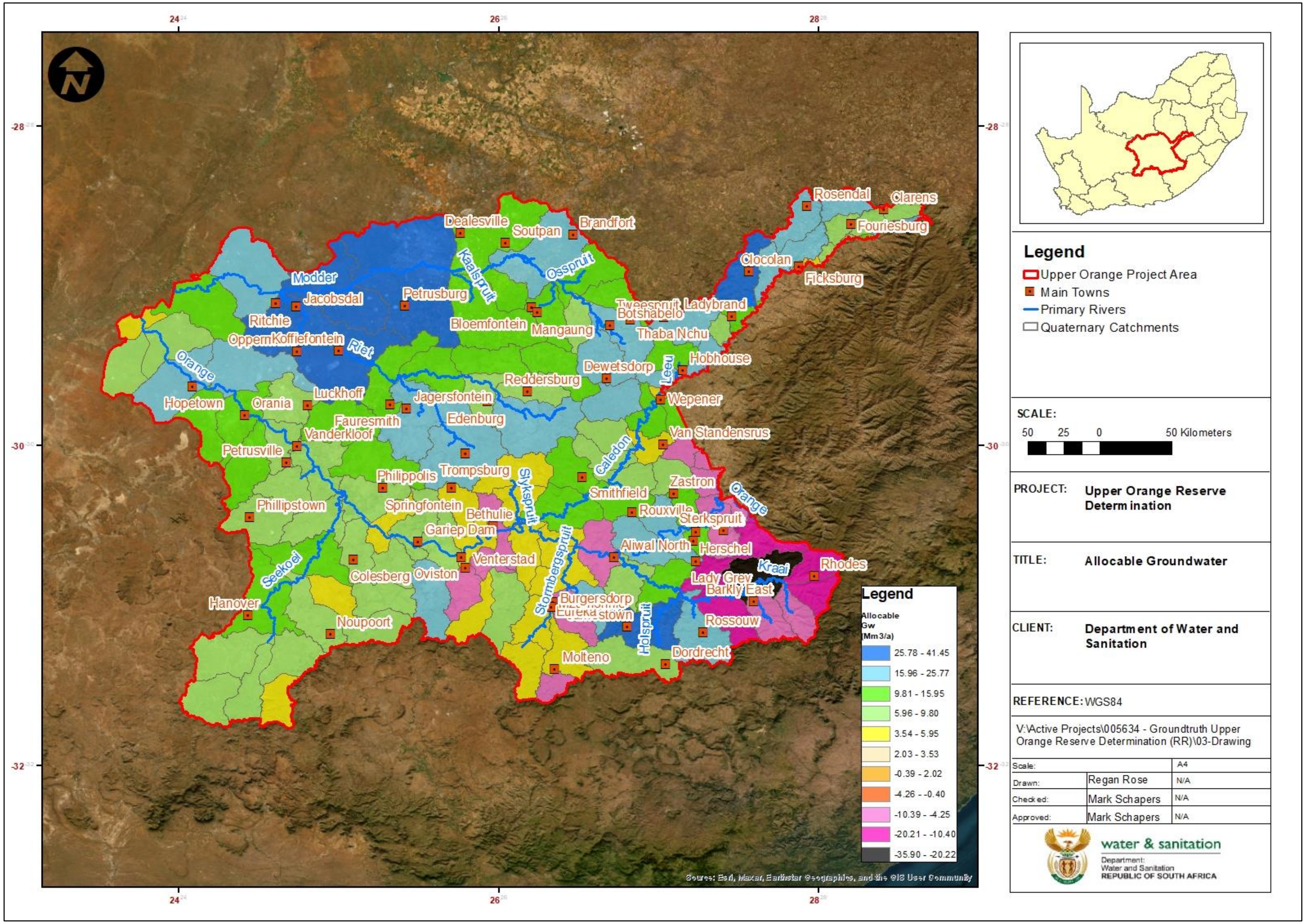

Figure 21: Allocable Groundwater indicating surplus or deficit in respective quaternary catchments

9. CONCLUSIONS

This report details the findings of the groundwater status quo in the catchment and provides estimates of the Groundwater Reserve. The available monitoring data, which comprises of groundwater levels, groundwater quality and surface flow were assessed to determine as far possible the groundwater components of the Reserve. 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. Estimates of the Groundwater Reserve are provided in **Annexure G** for each quaternary catchment. The Groundwater Reserve varies from 0.01% – 223.8% of Recharge.

The available Groundwater Recharge and Use data were used to quantify the SI. The SI results show that all quaternary catchments have surplus groundwater available, i.e. groundwater use is less than Recharge. The majority of the quaternary catchments falls in the "A" (Natural) category (69%), followed by the "A/B" (Natural to Good) category (13%), "B" (Good) category (13%) and "C" (Fair) category (2%). The largest SI in the Catchment is a "D/E", i.e. Poor to Seriously Modified for C52H and C52J, respectively.

A water balance approach was used to quantify allocable groundwater in the catchment. A large range in values can be observed from -35.897Mm^3/a to 42.076Mm^3/a. Negative values indicate that there is no surplus groundwater available in the quaternaries after accounting for the Groundwater Reserve and vice versa. However it must be noted that the quaternaries with negative Allocable Groundwater coincide with "A" (Natural) categories under the SI. This may further indicate that the groundwater contribution to baseflow has been over-estimated.

Groundwater Quality Reserves were determined for 18 of the 129 quaternary catchments as most quaternary catchments do not have groundwater quality data. As a result of this Groundwater Quality Reserves were aggregated to a GRU scale to represent quaternary catchments with no groundwater quality data. For GRU5, GRU6 and GRU11 no groundwater quality data is available for the relevant quaternary catchments. Groundwater quality is within the limits of a Class 1 water quality in terms of DWS Water quality guidelines; however, for GRU4, GRU9, GRU10 and GRU13, the limits exceed DWS Class 1 Water quality guidelines. GRU 4 and GRU 9 have the worst groundwater quality of Class 3 and Class 4, respectively.

Several limitations were identified during this assessment relating to the following:

1) The lack of monthly rainfall and abstraction data to determine more detailed groundwater recharge calculations. Although WR 2012 rainfall data was used, the data is only until end-2009.
2) The lack of rainfall chemistry data for detailed groundwater recharge calculations. In the absence of rainfall chemistry data, a default values were used as prescribed by the Recharge Toolkit.
3) The lack of groundwater quality data for the majority of the quaternary catchments.
4) Incomplete surface flow monitoring data. Although WR 2012 flow data was used, the data is only until end-2009.

5) The GRDM methodology is currently being updated and will only be available in 2024. The current assessment is therefore based on WRC (2012) methodology.

Due to the above-mentioned limitations, this report must be treated as an initial assessment for estimations of the groundwater component of the Reserve in the catchment. This needs to be updated once more detailed data and information become available.

10. RECOMMENDATIONS

Based on the results of the current assessment, the following are recommended:

- Acquire all monitoring data from the regional offices that is currently not in the DWS databases
  - Monthly groundwater level data as conducted by DWS field technicians
- Conduct rainfall sampling and laboratory analysis at strategic locations within the catchment
  - Laboratory analysis must include chloride as a minimum
- Establish and implement an improved regional groundwater monitoring plan. Utilise the outcomes of the current and future assessments to implement and improve the existing regional groundwater monitoring plan
  - Spatial and temporal optimisation of groundwater level monitoring sites
    - GRUs 3, 4, 5, 7, 10 & 14 (prioritised GRUs) to receive priority
  - Spatial and temporal optimisation of groundwater quality monitoring sites
    - GRUs 3, 4, 5, 7, 10 & 14 (prioritised GRUs) to receive priority
- Conduct a follow up on compliance of groundwater use licenses
- Engage with Water Services Providers to provide groundwater monitoring information

11. REFERENCES

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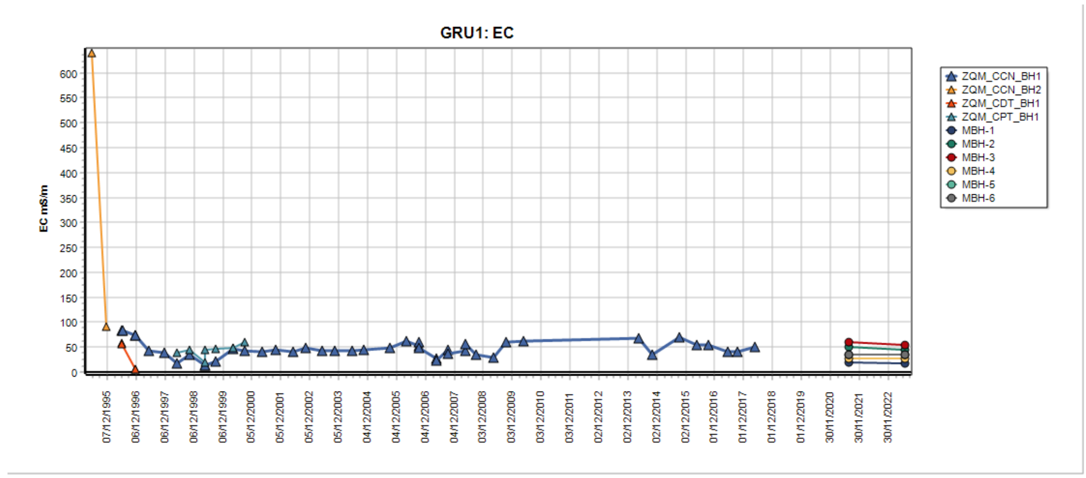
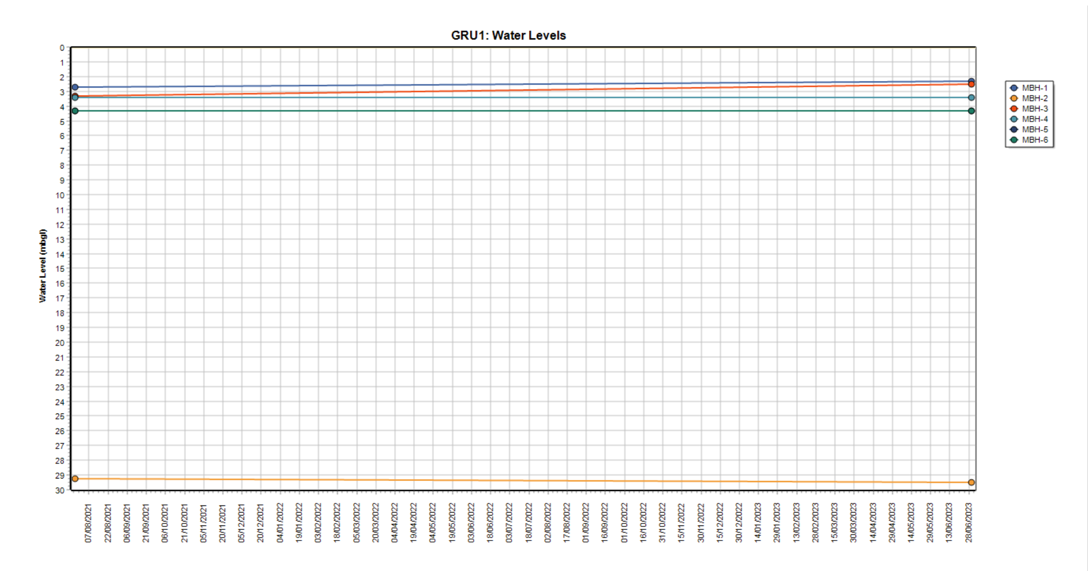
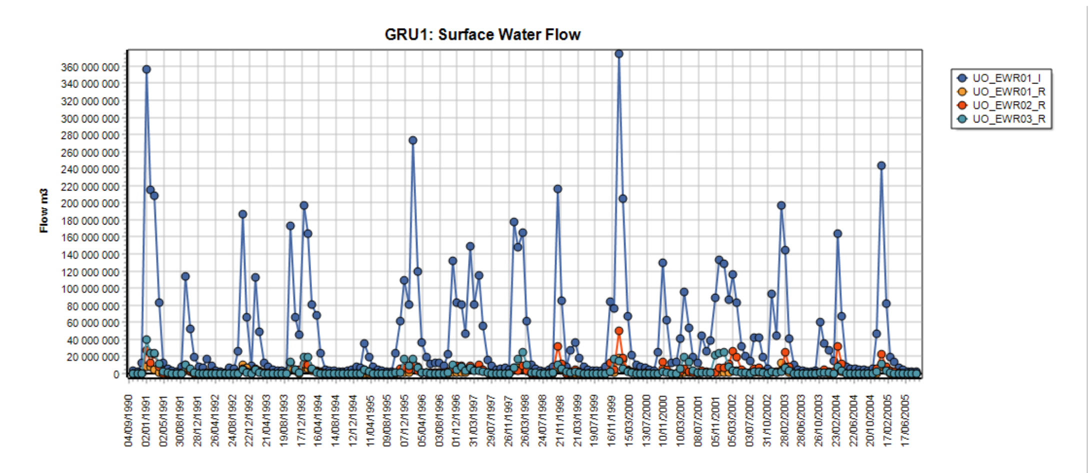
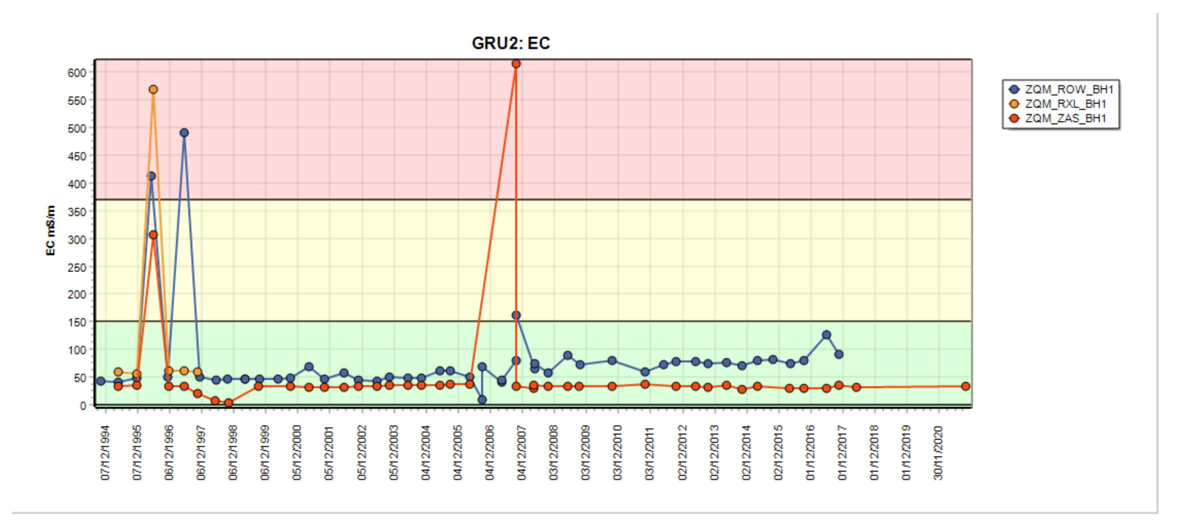
WRC (2012). Water Resources of South Africa, 2012 Study (WR2012). WRC Project No. K5/2143/1

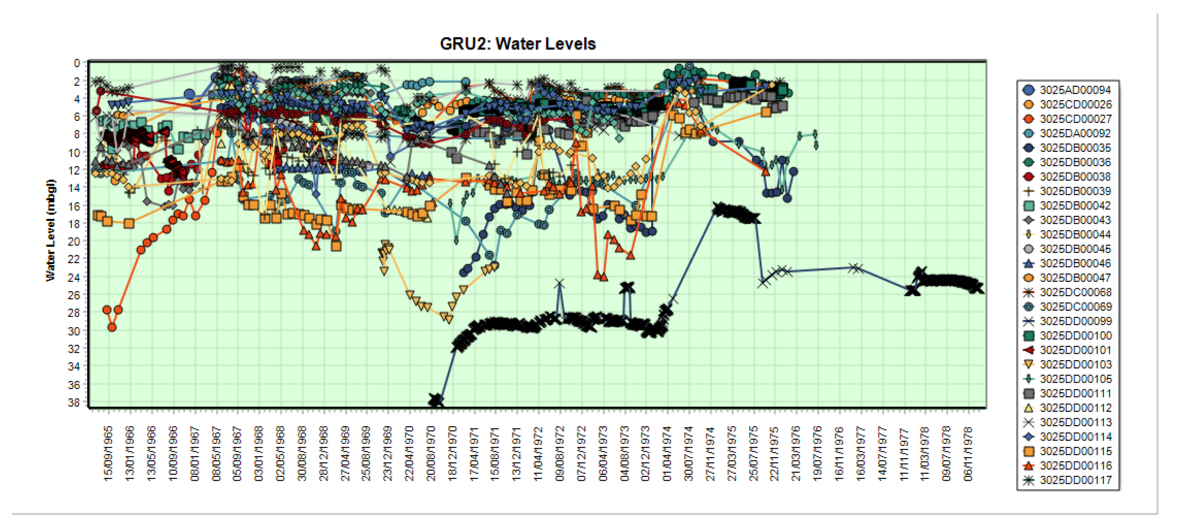
ANNEXURE A – EC, WATER LEVELS AND SURFACE WATER FLOW GRAPHS PER GRU








GRU2: EC
EC mS/m
ZQM_ROW_BH1
ZQM_RXL_BH1
ZQM_ZAS_BH1


GRU2: Water Levels
Water Level (mbgl)
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3025CD00027
3025DA00092
3025DB00035
3025DB00036
3025DB00038
3025DB00039
3025DB00042
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3025DB00044
3025DB00045
3025DB00046
3025DB00047
3025DC00068
3025DC00069
3025DD00099
3025DD00100
3025DD00101
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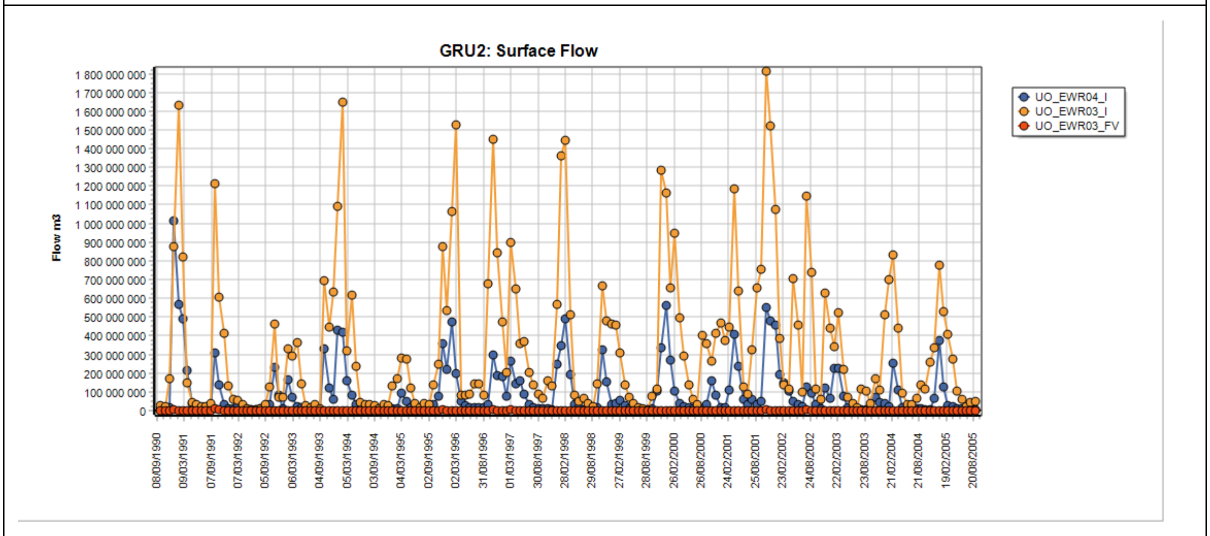
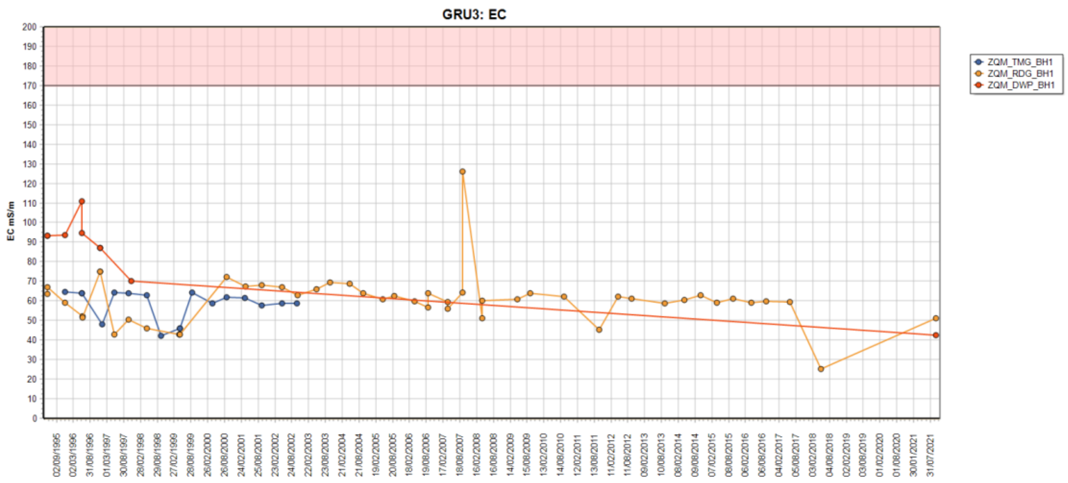
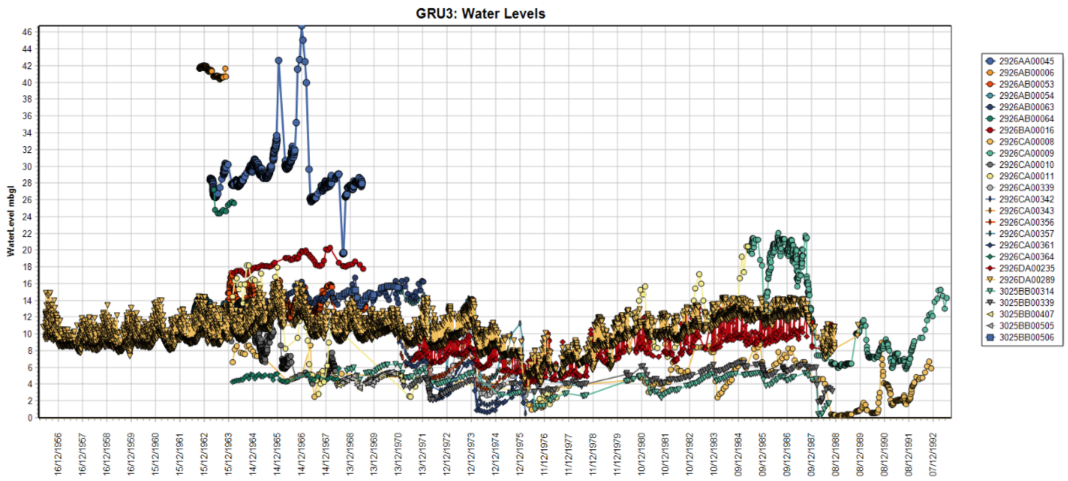
3025DD00117


GRU2: Surface Flow
Flow m3
UO_EWR04_I
UO_EWR03_I
UO_EWR03_FV


GRU3: EC
EC mS/m
ZQM_TMG_BH1
ZQM_RDG_BH1
ZQM_DWP_BH1


GRU3: Water Levels
Water Level mbgl
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2926AB00053
2926AB00054
2926AB00063
2926AB00064
2926BA00016
2926CA00008
2926CA00009
2926CA00010
2926CA00011
2926CA00339
2926CA00342
2926CA00343
2926CA00356
2926CA00357
2926CA00361
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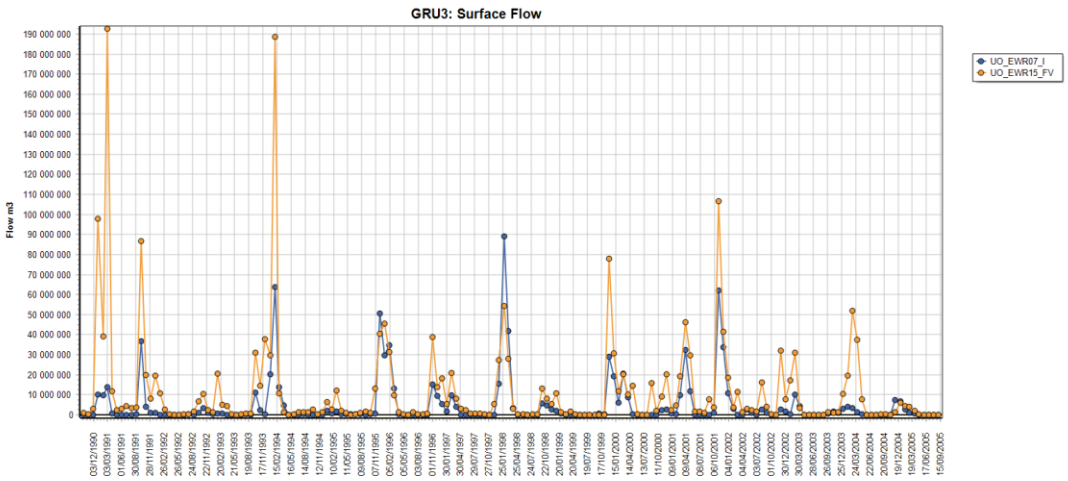
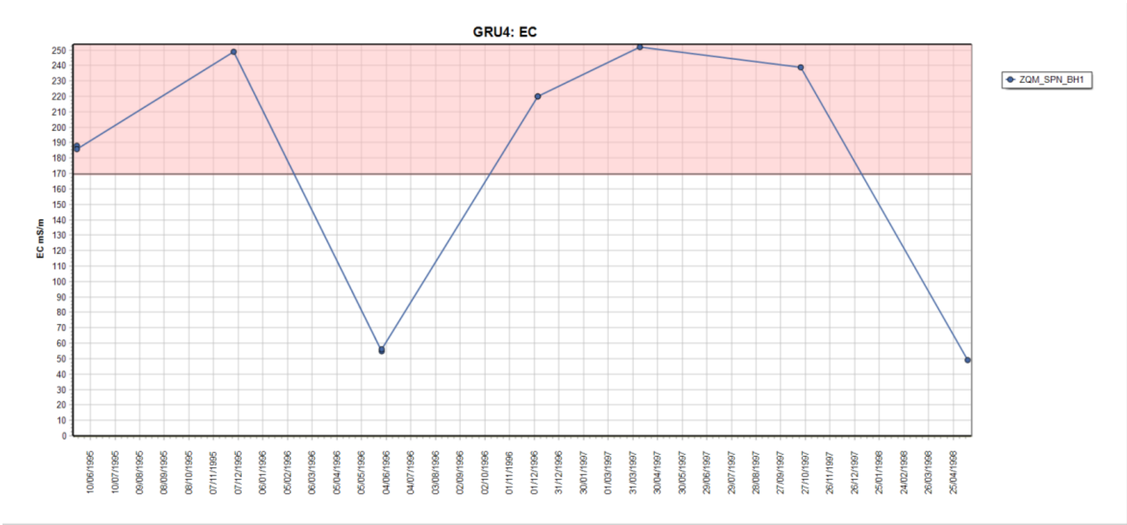
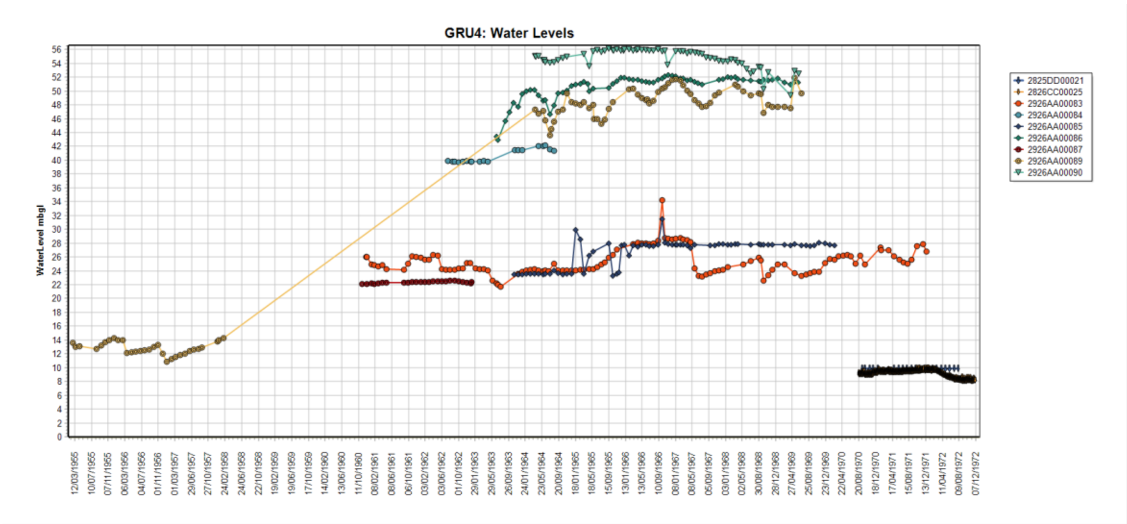

GRU3: Surface Flow
Flow m3
UO_EWR07_I
UO_EWR15_FV


GRU4: EC
EC mS/m
ZQM_SPN_BH1


GRU4: Water Levels
WaterLevel mbgl
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2926AA00083
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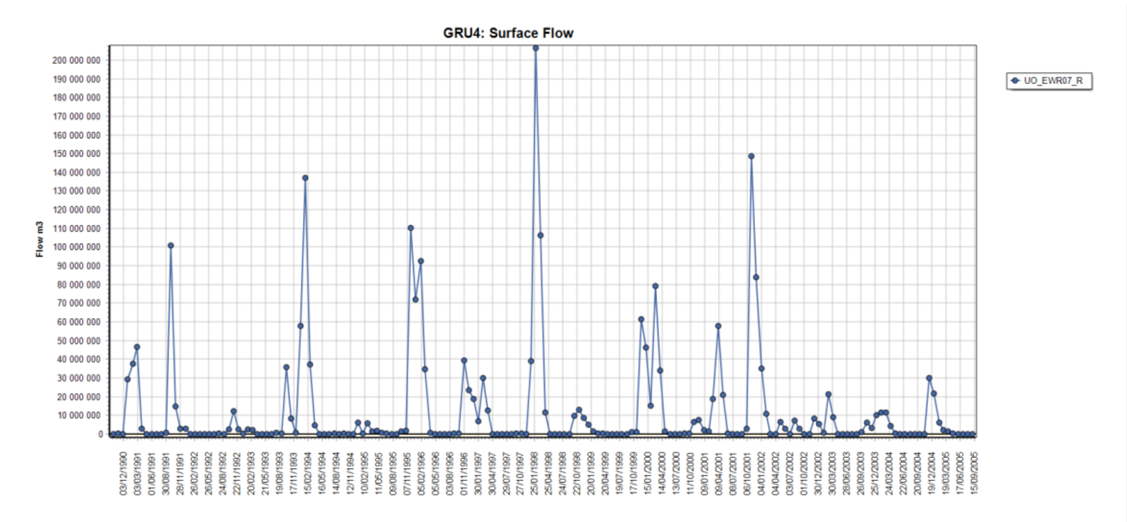
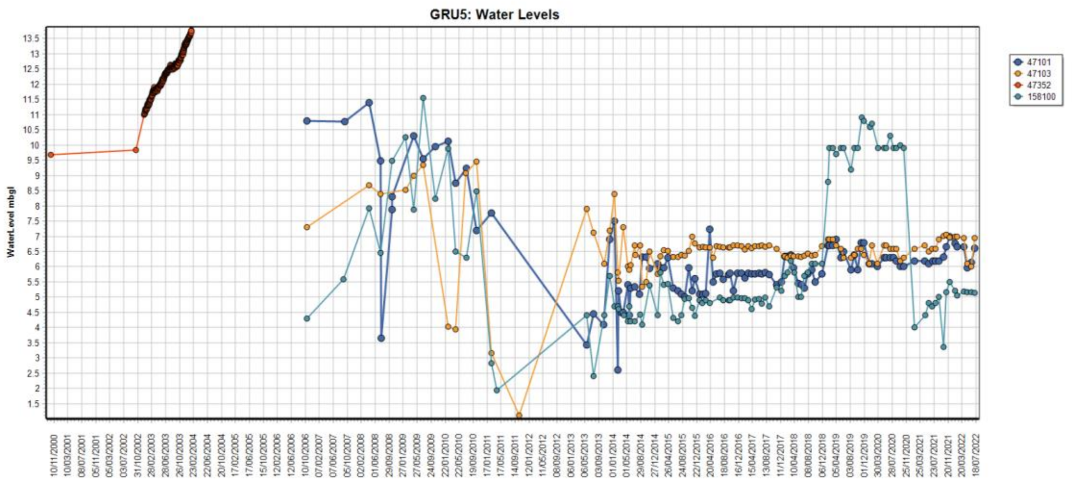
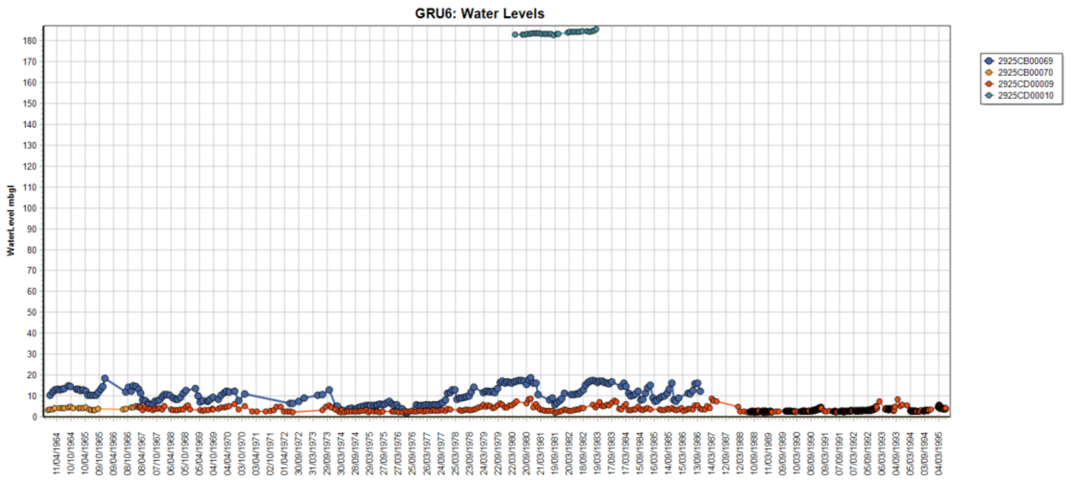
2926AA00089
2926AA00090


GRU4: Surface Flow
Flow m3
UO_EWR07_R


GRU5: Water Levels
Water Level mbgl
47101
47103
47352
158100


GRU6: Water Levels
Water Level mbgl
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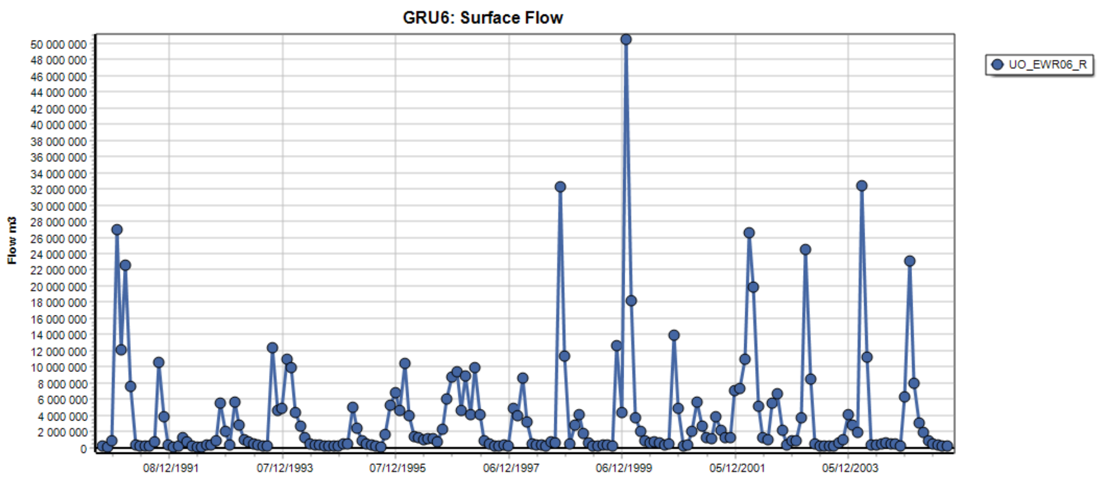
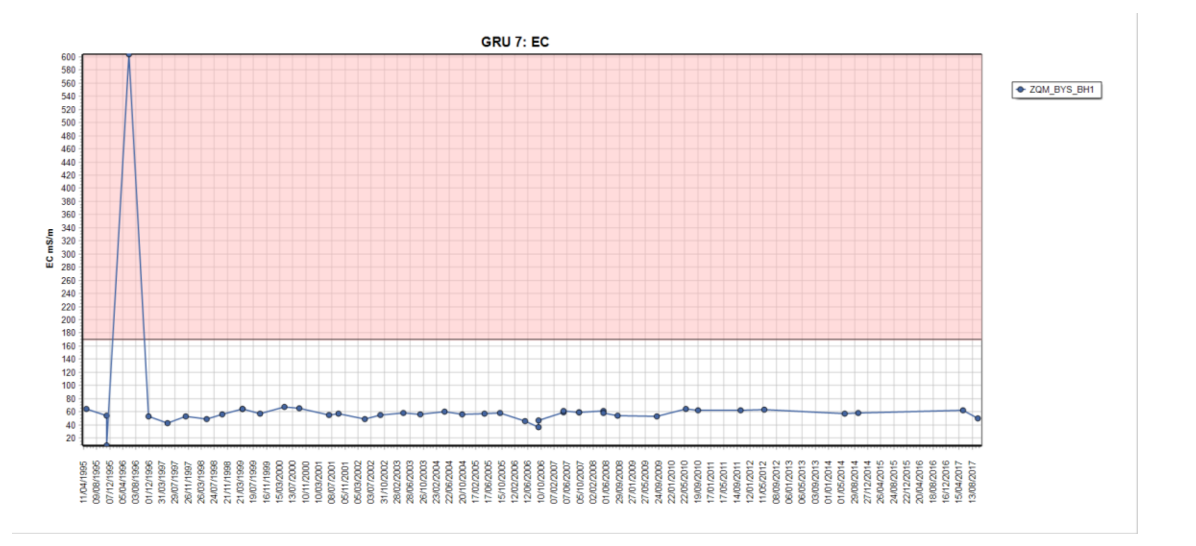
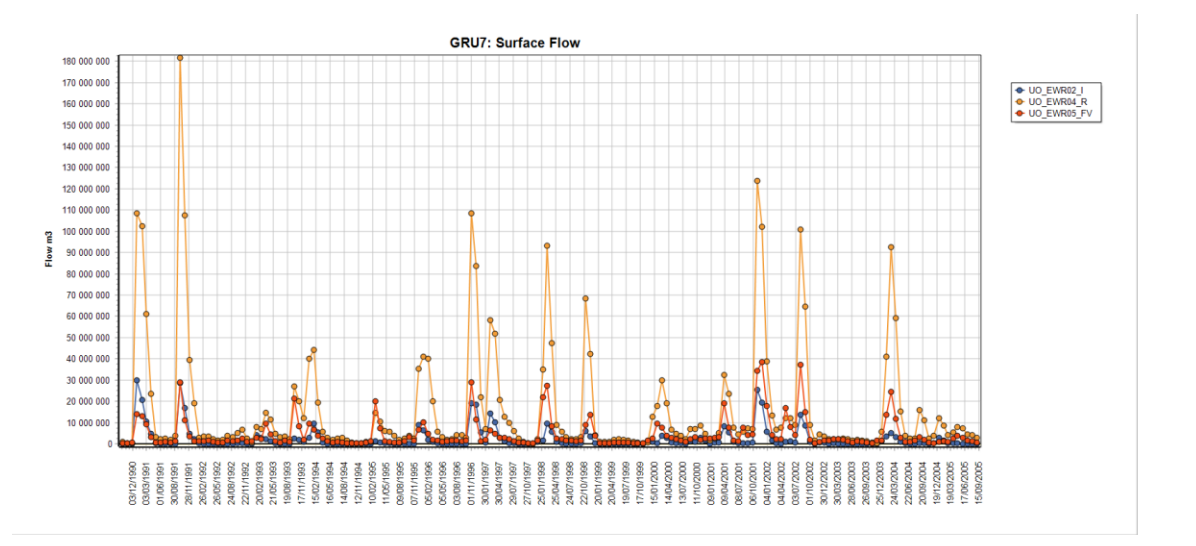
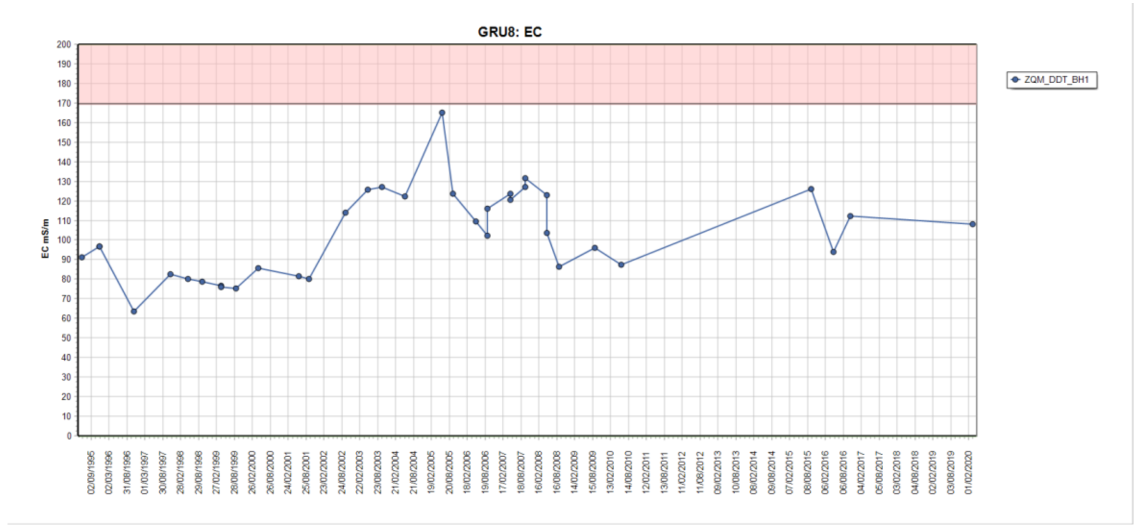
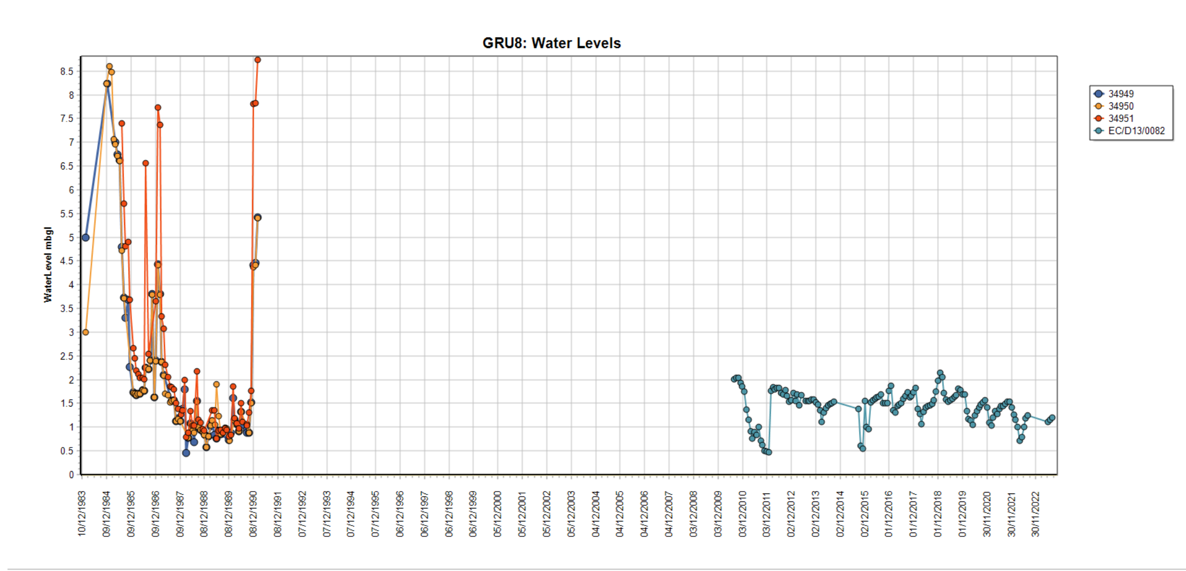
2925CB00070
2925CD00009
2925CD00010

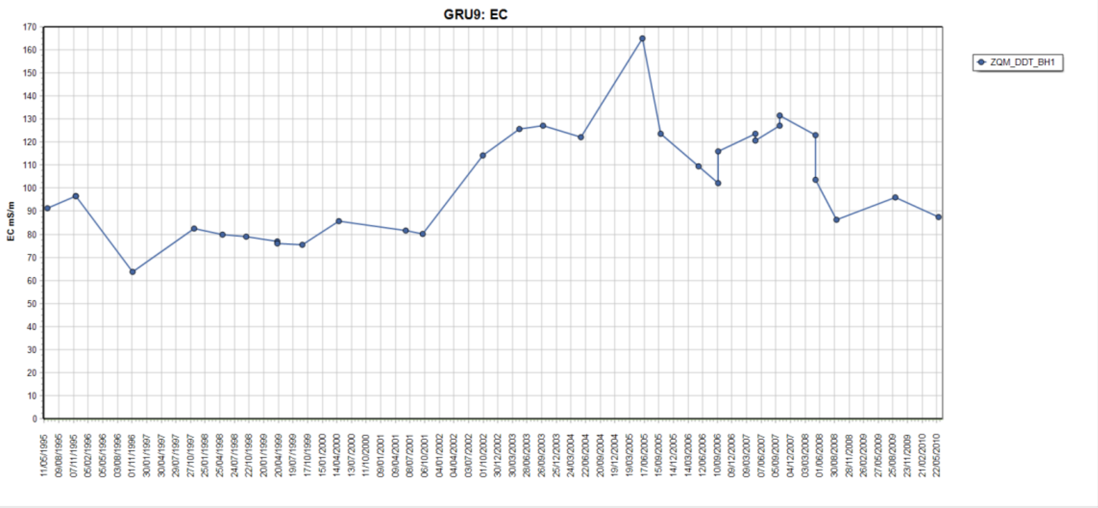

GRU6: Surface Flow
Flow m3
UO_EWR06_R
08/12/1991
07/12/1993
07/12/1995
06/12/1997
06/12/1999
05/12/2001
05/12/2003

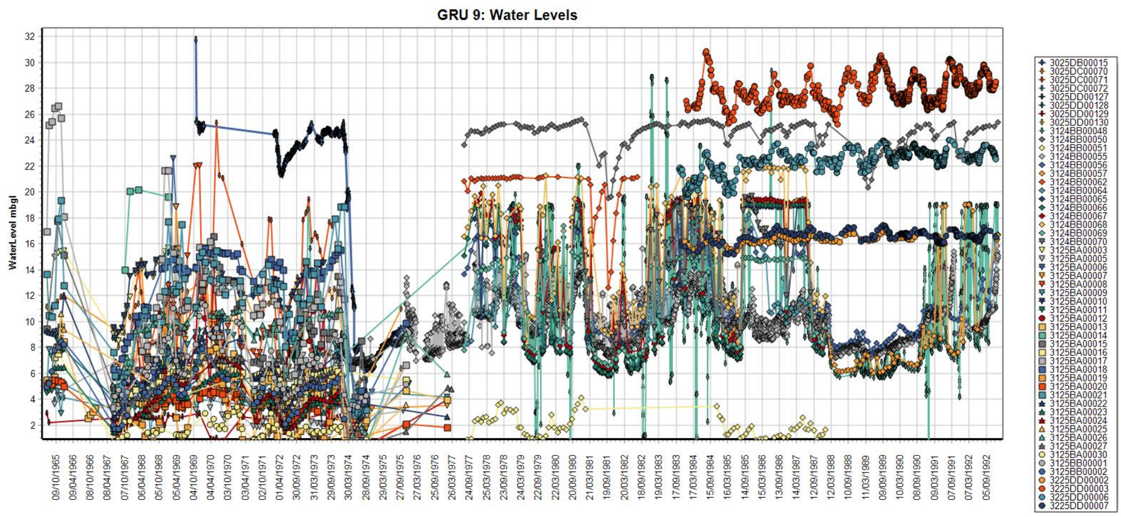

GRU 7: EC
EC mS/m
ZQM_BYS_BH1


GRU7: Surface Flow
Flow m3
UO_EWR02_I
UO_EWR04_R
UO_EWR05_FV


GRU8: EC
EC mS/m
ZQM_DDT_BH1


GRU8: Water Levels
WaterLevel mbgl
34949
34950
34951
EC/D13/0082


GRU9: EC
EC mS/m
ZQM_DDT_BH1


GRU 9: Water Levels
Water.Level mbgl
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3025DC00071
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3025DD00128
3025DD00129
3025DD00130
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3124BB00051
3124BB00055
3124BB00056
3124BB00057
3124BB00062
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3124BB00066
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3124BB00068
3124BB00069
3124BB00070
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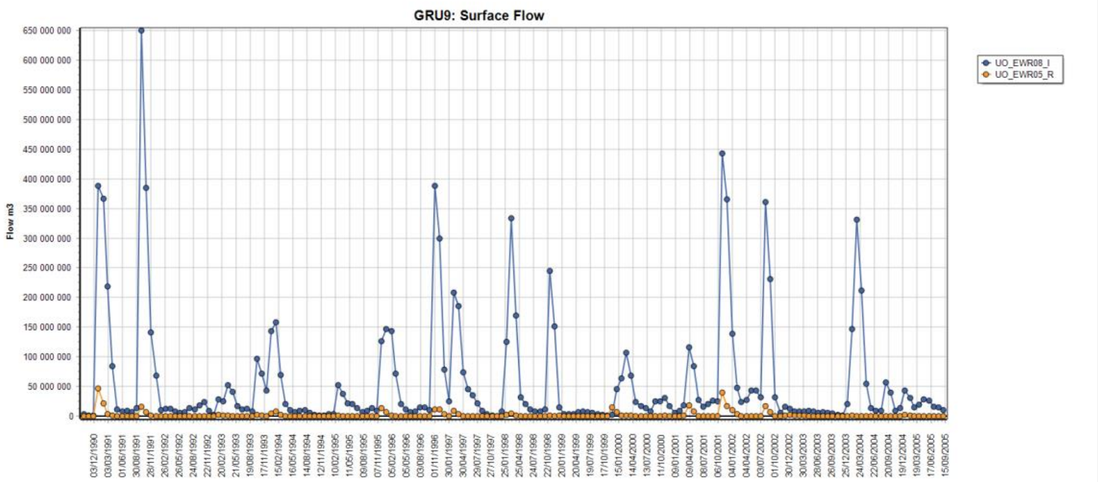
3225DD00007


GRU9: Surface Flow
Flow m3
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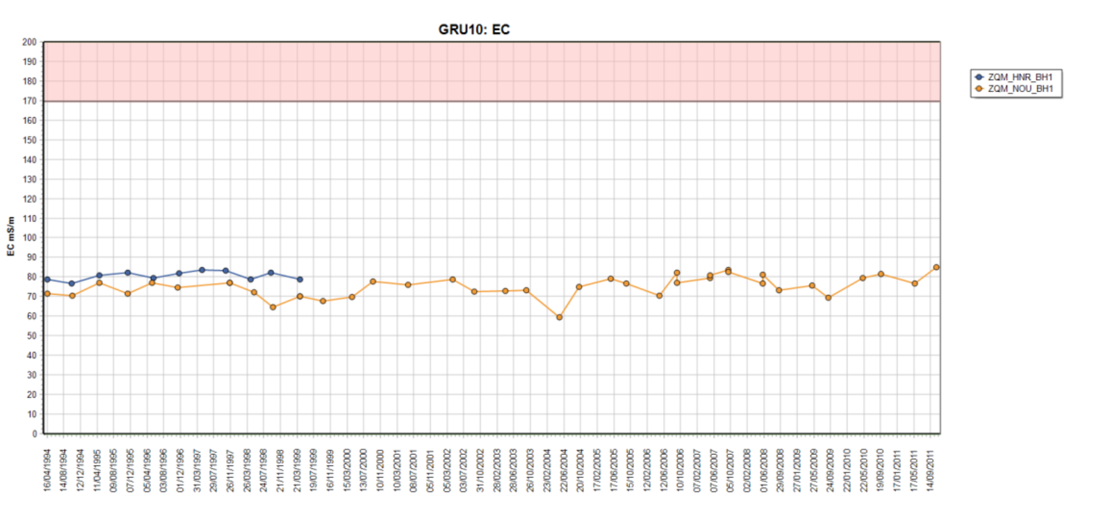
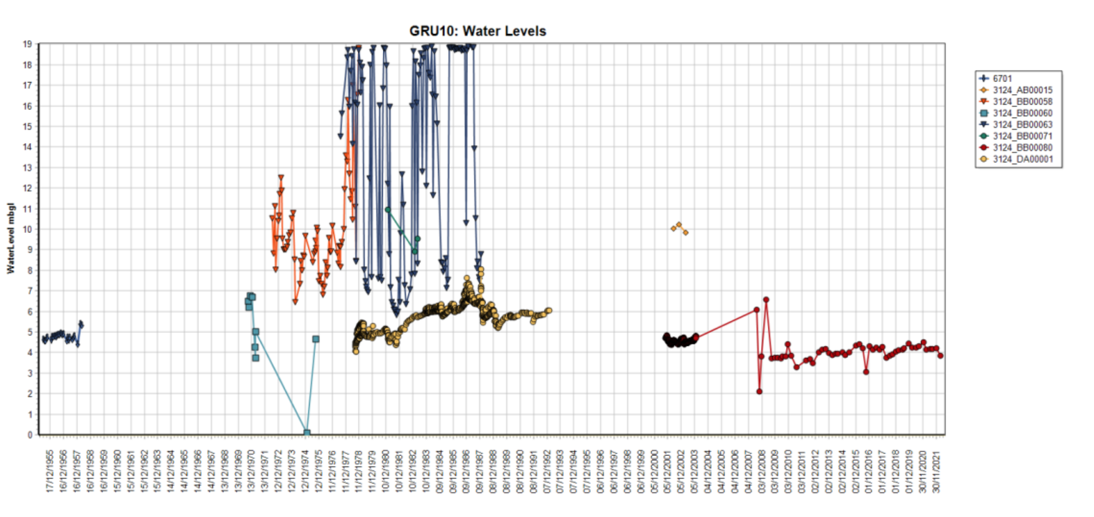
UO_EWR05_R


GRU10: EC
EC mS/m
ZQM_HNR_BH1
ZQM_NOU_BH1


GRU10: Water Levels
Water Level mbgl
6701
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3124_BB00058
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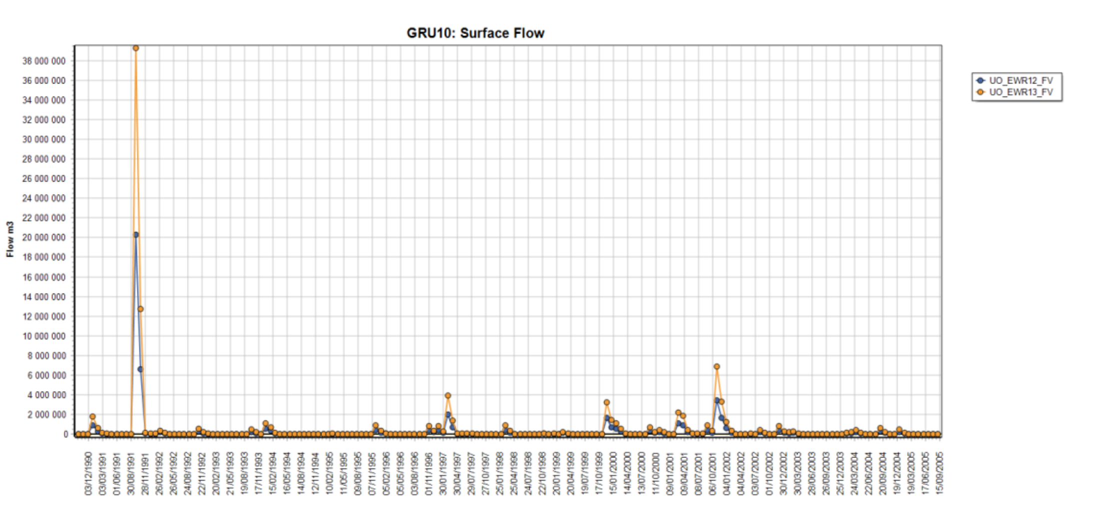
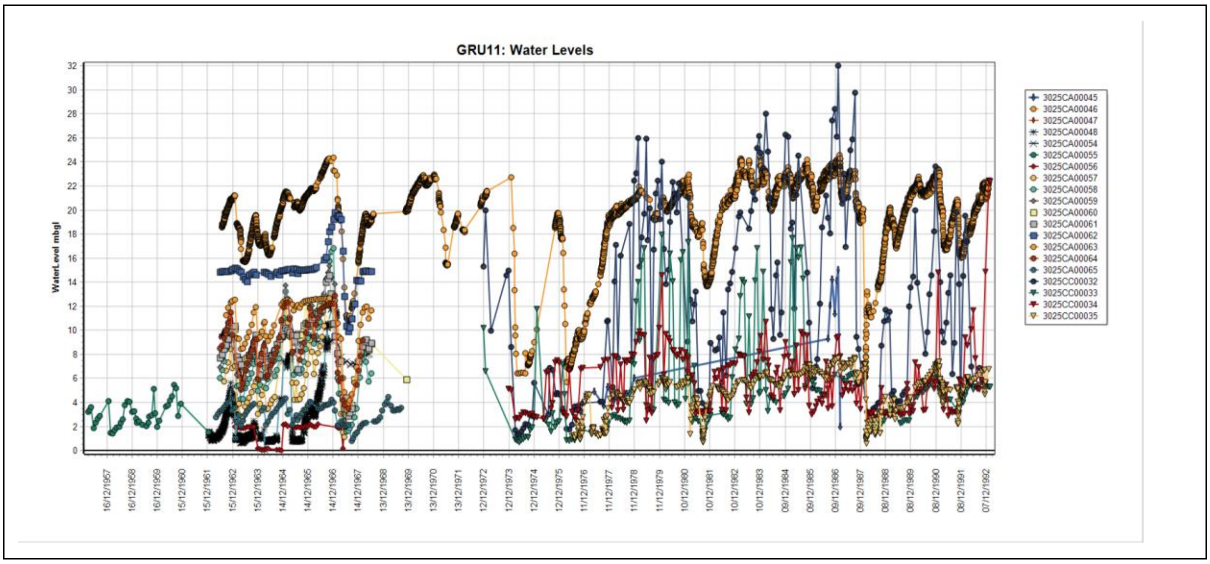
3124_BB00080
3124_DA00001


GRU10: Surface Flow
Flow m3
UO_EWR12_FV
UO_EWR13_FV


GRU11: Water Levels
Water Level mbgl
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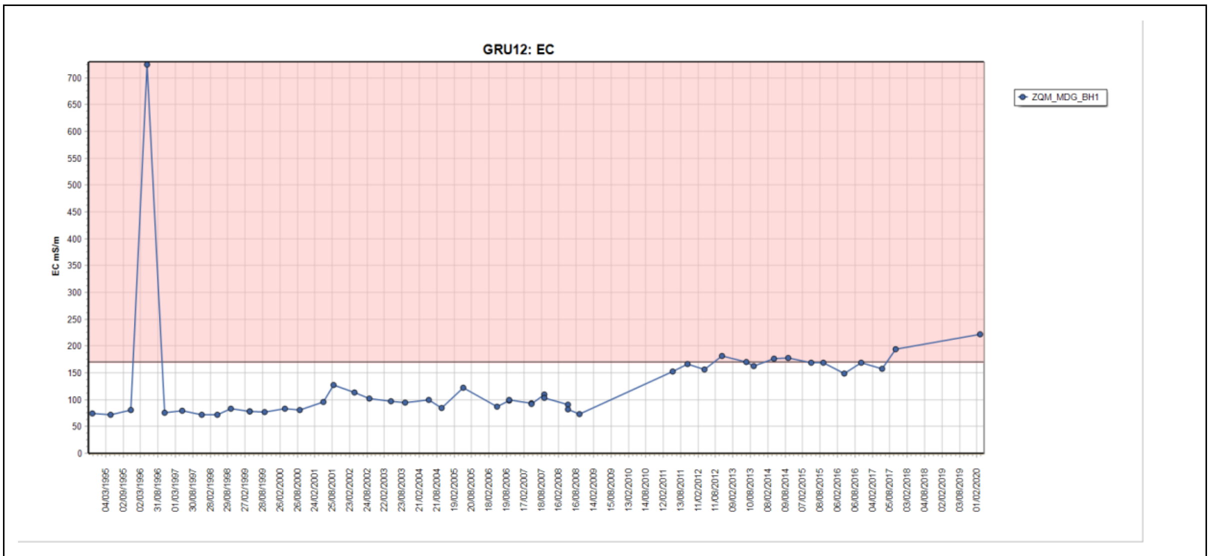
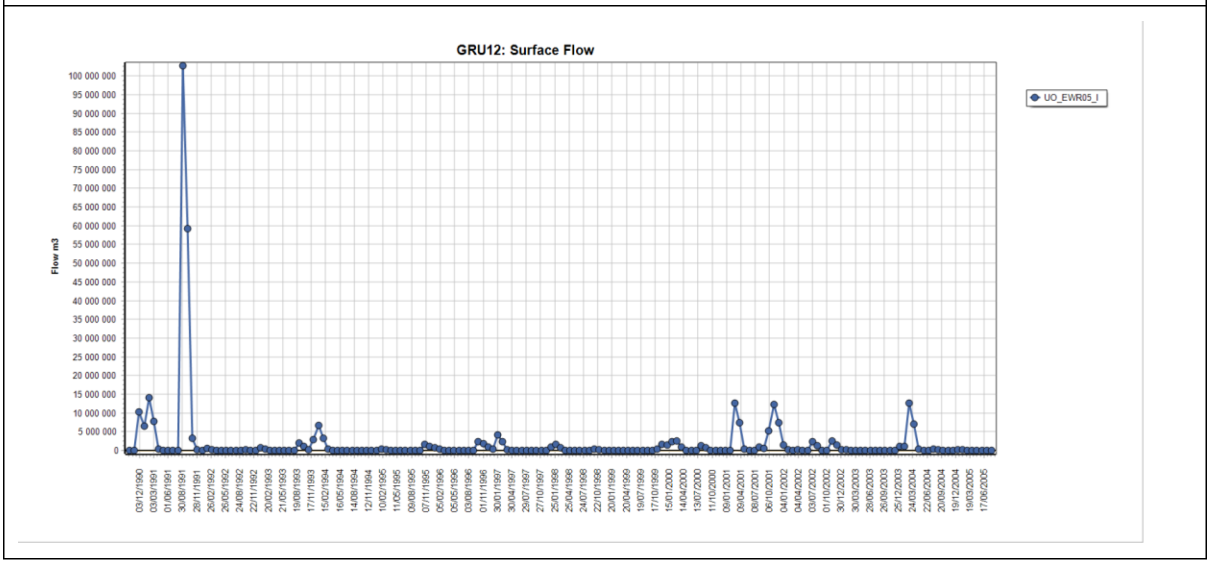
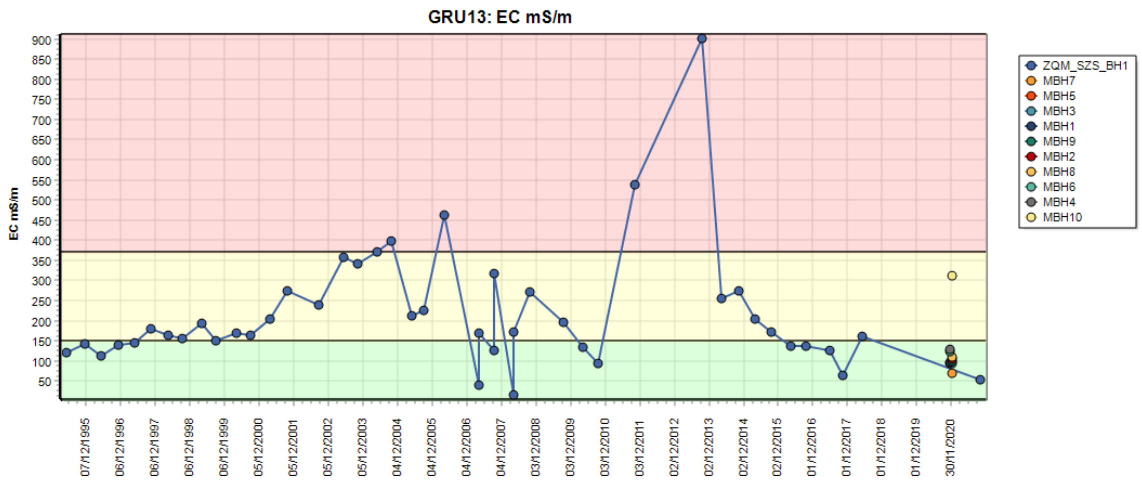

GRU12: EC
EC mS/m
ZQM_MDG_BH1


GRU12: Surface Flow
Flow m3
UO_EWR05_I


GRU13: EC mS/m
EC mS/m
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MBH5
MBH3
MBH1
MBH9
MBH2
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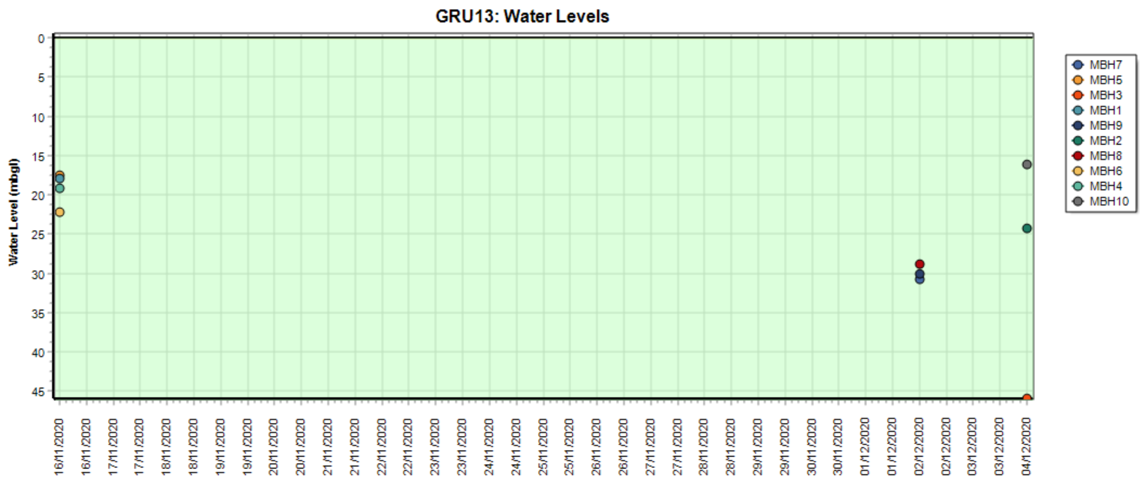
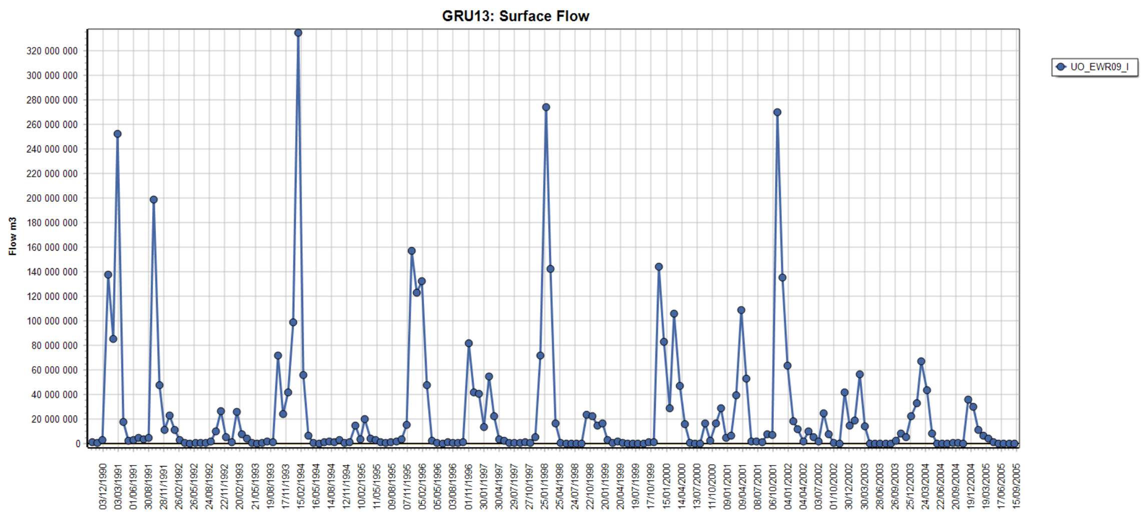
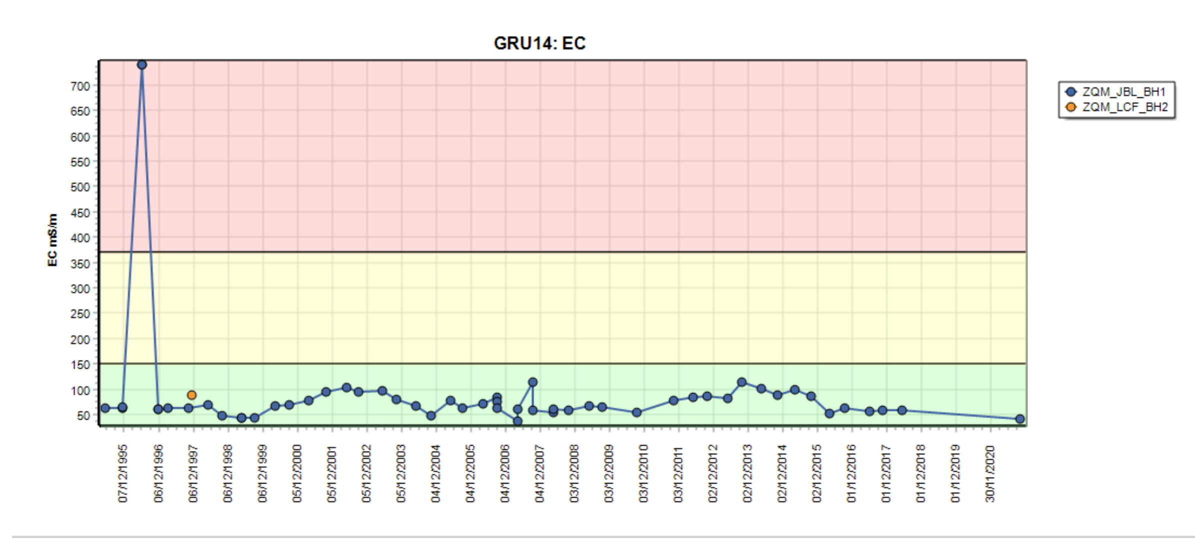
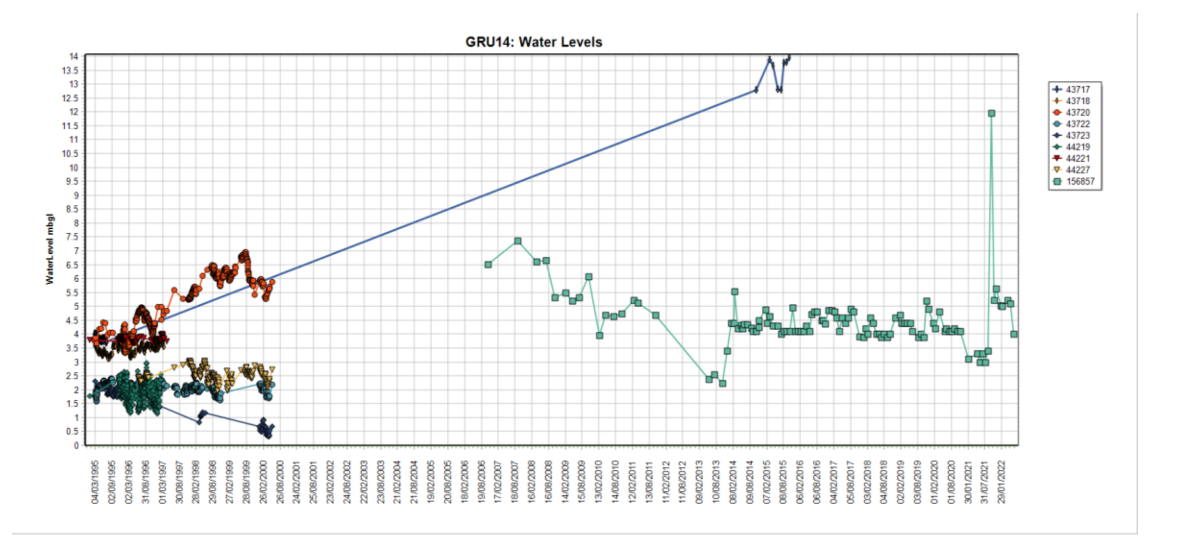
MBH6
MBH4
MBH10


GRU13: Water Levels
Water Level (mbgl)
MBH7
MBH5
MBH3
MBH1
MBH9
MBH2
MBH8
MBH6
MBH4
MBH10


GRU13: Surface Flow
Flow m3
UO_EWR09_I


GRU14: EC
EC mS/m
ZQM_JBL_BH1
ZQM_LCF_BH2


GRU14: Water Levels
Waterlevel mbgl
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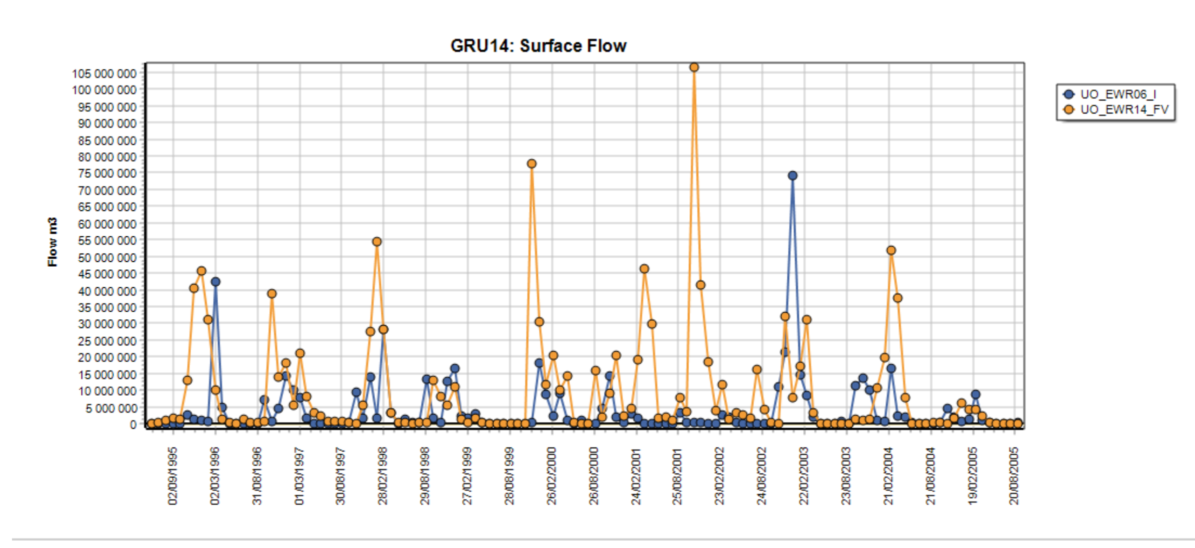
43718
43720
43722
43723
44219
44221
44227
156857


GRU14: Surface Flow
Flow m3
UO_EWR06_I
UO_EWR14_FV

ANNEXURE B – RECHARGE

Table 23: Summary of Groundwater Recharge Calculations

Quaternary Catchment	Recharge Method	Average Annual Recharge (mm)	Recharge (% of Rainfall)	Recharge (Mm^3/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
C51H	Qualified Guess	15.5	3.9	27.668
C51J	Qualified Guess	16.7	4.3	17.592
C51K	CMB+Qualified Guess	13.9	4	50.301
C51L	Qualified Guess	10.3	2.9	20.906
C51M	CMB+Qualified Guess	6.8	2.1	10.364
C52A	CMB+Qualified Guess	26.5	4.9	24.854
C52B	Qualified Guess	27.4	4.9	25.978
C52C	Qualified Guess	26.4	5	15.868
C52D	Qualified Guess	24.3	4.7	11.440
C52E	Qualified Guess	18.4	3.8	16.466
C52F	Qualified Guess	18.9	3.7	12.988
C52G	Qualified Guess	15.9	3.3	28.516
C52H	CMB+Qualified Guess	12.6	2.8	29.795
C52J	Qualified Guess	18	3.9	34.508
C52K	Qualified Guess	13.1	3.2	56.603
C52L	Qualified Guess	16.3	4.3	39.179
D12A	CMB+Qualified Guess	41.7	6.6	15.376
D12B	CMB+Qualified Guess	43.6	6.1	16.802
D12C	CMB+Qualified Guess	43.6	6.8	14.955
D12D	CMB+Qualified Guess	38.1	6.3	13.523
D12E	CMB+Qualified Guess	37.7	6.4	26.824
D12F	CMB+Qualified Guess	33.6	6.2	24.992
D13A	Qualified Guess	39.2	4.8	18.600
D13B	Qualified Guess	37.9	4.8	20.209
D13C	Qualified Guess	39.4	5.6	20.376
D13D	CMB+Qualified Guess	45.5	6.7	28.928
D13E	Qualified Guess	28	3.7	28.904

Quaternary Catchment	Recharge Method	Average Annual Recharge (mm)	Recharge (% of Rainfall)	Recharge (Mm³/a)
D13F	Qualified Guess	34	5.1	32.999
D13G	Qualified Guess	30.7	4.9	34.568
D13H	CMB+Qualified Guess	12.4	2.3	14.231
D13J	Qualified Guess	30	5.4	34.980
D13K	Qualified Guess	29.7	4.1	11.809
D13L	Qualified Guess	30.4	5.1	20.704
D13M	Qualified Guess	15.1	2.8	10.246
D14A	CMB+Qualified Guess	10.2	2.1	7.834
D14B	Qualified Guess	14.6	3	4.741
D14C	Qualified Guess	12.4	2.5	8.964
D14D	Qualified Guess	12	2.7	8.141
D14E	CMB+Qualified Guess	10.9	2.5	7.239
D14F	Qualified Guess	12.4	2.5	6.725
D14G	Qualified Guess	24.8	3.9	27.944
D14H	Qualified Guess	12.1	2.8	8.410
D14J	Qualified Guess	12.1	2.8	6.217
D14K	Qualified Guess	12	2.8	7.599
D15G	Qualified Guess	26.5	4	12.832
D15H	Qualified Guess	23.5	3.9	8.463
D18K	Qualified Guess	34.1	4.4	31.879
D18L	Qualified Guess	32.2	4.9	19.649
D21A	Qualified Guess	73.2	7.5	22.647
D21C	Qualified Guess	60.2	6.8	12.729
D21D	Qualified Guess	53.3	6.4	13.415
D21E	CMB+Qualified Guess	62.2	7.9	16.701
D21F	Qualified Guess	52.1	7.2	25.000
D21G	Qualified Guess	41.6	5.5	11.566
D21H	Qualified Guess	53.7	6.9	20.450
D22A	Qualified Guess	43.5	6.4	27.625
D22B	Qualified Guess	55.9	7.7	25.541
D22C	Qualified Guess	44.1	5.6	21.398
D22D	Qualified Guess	36.1	5.2	22.649
D22G	CMB+Qualified Guess	39.3	5.7	38.045
D22H	Qualified Guess	37.1	5.1	20.057
D22L	Qualified Guess	31.3	4.4	11.794
D23A	Qualified Guess	39.9	5.8	24.247
D23C	Qualified Guess	30.7	4.8	26.455
D23D	Qualified Guess	29	4.8	16.377
D23E	Qualified Guess	29	4.7	20.350

Quaternary Catchment	Recharge Method	Average Annual Recharge (mm)	Recharge (% of Rainfall)	Recharge (Mm^3/a)
D23F	Qualified Guess	18.4	2.9	6.475
D23G	Qualified Guess	28.9	4.7	14.804
D23H	Qualified Guess	26.4	5.1	20.477
D23J	Qualified Guess	27	5	14.398
D24A	Qualified Guess	19.3	3.1	5.973
D24B	Qualified Guess	19.2	3.3	9.050
D24C	Qualified Guess	17.3	3.3	6.902
D24D	Qualified Guess	16.9	3.5	10.140
D24E	Qualified Guess	17.1	3.5	8.383
D24F	Qualified Guess	18.5	3.6	10.515
D24G	CMB+Qualified Guess	21.6	4.1	13.514
D24H	Qualified Guess	17	3.6	12.517
D24J	Qualified Guess	16.7	3.7	17.252
D24K	Qualified Guess	18.6	2.1	8.223
D24L	Qualified Guess	14.5	3.3	7.392
D31A	Qualified Guess	11.8	3	13.713
D31B	Qualified Guess	10.1	3.2	10.076
D31C	Qualified Guess	10.3	3.1	6.959
D31D	Qualified Guess	13.6	3.6	15.036
D31E	Qualified Guess	10.6	3	10.251
D32A	Qualified Guess	10.9	3.5	7.783
D32B	Qualified Guess	11.2	3.3	6.479
D32C	Qualified Guess	11.8	3.7	10.060
D32D	Qualified Guess	10.9	3.5	9.236
D32E	CMB+Qualified Guess	8	2.9	9.282
D32F	Qualified Guess	10.8	3.5	15.570
D32G	CMB+Qualified Guess	10.4	3.1	10.829
D32H	CMB+Qualified Guess	10.4	3.2	5.974
D32J	Qualified Guess	10.2	3.3	14.635
D32K	CMB+Qualified Guess	9.5	2.9	7.795
D33A	Qualified Guess	15.2	4.6	9.024
D33B	Qualified Guess	10.1	3.2	10.307
D33C	Qualified Guess	12.5	3.7	10.015
D33D	Qualified Guess	11.8	4	11.249
D33E	Qualified Guess	12	3.9	18.597
D33F	Qualified Guess	13.6	4.7	11.686
D33G	Qualified Guess	11.6	4.1	16.263
D33H	Qualified Guess	8.8	3	9.296
D33J	Qualified Guess	8.5	3.1	7.330

Quaternary Catchment	Recharge Method	Average Annual Recharge (mm)	Recharge (% of Rainfall)	Recharge (Mm^3/a)
D33K	Qualified Guess	9.5	3.3	4.649
D34A	Qualified Guess	11.4	3	9.071
D34B	Qualified Guess	11.3	3.1	8.004
D34C	Qualified Guess	11.2	3.3	8.491
D34D	Qualified Guess	11.2	3.2	6.726
D34E	Qualified Guess	11.4	3.1	5.902
D34F	Qualified Guess	11.1	3.3	7.690
D34G	Qualified Guess	11.7	3.2	10.962
D35A	Qualified Guess	12.1	2.8	3.072
D35B	Qualified Guess	11.9	2.8	3.108
D35C	Qualified Guess	11.7	2.9	11.058
D35D	Qualified Guess	11.6	3	6.816
D35E	Qualified Guess	11.8	2.9	3.667
D35F	Qualified Guess	11.9	2.8	6.624
D35G	Qualified Guess	11.6	3	6.399
D35H	Qualified Guess	12.2	3	6.070
D35J	CMB+Qualified Guess	19.1	5.2	19.138
D35K	Qualified Guess	12.2	3.2	8.194

ANNEXURE C – BASIC HUMAN NEEDS

Table 24: Summary of BHN Groundwater Reserve

Quaternary drainage region	Population depending on groundwater as BHN	Per capita need (litres / day)	Basic human needs ground water Reserve required (MCM / annum)
C51A	489	25	0.004
C51B	804	25	0.007
C51C	313	25	0.003
C51D	1 894	25	0.017
C51E	1 140	25	0.01
C51F	528	25	0.005
C51G	752	25	0.007
C51H	1 062	25	0.01
C51J	585	25	0.005
C51K	1 833	25	0.017
C51L	1 032	25	0.009
C51M	723	25	0.007
C52A	906	25	0.008
C52B	1 394	25	0.013
C52C	594	25	0.005
C52D	590	25	0.005
C52E	750	25	0.007
C52F	5 048	25	0.046
C52G	1 609	25	0.015
C52H	3 174	25	0.029
C52J	7 480	25	0.068
C52K	2 652	25	0.024
C52L	1 690	25	0.015
D12A	4 237	25	0.039
D12B	6 317	25	0.058
D12C	1 401	25	0.013
D12D	224	25	0.002
D12E	799	25	0.007
D12F	530	25	0.005
D13A	329	25	0.003
D13B	366	25	0.003
D13C	358	25	0.003

Quaternary drainage region	Population depending on groundwater as BHN	Per capita need (litres / day)	Basic human needs ground water Reserve required (MCM / annum)
D13D	478	25	0.004
D13E	855	25	0.008
D13F	855	25	0.008
D13G	923	25	0.008
D13H	864	25	0.008
D13J	747	25	0.007
D13K	358	25	0.003
D13L	445	25	0.004
D13M	557	25	0.005
D14A	740	25	0.007
D14B	190	25	0.002
D14C	446	25	0.004
D14D	383	25	0.003
D14E	425	25	0.004
D14F	302	25	0.003
D14G	373	25	0.003
D14H	487	25	0.004
D14J	285	25	0.003
D14K	319	25	0.003
D15G	76	25	0.001
D15H	209	25	0.002
D18K	4 263	25	0.039
D18L	5 401	25	0.049
D21A	280	25	0.003
D21C	76	25	0.001
D21D	795	25	0.007
D21E	929	25	0.008
D21F	1 623	25	0.015
D21G	773	25	0.007
D21H	279	25	0.003
D22A	1 223	25	0.011
D22B	997	25	0.009
D22C	223	25	0.002
D22D	1 034	25	0.009
D22G	1 651	25	0.015
D22H	612	25	0.006

Quaternary drainage region	Population depending on groundwater as BHN	Per capita need (litres / day)	Basic human needs ground water Reserve required (MCM / annum)
D22L	551	25	0.005
D23A	622	25	0.006
D23C	1 444	25	0.013
D23D	1 218	25	0.011
D23E	639	25	0.006
D23F	56	25	0.001
D23G	224	25	0.002
D23H	507	25	0.005
D23J	468	25	0.004
D24A	236	25	0.002
D24B	268	25	0.002
D24C	322	25	0.003
D24D	195	25	0.002
D24E	151	25	0.001
D24F	166	25	0.002
D24G	314	25	0.003
D24H	305	25	0.003
D24J	569	25	0.005
D24K	364	25	0.003
D24L	167	25	0.002
D31A	439	25	0.004
D31B	204	25	0.002
D31C	160	25	0.001
D31D	364	25	0.003
D31E	290	25	0.003
D32A	146	25	0.001
D32B	282	25	0.003
D32C	297	25	0.003
D32D	151	25	0.001
D32E	242	25	0.002
D32F	351	25	0.003
D32G	374	25	0.003
D32H	216	25	0.002
D32J	368	25	0.003
D32K	272	25	0.002
D33A	169	25	0.002

Quaternary drainage region	Population depending on groundwater as BHN	Per capita need (litres / day)	Basic human needs ground water Reserve required (MCM / annum)
D33B	217	25	0.002
D33C	178	25	0.002
D33D	250	25	0.002
D33E	669	25	0.006
D33F	294	25	0.003
D33G	549	25	0.005
D33H	446	25	0.004
D33J	385	25	0.004
D33K	180	25	0.002
D34A	288	25	0.003
D34B	364	25	0.003
D34C	366	25	0.003
D34D	271	25	0.002
D34E	201	25	0.002
D34F	403	25	0.004
D34G	341	25	0.003
D35A	96	25	0.001
D35B	124	25	0.001
D35C	404	25	0.004
D35D	228	25	0.002
D35E	112	25	0.001
D35F	215	25	0.002
D35G	191	25	0.002
D35H	181	25	0.002
D35J	362	25	0.003
D35K	246	25	0.002

ANNEXURE D – GROUNDWATER CONTRIBUTION TO BASEFLOW

Table 25: Summary of Groundwater Baseflow Calculations

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
C51H	38.71	0.25	0.34	0.38	0.3	0.32	0.65	0.76	0.84	0.75	0.29	3.48
C51J	13.93	0.08	0.12	0.18	0.1	0.13	0.57	0.72	0.91	0.73	0.1	1.2
C51K	6.1	0.05	0.06	0.09	0.06	0.07	0.82	0.9	1.09	0.94	0.06	0.72
C51L	3.02	0.03	0.04	0.06	0.04	0.04	0.99	1.16	1.43	1.2	0.04	0.48
C51M	2.32	0.02	0.03	0.04	0.03	0.03	0.86	1.08	1.29	1.08	0.03	0.36
C52A	28.96	0.26	0.33	0.69	0.3	0.43	0.9	1.02	1.47	1.13	0.33	3.96
C52B	26.27	0.21	0.24	0.28	0.23	0.24	0.8	0.86	0.93	0.86	0.23	2.76
C52C	10.84	0.1	0.12	0.2	0.11	0.14	0.92	1.01	1.29	1.08	0.12	1.44

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm³/a)	Lowest average monthly flow (Mm³/m)	2nd Lowest average monthly flow (Mm³/m)	3rd Lowest average monthly flow (Mm³/m)	Average of two lowest monthly flows (Mm³/m)	Average of three lowest monthly flows (Mm³/m)	Lowest average monthly flow/average annual total flow (Mm³/m)	Average of two lowest monthly flows/average annual total flow (Mm³/m)	Average of three lowest monthly flows/average annual total flow (Mm³/m)	Average Baseflow (%)	Baseflow (Mm³/m)	Baseflow (Mm³/a)
C52D	7.69	0.07	0.08	0.14	0.08	0.1	0.91	0.98	1.26	1.05	0.08	0.96
C52E	11.86	0.1	0.11	0.13	0.11	0.11	0.84	0.89	0.96	0.89	0.11	1.32
C52F	11.2	0.09	0.1	0.11	0.1	0.1	0.8	0.85	0.89	0.85	0.1	1.2
C52G	24.28	0.12	0.14	0.25	0.13	0.17	0.49	0.54	0.7	0.58	0.14	1.68
C52H	1.65	0	0.01	0.03	0.01	0.01	0	0.3	0.81	0.37	0.01	0.12
C52J	3.12	0.02	0.03	0.05	0.03	0.03	0.64	0.8	1.07	0.84	0.03	0.36
C52K	1.44	0.01	0.02	0.03	0.02	0.02	0.69	1.04	1.39	1.04	0.02	0.24
C52L	1.19	0.01	0.02	0.03	0.02	0.02	0.84	1.26	1.68	1.26	0.02	0.24
C92B	4.11	0.03	0.04	0.05	0.04	0.04	0.73	0.85	0.97	0.85	0.04	0.48
C92C	1.74	0	0.01	0.02	0.01	0.01	0	0.29	0.57	0.29	0.01	0.12
D12A	26.09	1.05	1.17	1.19	1.11	1.14	4.02	4.25	4.36	4.21	1.1	13.2
D12B	40.36	1.52	1.54	1.73	1.53	1.6	3.77	3.79	3.96	3.84	1.55	18.6
D12C	18.05	0.19	0.23	0.3	0.21	0.24	1.05	1.16	1.33	1.18	0.21	2.52
D12D	15.56	0.12	0.18	0.23	0.15	0.18	0.77	0.96	1.14	0.96	0.15	1.8
D12E	29.01	0.23	0.36	0.45	0.3	0.35	0.79	1.02	1.19	1	0.29	3.48
D12F	24.5	0.21	0.34	0.37	0.28	0.31	0.86	1.12	1.25	1.08	0.26	3.12
D13A	70.67	2.51	3.11	3.31	2.81	2.98	3.55	3.98	4.21	3.91	2.77	33.24
D13B	73.35	2.7	3.32	3.51	3.01	3.18	3.68	4.1	4.33	4.04	2.96	35.52
D13C	53.64	2.23	2.67	2.7	2.45	2.53	4.16	4.57	4.72	4.48	2.4	28.8

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm³/a)	Lowest average monthly flow (Mm³/m)	2nd Lowest average monthly flow (Mm³/m)	3rd Lowest average monthly flow (Mm³/m)	Average of two lowest monthly flows (Mm³/m)	Average of three lowest monthly flows (Mm³/m)	Lowest average monthly flow/average annual total flow (Mm³/m)	Average of two lowest monthly flows/average annual total flow (Mm³/m)	Average of three lowest monthly flows/average annual total flow (Mm³/m)	Average Baseflow (%)	Baseflow (Mm³/m)	Baseflow (Mm³/a)
D13D	56.11	2.51	2.9	2.94	2.71	2.78	4.47	4.82	4.96	4.75	2.67	32.04
D13E	127.87	4.94	6.01	6.28	5.48	5.74	3.86	4.28	4.49	4.21	5.39	64.68
D13F	92.53	3.97	4.01	4.21	3.99	4.06	4.29	4.31	4.39	4.33	4.01	48.12
D13G	54.27	0.69	0.88	1.36	0.79	0.98	1.27	1.45	1.8	1.51	0.82	9.84
D13H	29.99	0.47	0.5	1.12	0.49	0.7	1.57	1.62	2.32	1.84	0.55	6.6
D13J	32.98	0.5	0.54	1.24	0.52	0.76	1.52	1.58	2.3	1.8	0.59	7.08
D13K	48.75	1.89	2.01	2.23	1.95	2.04	3.88	4	4.19	4.02	1.96	23.52
D13L	26	0.43	0.45	1.06	0.44	0.65	1.65	1.69	2.49	1.94	0.51	6.12
D13M	18.02	0.28	0.29	0.68	0.29	0.42	1.55	1.58	2.31	1.82	0.33	3.96
D14A	21.8	0.27	0.41	0.57	0.34	0.42	1.24	1.56	1.91	1.57	0.34	4.08
D14B	6.29	0.07	0.15	0.23	0.11	0.15	1.11	1.75	2.38	1.75	0.11	1.32
D14C	14.6	0.19	0.36	0.54	0.28	0.36	1.3	1.88	2.49	1.89	0.28	3.36
D14D	9.09	0.11	0.22	0.33	0.17	0.22	1.21	1.82	2.42	1.82	0.17	2.04
D14E	7.97	0.1	0.2	0.29	0.15	0.2	1.25	1.88	2.47	1.87	0.15	1.8
D14F	13.22	0.17	0.31	0.47	0.24	0.32	1.29	1.82	2.4	1.83	0.24	2.88
D14G	14.8	0.18	0.34	0.52	0.26	0.35	1.22	1.76	2.34	1.77	0.26	3.12
D14H	12.81	0.13	0.23	0.31	0.18	0.22	1.01	1.41	1.74	1.39	0.18	2.16
D14J	9.56	0.1	0.17	0.23	0.14	0.17	1.05	1.41	1.74	1.4	0.13	1.56
D14K	10.94	0.11	0.2	0.26	0.16	0.19	1.01	1.42	1.74	1.39	0.15	1.8

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm³/a)	Lowest average monthly flow (Mm³/m)	2nd Lowest average monthly flow (Mm³/m)	3rd Lowest average monthly flow (Mm³/m)	Average of two lowest monthly flows (Mm³/m)	Average of three lowest monthly flows (Mm³/m)	Lowest average monthly flow/average annual total flow (Mm³/m)	Average of two lowest monthly flows/average annual total flow (Mm³/m)	Average of three lowest monthly flows/average annual total flow (Mm³/m)	Average Baseflow (%)	Baseflow (Mm³/m)	Baseflow (Mm³/a)
D15G	44.49	1.48	1.6	1.78	1.54	1.62	3.33	3.46	3.64	3.48	1.55	18.6
D15H	25.67	0.99	1.03	1.09	1.01	1.04	3.86	3.93	4.04	3.94	1.01	12.12
D18G	80.08	2	2.31	2.64	2.16	2.32	2.5	2.69	2.89	2.69	2.16	25.92
D18K	144.51	3.73	4.23	4.91	3.98	4.29	2.58	2.75	2.97	2.77	4	48
D18L	64.34	2	2.16	2.52	2.08	2.23	3.11	3.23	3.46	3.27	2.1	25.2
D21D	22.59	0.54	0.55	0.8	0.55	0.63	2.39	2.41	2.79	2.53	0.57	6.84
D21E	18.6	0.52	0.75	0.79	0.64	0.69	2.8	3.41	3.69	3.3	0.61	7.32
D21F	33.04	0.32	0.47	0.5	0.4	0.43	0.97	1.2	1.3	1.16	0.38	4.56
D21G	20.97	0.2	0.24	0.28	0.22	0.24	0.95	1.05	1.14	1.05	0.22	2.64
D21H	41.62	1.05	1.07	1.47	1.06	1.2	2.52	2.55	2.88	2.65	1.1	13.2
D22A	35.97	0.35	0.39	0.46	0.37	0.4	0.97	1.03	1.11	1.04	0.37	4.44
D22B	32.25	0.29	0.34	0.4	0.32	0.34	0.9	0.98	1.06	0.98	0.32	3.84
D22C	50.26	1.29	1.31	1.78	1.3	1.46	2.57	2.59	2.9	2.69	1.35	16.2
D22D	37.08	0.34	0.39	0.45	0.37	0.39	0.92	0.98	1.06	0.99	0.37	4.44
D22F	57	1.51	1.57	2.08	1.54	1.72	2.65	2.7	3.02	2.79	1.59	19.08
D22G	53.3	0.48	0.54	0.64	0.51	0.55	0.9	0.96	1.04	0.97	0.51	6.12
D22H	36.91	0.33	0.38	0.43	0.36	0.38	0.89	0.96	1.03	0.96	0.36	4.32
D22L	22.14	0.19	0.21	0.25	0.2	0.22	0.86	0.9	0.98	0.91	0.2	2.4
D23A	26.99	0.22	0.34	0.38	0.28	0.31	0.82	1.04	1.16	1	0.27	3.24

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)
D23C	26.19	0.3	0.32	0.37	0.31	0.33	1.15	1.18	1.26	1.2	0.31	3.72
D23D	21.72	0.2	0.21	0.24	0.21	0.22	0.92	0.94	1	0.95	0.21	2.52
D23E	28.29	0.25	0.27	0.3	0.26	0.27	0.88	0.92	0.97	0.92	0.26	3.12
D23F	19.13	0.15	0.23	0.26	0.19	0.21	0.78	0.99	1.12	0.96	0.18	2.16
D23G	25.46	0.19	0.31	0.32	0.25	0.27	0.75	0.98	1.07	0.93	0.24	2.88
D23H	26.25	0.2	0.25	0.31	0.23	0.25	0.76	0.86	0.97	0.86	0.23	2.76
D23J	21.18	0.16	0.22	0.25	0.19	0.21	0.76	0.9	0.99	0.88	0.19	2.28
D24A	14.47	0.13	0.21	0.23	0.17	0.19	0.9	1.17	1.31	1.13	0.16	1.92
D24B	19.5	0.13	0.23	0.26	0.18	0.21	0.67	0.92	1.06	0.88	0.17	2.04
D24C	11.53	0.08	0.11	0.17	0.1	0.12	0.69	0.82	1.04	0.85	0.1	1.2
D24D	12.93	0.1	0.12	0.2	0.11	0.14	0.77	0.85	1.08	0.9	0.12	1.44
D24E	10.65	0.08	0.1	0.16	0.09	0.11	0.75	0.85	1.06	0.89	0.09	1.08
D24F	15.04	0.11	0.13	0.22	0.12	0.15	0.73	0.8	1.02	0.85	0.13	1.56
D24G	20.15	0.16	0.25	0.38	0.21	0.26	0.79	1.02	1.31	1.04	0.21	2.52
D24H	17.22	0.13	0.2	0.3	0.17	0.21	0.75	0.96	1.22	0.98	0.17	2.04
D24J	19.02	0.15	0.21	0.3	0.18	0.22	0.79	0.95	1.16	0.96	0.18	2.16
D24K	15.56	0.13	0.18	0.25	0.16	0.19	0.84	1	1.2	1.01	0.16	1.92
D24L	8.48	0.08	0.1	0.14	0.09	0.11	0.94	1.06	1.26	1.09	0.09	1.08
D31A	14.51	0.12	0.25	0.35	0.19	0.24	0.83	1.27	1.65	1.25	0.18	2.16

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)
D31B	3.61	0.04	0.05	0.06	0.05	0.05	1.11	1.25	1.39	1.25	0.05	0.6
D31C	3.92	0.04	0.06	0.07	0.05	0.06	1.02	1.28	1.45	1.25	0.05	0.6
D31D	8.49	0.07	0.14	0.17	0.11	0.13	0.82	1.24	1.49	1.18	0.1	1.2
D31E	7.69	0.08	0.12	0.14	0.1	0.11	1.04	1.3	1.47	1.27	0.1	1.2
D32A	3.2	0.04	0.05	0.06	0.05	0.05	1.25	1.41	1.56	1.41	0.05	0.6
D32B	3.67	0.04	0.07	0.1	0.06	0.07	1.09	1.5	1.91	1.5	0.06	0.72
D32C	3.91	0.04	0.05	0.06	0.05	0.05	1.02	1.15	1.28	1.15	0.05	0.6
D32D	3.71	0.04	0.05	0.07	0.05	0.05	1.08	1.21	1.44	1.24	0.05	0.6
D32E	2.82	0.04	0.05	0.06	0.05	0.05	1.42	1.6	1.77	1.6	0.05	0.6
D32F	4.97	0.06	0.08	0.09	0.07	0.08	1.21	1.41	1.54	1.39	0.07	0.84
D32G	5.17	0.06	0.08	0.09	0.07	0.08	1.16	1.35	1.48	1.33	0.07	0.84
D32H	2.75	0.03	0.04	0.05	0.04	0.04	1.09	1.27	1.45	1.27	0.04	0.48
D32J	4.15	0.05	0.07	0.14	0.06	0.09	1.2	1.45	2.09	1.58	0.07	0.84
D32K	3.4	0.04	0.05	0.06	0.05	0.05	1.18	1.32	1.47	1.32	0.05	0.6
D33A	2.89	0.02	0.03	0.04	0.03	0.03	0.69	0.87	1.04	0.87	0.03	0.36
D33B	1.58	0.01	0.02	0.04	0.02	0.02	0.63	0.95	1.48	1.02	0.02	0.24
D33C	3.15	0.02	0.03	0.04	0.03	0.03	0.63	0.79	0.95	0.79	0.03	0.36
D33D	1.22	0.01	0.02	0.03	0.02	0.02	0.82	1.23	1.64	1.23	0.02	0.24
D33E	1.41	0	0.01	0.03	0.01	0.01	0	0.35	0.95	0.43	0.01	0.12

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm³/a)	Lowest average monthly flow (Mm³/m)	2nd Lowest average monthly flow (Mm³/m)	3rd Lowest average monthly flow (Mm³/m)	Average of two lowest monthly flows (Mm³/m)	Average of three lowest monthly flows (Mm³/m)	Lowest average monthly flow/average annual total flow (Mm³/m)	Average of two lowest monthly flows/average annual total flow (Mm³/m)	Average of three lowest monthly flows/average annual total flow (Mm³/m)	Average Baseflow (%)	Baseflow (Mm³/m)	Baseflow (Mm³/a)
D33F	0.25	0	0.01	0.03	0.01	0.01	0	2	5.33	2.44	0.01	0.12
D33G	1.24	0.01	0.02	0.03	0.02	0.02	0.81	1.21	1.61	1.21	0.02	0.24
D33H	1.73	0.01	0.02	0.04	0.02	0.02	0.58	0.87	1.35	0.93	0.02	0.24
D33J	0.52	0	0.01	0.02	0.01	0.01	0	0.96	1.92	0.96	0.01	0.12
D33K	0.94	0.01	0.03	0.04	0.02	0.03	1.06	2.13	2.84	2.01	0.02	0.24
D34A	8.11	0.01	0.05	0.08	0.03	0.05	0.12	0.37	0.58	0.36	0.03	0.36
D34B	5.39	0	0.02	0.05	0.01	0.02	0	0.19	0.43	0.21	0.01	0.12
D34C	4.69	0	0.02	0.05	0.01	0.02	0	0.21	0.5	0.24	0.01	0.12
D34D	3.98	0	0.02	0.04	0.01	0.02	0	0.25	0.5	0.25	0.01	0.12
D34E	4.09	0	0.02	0.04	0.01	0.02	0	0.24	0.49	0.24	0.01	0.12
D34F	4.01	0	0.02	0.04	0.01	0.02	0	0.25	0.5	0.25	0.01	0.12
D34G	8.2	0.01	0.04	0.08	0.03	0.04	0.12	0.3	0.53	0.32	0.03	0.36
D35A	4.34	0.05	0.09	0.13	0.07	0.09	1.15	1.61	2.07	1.61	0.07	0.84
D35B	3.96	0.04	0.07	0.11	0.06	0.07	1.01	1.39	1.85	1.42	0.06	0.72
D35C	11.72	0.11	0.31	0.34	0.21	0.25	0.94	1.79	2.16	1.63	0.19	2.28
D35D	6.01	0.06	0.16	0.17	0.11	0.13	1	1.83	2.16	1.66	0.1	1.2
D35E	3.83	0.04	0.07	0.1	0.06	0.07	1.04	1.44	1.83	1.44	0.06	0.72
D35F	8.52	0.1	0.16	0.24	0.13	0.17	1.17	1.53	1.96	1.55	0.13	1.56
D35G	5.64	0.05	0.09	0.13	0.07	0.09	0.89	1.24	1.6	1.24	0.07	0.84

Quaternary	Flows						Baseflow					
	Average Annual total flow (1920-2009) (Mm³/a)	Lowest average monthly flow (Mm³/m)	2nd Lowest average monthly flow (Mm³/m)	3rd Lowest average monthly flow (Mm³/m)	Average of two lowest monthly flows (Mm³/m)	Average of three lowest monthly flows (Mm³/m)	Lowest average monthly flow/average annual total flow (Mm³/m)	Average of two lowest monthly flows/average annual total flow (Mm³/m)	Average of three lowest monthly flows/average annual total flow (Mm³/m)	Average Baseflow (%)	Baseflow (Mm³/m)	Baseflow (Mm³/a)
D35H	6.03	0.07	0.11	0.16	0.09	0.11	1.16	1.49	1.88	1.51	0.09	1.08
D35J	8.13	0.09	0.22	0.26	0.16	0.19	1.11	1.91	2.34	1.78	0.15	1.8
D35K	6.89	0.07	0.12	0.16	0.1	0.12	1.02	1.38	1.69	1.36	0.09	1.08

ANNEXURE E – GROUNDWATER QUALITY RESERVE (QUATERNARY CATCHMENTS)

Table 26: Groundwater quality Reserve D22G

Chemical Parameter	Unit	Quaternary D22G			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	46	8.10	5.0 – 9.5	7.29 - 8.91
Electrical Conductivity	mS/m	46	44.60	<150	49.06
Calcium as Ca	mg/l	39	26.39	<150	29.03
Magnesium as Mg	mg/l	39	8.60	<100	9.46
Sodium as Na	mg/l	38	62.11	<200	68.32
Potassium as K	mg/l	38	3.42	<50	3.76
Total Alkalinity as $CaCO_3$	mg/l	40	189.07	<330	207.98
Chloride as Cl	mg/l	39	19.60	<200	21.56
Sulphate as SO_4	mg/l	39	18.50	<400	20.35
Nitrate and Nitrite as N	mg/l	38	1.77	<1.0	1.77
Fluoride as F	mg/l	1	0.83	<1.0	0.91
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 27: Groundwater Quality Reserve D21E

Chemical Parameter	Unit	Quaternary D21E			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	11	8.00	5.0 – 9.5	7.20 - 8.80
Electrical Conductivity	mS/m	11	45.40	<150	49.94
Calcium as Ca	mg/l	9	65.80	<150	72.38
Magnesium as Mg	mg/l	9	13.50	<100	14.85
Sodium as Na	mg/l	9	30.08	<200	33.09
Potassium as K	mg/l	9	1.16	<50	1.28
Total Alkalinity as $CaCO_3$	mg/l	9	259.86	<330	285.84
Chloride as Cl	mg/l	9	7.60	<200	8.36
Sulphate as SO_4	mg/l	9	24.30	<400	26.73
Nitrate and Nitrite as N	mg/l	9	0.21	<1.0	0.23
Fluoride as F	mg/l	2	0.36	<1.0	0.39
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 28: Groundwater Quality Reserve D21D

Chemical Parameter	Unit	Quaternary D21D			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–			5.0 – 9.5	5.0 - 9.5
Electrical Conductivity	mS/m	12	35.05	<150	38.56
Calcium as Ca	mg/l			<150	150.00
Magnesium as Mg	mg/l			<100	100.00
Sodium as Na	mg/l			<200	200.00
Potassium as K	mg/l			<50	50.00
Total Alkalinity as $CaCO_3$	mg/l			<330	330.00
Chloride as Cl	mg/l			<200	200.00
Sulphate as SO_4	mg/l			<400	400.00
Nitrate and Nitrite as N	mg/l			<1.0	1.00
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 29: Groundwater Quality Reserve D35J

Chemical Parameter	Unit	Quaternary D35J			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	51	8.13	5.0 – 9.5	7.32 - 8.94
Electrical Conductivity	mS/m	51	62.00	<150	68.20
Calcium as Ca	mg/l	46	28.03	<150	30.83
Magnesium as Mg	mg/l	46	7.52	<100	8.28
Sodium as Na	mg/l	44	82.46	<200	90.71
Potassium as K	mg/l	45	1.02	<50	1.12
Total Alkalinity as $CaCO_3$	mg/l	47	204.19	<330	224.61
Chloride as Cl	mg/l	46	23.49	<200	25.84
Sulphate as SO_4	mg/l	46	40.12	<400	44.14
Nitrate and Nitrite as N	mg/l	46	0.05	<1.0	0.06
Fluoride as F	mg/l	1	2.88	<1.0	2.88
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 30: Groundwater Quality Reserve D24G

Chemical Parameter	Unit	Quaternary D24G			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	6	8.06	5.0 – 9.5	7.25 - 8.87
Electrical Conductivity	mS/m	6	60.40	<150	66.44
Calcium as Ca	mg/l	6	39.90	<150	43.89
Magnesium as Mg	mg/l	6	20.35	<100	22.39
Sodium as Na	mg/l	6	60.35	<200	66.39
Potassium as K	mg/l	6	5.39	<50	5.93
Total Alkalinity as $CaCO_3$	mg/l	6	278.95	<330	306.85
Chloride as Cl	mg/l	6	13.00	<200	14.30
Sulphate as SO_4	mg/l	6	18.45	<400	20.30
Nitrate and Nitrite as N	mg/l	6	0.64	<1.0	0.70
Fluoride as F	mg/l	1	0.34	<1.0	0.37
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 31: Groundwater Quality Reserve D12D

Chemical Parameter	Unit	Quaternary D12D			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	43	8.11	5.0 – 9.5	7.30 - 8.92
Electrical Conductivity	mS/m	42	33.75	<150	37.13
Calcium as Ca	mg/l	40	37.46	<150	41.21
Magnesium as Mg	mg/l	40	9.28	<100	10.21
Sodium as Na	mg/l	38	19.95	<200	21.95
Potassium as K	mg/l	38	0.91	<50	1.00
Total Alkalinity as $CaCO_3$	mg/l	40	161.85	<330	178.04
Chloride as Cl	mg/l	39	4.90	<200	5.39
Sulphate as SO_4	mg/l	40	8.95	<400	9.85
Nitrate and Nitrite as N	mg/l	39	0.15	<1.0	0.17
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 32: Groundwater Quality Reserve C51G

Chemical Parameter	Unit	Quaternary C51G			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	17	7.98	5.0 – 9.5	7.18 - 8.78
Electrical Conductivity	mS/m	17	61.50	<150	67.65
Calcium as Ca	mg/l	15	58.22	<150	64.04
Magnesium as Mg	mg/l	16	20.95	<100	23.05
Sodium as Na	mg/l	16	36.79	<200	40.47
Potassium as K	mg/l	16	1.54	<50	1.69
Total Alkalinity as $CaCO_3$	mg/l	16	244.70	<330	269.17
Chloride as Cl	mg/l	16	17.30	<200	19.03
Sulphate as SO_4	mg/l	16	32.43	<400	35.67
Nitrate and Nitrite as N	mg/l	16	2.85	<1.0	2.85
Fluoride as F	mg/l	1	0.67	<1.0	1.00
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 33: Groundwater Quality Reserve C51A

Chemical Parameter	Unit	Quaternary C51A			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	49	8.18	5.0 – 9.5	7.37 - 9.00
Electrical Conductivity	mS/m	48	60.70	<150	66.77
Calcium as Ca	mg/l	43	65.65	<150	72.21
Magnesium as Mg	mg/l	43	20.62	<100	22.68
Sodium as Na	mg/l	41	39.00	<200	42.90
Potassium as K	mg/l	41	6.34	<50	6.97
Total Alkalinity as $CaCO_3$	mg/l	43	286.10	<330	314.71
Chloride as Cl	mg/l	43	18.30	<200	20.12
Sulphate as SO_4	mg/l	43	20.45	<400	22.49
Nitrate and Nitrite as N	mg/l	43	1.96	<1.0	1.96
Fluoride as F	mg/l	1	0.92	<1.0	1.01
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 34: Groundwater Quality Reserve C52A

Chemical Parameter	Unit	Quaternary C52A			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	9	8.00	5.0 – 9.5	7.20 - 8.80
Electrical Conductivity	mS/m	9	93.10	<150	102.41
Calcium as Ca	mg/l	8	90.20	<150	99.22
Magnesium as Mg	mg/l	8	32.45	<100	35.70
Sodium as Na	mg/l	8	75.50	<200	83.05
Potassium as K	mg/l	8	1.15	<50	1.27
Total Alkalinity as $CaCO_3$	mg/l	8	383.50	<330	383.50
Chloride as Cl	mg/l	8	58.35	<200	64.19
Sulphate as SO_4	mg/l	8	29.35	<400	32.29
Nitrate and Nitrite as N	mg/l	8	0.35	<1.0	0.38
Fluoride as F	mg/l	2	0.22	<1.0	0.24
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 35: Groundwater Quality Reserve C52H

Chemical Parameter	Unit	Quaternary C52H			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	11	8.24	5.0 – 9.5	7.42 - 9.06
Electrical Conductivity	mS/m	11	188.00	<150	188.00
Calcium as Ca	mg/l	10	55.45	<150	61.00
Magnesium as Mg	mg/l	10	15.05	<100	16.56
Sodium as Na	mg/l	10	414.95	<200	414.95
Potassium as K	mg/l	10	5.06	<50	5.56
Total Alkalinity as $CaCO_3$	mg/l	10	232.90	<330	256.19
Chloride as Cl	mg/l	10	551.20	<200	551.20
Sulphate as SO_4	mg/l	10	45.50	<400	50.05
Nitrate and Nitrite as N	mg/l	10	1.99	<1.0	1.99
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 2

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 36: Groundwater Quality Reserve D13D

Chemical Parameter	Unit	Quaternary D13D			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	41	8.03	5.0 – 9.5	7.23 - 8.83
Electrical Conductivity	mS/m	43	57.50	<150	63.25
Calcium as Ca	mg/l	37	65.21	<150	71.73
Magnesium as Mg	mg/l	37	28.45	<100	31.30
Sodium as Na	mg/l	35	14.81	<200	16.29
Potassium as K	mg/l	35	0.15	<50	0.17
Total Alkalinity as $CaCO_3$	mg/l	37	251.12	<330	276.23
Chloride as Cl	mg/l	37	12.55	<200	13.80
Sulphate as SO_4	mg/l	36	23.68	<400	26.05
Nitrate and Nitrite as N	mg/l	37	2.12	<1.0	2.12
Fluoride as F	mg/l	1	0.47	<1.0	0.52
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 37: Groundwater Quality Reserve D13H

Chemical Parameter	Unit	Quaternary D13H			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	32	7.75	5.0 – 9.5	6.98 - 8.53
Electrical Conductivity	mS/m	35	102.20	<150	112.42
Calcium as Ca	mg/l	27	89.29	<150	98.22
Magnesium as Mg	mg/l	27	42.50	<100	46.75
Sodium as Na	mg/l	27	60.00	<200	66.00
Potassium as K	mg/l	27	3.05	<50	3.35
Total Alkalinity as $CaCO_3$	mg/l	27	315.50	<330	315.50
Chloride as Cl	mg/l	27	132.69	<200	145.96
Sulphate as SO_4	mg/l	27	67.20	<400	73.92
Nitrate and Nitrite as N	mg/l	27	0.05	<1.0	0.06
Fluoride as F	mg/l	1	0.53	<1.0	0.58
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 38: Groundwater Quality Reserve D14A

Chemical Parameter	Unit	Quaternary D14A			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	51	7.59	5.0 – 9.5	6.83 - 8.35
Electrical Conductivity	mS/m	51	219.80	<150	219.80
Calcium as Ca	mg/l	45	84.00	<150	92.40
Magnesium as Mg	mg/l	45	0.63	<100	0.69
Sodium as Na	mg/l	43	332.36	<200	332.36
Potassium as K	mg/l	43	2.35	<50	2.59
Total Alkalinity as $CaCO_3$	mg/l	45	21.79	<330	23.97
Chloride as Cl	mg/l	43	638.07	<200	638.07
Sulphate as SO_4	mg/l	45	5.59	<400	6.15
Nitrate and Nitrite as N	mg/l	44	0.04	<1.0	0.04
Fluoride as F	mg/l	1	4.10	<1.0	4.10
				Water quality class	Class 2

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 39: Groundwater Quality Reserve D14E

Chemical Parameter	Unit	Quaternary D14E			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	11	7.88	5.0 – 9.5	7.09 - 8.66
Electrical Conductivity	mS/m	12	84.65	<150	93.12
Calcium as Ca	mg/l	10	63.25	<150	69.58
Magnesium as Mg	mg/l	10	28.60	<100	31.46
Sodium as Na	mg/l	10	69.65	<200	76.62
Potassium as K	mg/l	10	1.00	<50	1.09
Total Alkalinity as $CaCO_3$	mg/l	10	280.76	<330	308.83
Chloride as Cl	mg/l	10	34.95	<200	38.45
Sulphate as SO_4	mg/l	10	75.30	<400	82.83
Nitrate and Nitrite as N	mg/l	10	1.64	<1.0	1.64
Fluoride as F	mg/l	1	1.16	<1.0	1.16
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 40: Groundwater Quality Reserve D32E

Chemical Parameter	Unit	Quaternary D32E			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	11	7.96	5.0 – 9.5	7.16 - 8.76
Electrical Conductivity	mS/m	11	81.00	<150	89.10
Calcium as Ca	mg/l	11	73.60	<150	80.96
Magnesium as Mg	mg/l	11	37.80	<100	41.58
Sodium as Na	mg/l	11	34.40	<200	37.84
Potassium as K	mg/l	11	2.49	<50	2.74
Total Alkalinity as $CaCO_3$	mg/l	11	278.90	<330	306.79
Chloride as Cl	mg/l	11	32.10	<200	35.31
Sulphate as SO_4	mg/l	11	32.30	<400	35.53
Nitrate and Nitrite as N	mg/l	11	12.85	<1.0	12.85
Fluoride as F	mg/l			<1.0	1.00
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 41: Groundwater Quality Reserve D32G

Chemical Parameter	Unit	Quaternary D32G			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	39	8.15	5.0 – 9.5	7.33 - 8.96
Electrical Conductivity	mS/m	40	76.30	<150	83.93
Calcium as Ca	mg/l	33	74.04	<150	81.44
Magnesium as Mg	mg/l	34	22.05	<100	24.25
Sodium as Na	mg/l	33	65.82	<200	72.41
Potassium as K	mg/l	34	1.67	<50	1.84
Total Alkalinity as $CaCO_3$	mg/l	33	334.89	<330	334.89
Chloride as Cl	mg/l	33	25.50	<200	28.05
Sulphate as SO_4	mg/l	33	39.40	<400	43.34
Nitrate and Nitrite as N	mg/l	33	1.48	<1.0	1.48
Fluoride as F	mg/l			<1.0	1.00
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 42: Groundwater Quality Reserve D32K

Chemical Parameter	Unit	Quaternary D32K			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	47	8.20	5.0 – 9.5	7.38 - 9.02
Electrical Conductivity	mS/m	48	98.75	<150	108.63
Calcium as Ca	mg/l	42	47.70	<150	52.47
Magnesium as Mg	mg/l	41	82.75	<100	91.03
Sodium as Na	mg/l	40	38.38	<200	42.22
Potassium as K	mg/l	40	3.35	<50	3.69
Total Alkalinity as $CaCO_3$	mg/l	42	366.66	<330	366.66
Chloride as Cl	mg/l	42	77.60	<200	85.36
Sulphate as SO_4	mg/l	42	80.51	<400	88.56
Nitrate and Nitrite as N	mg/l	40	1.91	<1.0	1.91
Fluoride as F	mg/l	1	0.53	<1.0	0.58
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 43: Groundwater Quality Reserve C51M

Chemical Parameter	Unit	Quaternary C51M			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	44	8.05	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	50	165.00	<150	165.00
Calcium as Ca	mg/l	40	97.80	<150	107.58
Magnesium as Mg	mg/l	38	66.28	<100	72.91
Sodium as Na	mg/l	38	140.36	<200	154.40
Potassium as K	mg/l	38	2.11	<50	2.32
Total Alkalinity as $CaCO_3$	mg/l	40	277.00	<330	304.70
Chloride as Cl	mg/l	40	351.74	<200	351.74
Sulphate as SO_4	mg/l	40	66.25	<400	72.88
Nitrate and Nitrite as N	mg/l	40	4.55	<1.0	4.55
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 2

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

[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.

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

Table 44: Groundwater Quality Reserve C51L

Chemical Parameter	Unit	Quaternary C51L			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–			5.0 – 9.5	7.33 - 8.96
Electrical Conductivity	mS/m	4	103.90	<150	114.29
Calcium as Ca	mg/l			<150	150.00
Magnesium as Mg	mg/l			<100	100.00
Sodium as Na	mg/l			<200	200.00
Potassium as K	mg/l			<50	50.00
Total Alkalinity as $CaCO_3$	mg/l			<330	330.00
Chloride as Cl	mg/l			<200	200.00
Sulphate as SO_4	mg/l			<400	400.00
Nitrate and Nitrite as N	mg/l			<1.0	1.00
Fluoride as F	mg/l			<1.0	1.00
				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) and SANS (241: 2015) drinking water limits.

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

Table 45: Groundwater Quality Reserve C51K

Chemical Parameter	Unit	Quaternary C51K			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	59	8.15	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	58	65.50	<150	72.05
Calcium as Ca	mg/l	51	59.60	<150	65.56
Magnesium as Mg	mg/l	52	39.93	<100	43.92
Sodium as Na	mg/l	49	23.57	<200	25.93
Potassium as K	mg/l	50	2.32	<50	2.55
Total Alkalinity as $CaCO_3$	mg/l	52	246.47	<330	271.12
Chloride as Cl	mg/l	52	38.33	<200	42.16
Sulphate as SO_4	mg/l	52	32.75	<400	36.03
Nitrate and Nitrite as N	mg/l	51	3.98	<1.0	3.98
Fluoride as F	mg/l	2	0.45	<1.0	0.50
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

ANNEXURE F – GROUNDWATER QUALITY RESERVE (GRUs)

Table 46: Groundwater Quality GRU1

Chemical Parameter	Unit	GRU1			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	57	8.05	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	69	44.60	<150	49.06
Calcium as Ca	mg/l	48	46.10	<150	50.71
Magnesium as Mg	mg/l	48	11.05	<100	12.16
Sodium as Na	mg/l	47	46.09	<200	50.70
Potassium as K	mg/l	47	2.29	<50	2.52
Total Alkalinity as $CaCO_3$	mg/l	49	224.46	<330	246.91
Chloride as Cl	mg/l	48	13.60	<200	14.96
Sulphate as SO_4	mg/l	48	21.40	<400	23.54
Nitrate and Nitrite as N	mg/l	47	0.99	<1.0	1.09
Fluoride as F	mg/l	3	0.59	<1.0	0.65
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 47: Groundwater Quality Reserve GRU2

Chemical Parameter	Unit	GRU2			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	100	8.11	5.0 – 9.5	7.30 - 8.92
Electrical Conductivity	mS/m	99	60.40	<150	66.44
Calcium as Ca	mg/l	92	37.46	<150	41.21
Magnesium as Mg	mg/l	92	9.28	<100	10.21
Sodium as Na	mg/l	88	60.35	<200	66.39
Potassium as K	mg/l	89	1.02	<50	1.12
Total Alkalinity as $CaCO_3$	mg/l	93	204.19	<330	224.61
Chloride as Cl	mg/l	91	13.00	<200	14.30
Sulphate as SO_4	mg/l	92	18.45	<400	20.30
Nitrate and Nitrite as N	mg/l	91	0.15	<1.0	0.17
Fluoride as F	mg/l	2	1.61	<1.0	1.61
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 48: Groundwater Quality Reserve GRU3

Chemical Parameter	Unit	GRU3			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	75	8.00	5.0 – 9.5	7.20 - 8.80
Electrical Conductivity	mS/m	74	61.50	<150	67.65
Calcium as Ca	mg/l	66	65.65	<150	72.21
Magnesium as Mg	mg/l	67	20.95	<100	23.05
Sodium as Na	mg/l	65	39.00	<200	42.90
Potassium as K	mg/l	65	1.54	<50	1.69
Total Alkalinity as $CaCO_3$	mg/l	67	286.10	<330	314.71
Chloride as Cl	mg/l	67	18.30	<200	20.12
Sulphate as SO_4	mg/l	67	29.35	<400	32.29
Nitrate and Nitrite as N	mg/l	67	1.96	<1.0	2.16
Fluoride as F	mg/l	4	0.67	<1.0	0.74
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 49: Groundwater Quality Reserve GRU4

Chemical Parameter	Unit	GRU4			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	11	8.24	5.0 – 9.5	7.42 - 9.06
Electrical Conductivity	mS/m	11	188.00	<150	188.00
Calcium as Ca	mg/l	10	55.45	<150	61.00
Magnesium as Mg	mg/l	10	15.05	<100	16.56
Sodium as Na	mg/l	10	414.95	<200	414.95
Potassium as K	mg/l	10	5.06	<50	5.56
Total Alkalinity as $CaCO_3$	mg/l	10	232.90	<330	256.19
Chloride as Cl	mg/l	10	551.20	<200	551.20
Sulphate as SO_4	mg/l	10	45.50	<400	50.05
Nitrate and Nitrite as N	mg/l	10	1.99	<1.0	1.99
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 2

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 50: Groundwater Quality Reserve GRU7

Chemical Parameter	Unit	GRU7			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	41	8.03	5.0 – 9.5	7.42 - 9.06
Electrical Conductivity	mS/m	43	57.50	<150	63.25
Calcium as Ca	mg/l	37	65.21	<150	71.73
Magnesium as Mg	mg/l	37	28.45	<100	31.30
Sodium as Na	mg/l	35	14.81	<200	16.29
Potassium as K	mg/l	35	0.15	<50	0.17
Total Alkalinity as $CaCO_3$	mg/l	37	251.12	<330	276.23
Chloride as Cl	mg/l	37	12.55	<200	13.80
Sulphate as SO_4	mg/l	36	23.68	<400	26.05
Nitrate and Nitrite as N	mg/l	37	2.12	<1.0	2.33
Fluoride as F	mg/l	1	0.47	<1.0	0.52
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 51: Groundwater Quality Reserve GRU8

Chemical Parameter	Unit	GRU8			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	32	7.75	5.0 – 9.5	6.98 - 8.53
Electrical Conductivity	mS/m	35	102.20	<150	112.42
Calcium as Ca	mg/l	27	89.29	<150	98.22
Magnesium as Mg	mg/l	27	42.50	<100	46.75
Sodium as Na	mg/l	27	60.00	<200	66.00
Potassium as K	mg/l	27	3.05	<50	3.35
Total Alkalinity as $CaCO_3$	mg/l	27	315.50	<330	347.05
Chloride as Cl	mg/l	27	132.69	<200	145.96
Sulphate as SO_4	mg/l	27	67.20	<400	73.92
Nitrate and Nitrite as N	mg/l	27	0.05	<1.0	0.06
Fluoride as F	mg/l	1	0.53	<1.0	0.58
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 52: Groundwater Quality Reserve GRU9

Chemical Parameter	Unit	GRU9			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	62	7.73	5.0 – 9.5	6.96 - 8.51
Electrical Conductivity	mS/m	63	152.23	<150	152.23
Calcium as Ca	mg/l	55	73.63	<150	80.99
Magnesium as Mg	mg/l	55	14.61	<100	16.07
Sodium as Na	mg/l	53	201.00	<200	201.00
Potassium as K	mg/l	53	1.67	<50	1.84
Total Alkalinity as $CaCO_3$	mg/l	55	151.27	<330	166.40
Chloride as Cl	mg/l	53	336.51	<200	336.51
Sulphate as SO_4	mg/l	55	40.45	<400	44.49
Nitrate and Nitrite as N	mg/l	54	0.84	<1.0	0.92
Fluoride as F	mg/l	2	2.63	<1.0	2.63
				Water quality class	Class 2

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 53: Groundwater Quality Reserve GRU10

Chemical Parameter	Unit	GRU10			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	50	8.05	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	51	78.65	<150	86.52
Calcium as Ca	mg/l	44	73.82	<150	81.20
Magnesium as Mg	mg/l	45	29.92	<100	32.92
Sodium as Na	mg/l	44	50.11	<200	55.12
Potassium as K	mg/l	45	2.08	<50	2.29
Total Alkalinity as $CaCO_3$	mg/l	44	306.89	<330	337.58
Chloride as Cl	mg/l	44	28.80	<200	31.68
Sulphate as SO_4	mg/l	44	35.85	<400	39.44
Nitrate and Nitrite as N	mg/l	44	7.16	<1.0	7.16
Fluoride as F	mg/l			<1.0	1.00
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 54: Groundwater Quality Reserve GRU12

Chemical Parameter	Unit	GRU12			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	47	8.20	5.0 – 9.5	7.38 - 9.02
Electrical Conductivity	mS/m	48	98.75	<150	108.63
Calcium as Ca	mg/l	42	47.70	<150	52.47
Magnesium as Mg	mg/l	41	82.75	<100	91.03
Sodium as Na	mg/l	40	38.38	<200	42.22
Potassium as K	mg/l	40	3.35	<50	3.69
Total Alkalinity as $CaCO_3$	mg/l	42	366.66	<330	366.66
Chloride as Cl	mg/l	42	77.60	<200	85.36
Sulphate as SO_4	mg/l	42	80.51	<400	88.56
Nitrate and Nitrite as N	mg/l	40	1.91	<1.0	1.91
Fluoride as F	mg/l	1	0.53	<1.0	0.58
				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) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 55: Groundwater Quality Reserve GRU13

Chemical Parameter	Unit	GRU13			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	44	8.05	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	54	134.45	<150	147.90
Calcium as Ca	mg/l	40	97.80	<150	107.58
Magnesium as Mg	mg/l	38	66.28	<100	72.91
Sodium as Na	mg/l	38	140.36	<200	154.40
Potassium as K	mg/l	38	2.11	<50	2.32
Total Alkalinity as $CaCO_3$	mg/l	40	277.00	<330	304.70
Chloride as Cl	mg/l	40	351.74	<200	351.74
Sulphate as SO_4	mg/l	40	66.25	<400	72.88
Nitrate and Nitrite as N	mg/l	40	4.55	<1.0	4.55
Fluoride as F	mg/l			<1.0	1.00
				Water quality class	Class 2

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

Table 56: Groundwater Quality Reserve GRU14

Chemical Parameter	Unit	GRU14			
		No. of Samples	Ambient GW quality or median[1]	BHN Threshold[2]	Groundwater Quality Reserve[3]
pH	–	59	8.15	5.0 – 9.5	7.25 - 8.86
Electrical Conductivity	mS/m	58	65.50	<150	72.05
Calcium as Ca	mg/l	51	59.60	<150	65.56
Magnesium as Mg	mg/l	52	39.93	<100	43.92
Sodium as Na	mg/l	49	23.57	<200	25.93
Potassium as K	mg/l	50	2.32	<50	2.55
Total Alkalinity as $CaCO_3$	mg/l	52	246.47	<330	271.12
Chloride as Cl	mg/l	52	38.33	<200	42.16
Sulphate as SO_4	mg/l	52	32.75	<400	36.03
Nitrate and Nitrite as N	mg/l	51	3.98	<1.0	3.98
Fluoride as F	mg/l	2	0.45	<1.0	0.50
				Water quality class	Class 0

[1] Median value (calculated from population of samples in QC).
[2] Upper limit of Class I water quality (DWAF et al 1998) and SANS (241: 2015) drinking water limits.
[3] The median plus 10% for the Groundwater Quality Reserve.

ANNEXURE G – GROUNDWATER RESERVE ESTIMATIONS

Table 57: Groundwater Reserve, Stress Index and Allocable Groundwater

Quaternary Catchment	Recharge (Mm³/a)	BHN GW Reserve (Mm³/a)	GW Baseflow (Mm³/a)	GW Reserve (Mm³/a)	GW Use (Mm³/a)	Stress Index	Stress Index Symbol	Allocable GW (Mm³/a)
C51A	11.21	0.004	1.92	1.924	1.754	15.65	B	7.527
C51B	24.55	0.007	3.00	3.007	1.089	4.44	A	20.452
C51C	10.51	0.003	0.96	0.963	1.376	13.10	B	8.169
C51D	15.80	0.017	1.92	1.937	0.470	2.97	A	13.389
C51E	13.68	0.010	2.04	2.05	1.109	8.11	A/B	10.522
C51F	13.88	0.005	1.08	1.085	1.018	7.33	A/B	11.777
C51G	27.11	0.007	4.68	4.687	2.072	7.64	A/B	20.353
C51H	27.67	0.010	3.48	3.49	3.354	12.12	B	20.824
C51J	17.59	0.005	1.20	1.205	3.128	17.78	B	13.259
C51K	50.30	0.017	0.72	0.737	7.488	14.89	B	42.076
C51L	20.91	0.009	0.48	0.489	0.428	2.05	A	19.989
C51M	10.36	0.007	0.36	0.367	0.014	0.14	A	9.983
C52A	24.85	0.008	3.96	3.968	2.970	11.95	B	17.916
C52B	25.98	0.013	2.76	2.773	0.026	0.10	A	23.179
C52C	15.87	0.005	1.44	1.445	0.216	1.36	A	14.207
C52D	11.44	0.005	0.96	0.965	0.845	7.39	A/B	9.630
C52E	16.47	0.007	1.32	1.327	0.755	4.59	A	14.384
C52F	12.99	0.046	1.20	1.246	1.759	13.54	B	9.983
C52G	28.52	0.015	1.68	1.695	10.725	37.61	C	16.096
C52H	29.80	0.029	0.12	0.149	18.939	63.56	D/E	10.707
C52J	34.51	0.068	0.36	0.428	23.287	67.48	D/E	10.793
C52K	56.60	0.024	0.24	0.264	29.382	51.91	D	26.957
C52L	39.18	0.015	0.24	0.255	5.114	13.05	B	33.810
D12A	15.38	0.039	13.20	13.239	0.306	1.99	A	1.831
D12B	16.80	0.058	18.60	18.658	0.066	0.39	A	-1.922
D12C	14.96	0.013	2.52	2.533	0.000	0.00	A	12.422
D12D	13.52	0.002	1.80	1.802	0.006	0.05	A	11.715
D12E	26.82	0.007	3.48	3.487	1.057	3.94	A	22.280
D12F	24.99	0.005	3.12	3.125	0.184	0.74	A	21.683
D13A	18.60	0.003	33.24	33.243	0.135	0.73	A	-14.778
D13B	20.21	0.003	35.52	35.523	0.006	0.03	A	-15.320
D13C	20.38	0.003	28.80	28.803	0.000	0.00	A	-8.427
D13D	28.93	0.004	32.04	32.044	0.881	3.05	A	-3.997
D13E	28.90	0.008	64.68	64.688	0.113	0.39	A	-35.897
D13F	33.00	0.008	48.12	48.128	0.040	0.12	A	-15.169
D13G	34.57	0.008	9.84	9.848	0.069	0.20	A	24.651

Quaternary Catchment	Recharge (Mm³/a)	BHN GW Reserve (Mm³/a)	GW Baseflow (Mm³/a)	GW Reserve (Mm³/a)	GW Use (Mm³/a)	Stress Index	Stress Index Symbol	Allocable GW (Mm³/a)
D13H	14.89	0.008	6.60	6.608	0.049	0.33	A	8.235
D13J	34.98	0.007	7.08	7.087	0.600	1.72	A	27.293
D13K	11.81	0.003	23.52	23.523	0.161	1.36	A	-11.875
D13L	20.70	0.004	6.12	6.124	0.229	1.10	A	14.351
D13M	10.25	0.005	3.96	3.965	0.254	2.48	A	6.027
D14A	7.83	0.007	4.08	4.087	0.323	4.12	A	3.424
D14B	4.74	0.002	1.32	1.322	0.000	0.00	A	3.419
D14C	8.96	0.004	3.36	3.364	0.284	3.17	A	5.316
D14D	8.14	0.003	2.04	2.043	0.499	6.13	A/B	5.599
D14E	7.24	0.004	1.80	1.804	0.360	4.98	A	5.075
D14F	6.73	0.003	2.88	2.883	0.054	0.80	A	3.788
D14G	27.94	0.003	3.12	3.123	0.091	0.33	A	24.730
D14H	8.41	0.004	2.16	2.164	0.517	6.15	A/B	5.729
D14J	6.22	0.003	1.56	1.563	0.286	4.60	A	4.368
D14K	7.60	0.003	1.80	1.803	0.269	3.55	A	5.527
D15G	12.83	0.001	18.60	18.601	0.000	0.00	A	-5.769
D15H	8.46	0.002	12.12	12.122	0.002	0.02	A	-3.661
D18K	31.88	0.039	48.00	48.039	0.000	0.00	A	-16.160
D18L	19.65	0.049	25.20	25.249	0.000	0.00	A	-5.600
D21A	22.65	0.003	0.00	0.003	0.006	0.03	A	22.638
D21C	12.73	0.001	0.00	0.001	0.000	0.00	A	12.728
D21D	13.42	0.007	6.84	6.847	0.004	0.03	A	6.564
D21E	16.70	0.008	7.32	7.328	0.370	2.22	A	9.003
D21F	25.00	0.015	4.56	4.575	0.350	1.40	A	20.075
D21G	11.57	0.007	2.64	2.647	0.021	0.18	A	8.898
D21H	20.45	0.003	13.20	13.203	0.000	0.00	A	7.247
D22A	27.63	0.011	4.44	4.451	0.092	0.33	A	23.082
D22B	25.54	0.009	3.84	3.849	0.005	0.02	A	21.687
D22C	21.40	0.002	16.20	16.202	0.000	0.00	A	5.196
D22D	22.65	0.009	4.44	4.449	0.289	1.28	A	17.911
D22G	38.05	0.015	6.12	6.135	0.156	0.41	A	31.754
D22H	20.06	0.006	4.32	4.326	0.174	0.87	A	15.557
D22L	11.79	0.005	2.40	2.405	0.127	1.08	A	9.262
D23A	24.25	0.006	3.24	3.246	0.058	0.24	A	20.943
D23C	26.46	0.013	3.72	3.733	0.022	0.08	A	22.700
D23D	16.38	0.011	2.52	2.531	0.000	0.00	A	13.846
D23E	20.35	0.006	3.12	3.126	0.000	0.00	A	17.224
D23F	6.48	0.001	2.16	2.161	0.000	0.00	A	4.314
D23G	14.80	0.002	2.88	2.882	0.002	0.01	A	11.920
D23H	20.48	0.005	2.76	2.765	0.429	2.09	A	17.283

Quaternary Catchment	Recharge (Mm³/a)	BHN GW Reserve (Mm³/a)	GW Baseflow (Mm³/a)	GW Reserve (Mm³/a)	GW Use (Mm³/a)	Stress Index	Stress Index Symbol	Allocable GW (Mm³/a)
D23J	14.40	0.004	2.28	2.284	0.237	1.64	A	11.877
D24A	5.97	0.002	1.92	1.922	0.033	0.56	A	4.018
D24B	9.05	0.002	2.04	2.042	0.090	0.99	A	6.918
D24C	6.90	0.003	1.20	1.203	0.252	3.65	A	5.447
D24D	10.14	0.002	1.44	1.442	0.019	0.19	A	8.679
D24E	8.38	0.001	1.08	1.081	0.262	3.12	A	7.040
D24F	10.52	0.002	1.56	1.562	0.000	0.00	A	8.953
D24G	13.51	0.003	2.52	2.523	0.000	0.00	A	10.991
D24H	12.52	0.003	2.04	2.043	0.363	2.90	A	10.111
D24J	17.25	0.005	2.16	2.165	0.766	4.44	A	14.321
D24K	8.22	0.003	1.92	1.923	0.967	11.76	B	5.333
D24L	7.39	0.002	1.08	1.082	0.491	6.64	A/B	5.819
D31A	13.71	0.004	2.16	2.164	1.285	9.37	A/B	10.264
D31B	10.08	0.002	0.60	0.602	0.223	2.22	A	9.251
D31C	6.96	0.001	0.60	0.601	0.053	0.77	A	6.305
D31D	15.04	0.003	1.20	1.203	1.069	7.11	A/B	12.764
D31E	10.25	0.003	1.20	1.203	0.071	0.70	A	8.977
D32A	7.78	0.001	0.60	0.601	0.401	5.15	A/B	6.781
D32B	6.48	0.003	0.72	0.723	1.104	17.04	B	4.652
D32C	10.06	0.003	0.60	0.603	0.255	2.54	A	9.202
D32D	9.24	0.001	0.60	0.601	0.000	0.00	A	8.635
D32E	9.28	0.002	0.60	0.602	0.279	3.01	A	8.401
D32F	15.57	0.003	0.84	0.843	0.402	2.58	A	14.325
D32G	10.83	0.003	0.84	0.843	2.310	21.33	B/C	7.676
D32H	5.97	0.002	0.48	0.482	0.385	6.45	A/B	5.107
D32J	14.64	0.003	0.84	0.843	0.136	0.93	A	13.656
D32K	7.80	0.002	0.60	0.602	0.118	1.52	A	7.075
D33A	9.02	0.002	0.36	0.362	0.120	1.33	A	8.542
D33B	10.31	0.002	0.24	0.242	0.095	0.92	A	9.970
D33C	10.02	0.002	0.36	0.362	0.161	1.61	A	9.492
D33D	11.25	0.002	0.24	0.242	0.010	0.09	A	10.997
D33E	18.60	0.006	0.12	0.126	0.550	2.96	A	17.921
D33F	11.69	0.003	0.12	0.123	0.018	0.15	A	11.545
D33G	16.26	0.005	0.24	0.245	0.023	0.14	A	15.995
D33H	9.30	0.004	0.24	0.244	0.000	0.00	A	9.052
D33J	7.33	0.004	0.12	0.124	0.069	0.93	A	7.138
D33K	4.65	0.002	0.24	0.242	0.000	0.00	A	4.407
D34A	9.07	0.003	0.36	0.363	1.782	19.64	B	6.926
D34B	8.00	0.003	0.12	0.123	0.819	10.23	B	7.062
D34C	8.49	0.003	0.12	0.123	0.930	10.96	B	7.438

Quaternary Catchment	Recharge (Mm³/a)	BHN GW Reserve (Mm³/a)	GW Baseflow (Mm³/a)	GW Reserve (Mm³/a)	GW Use (Mm³/a)	Stress Index	Stress Index Symbol	Allocable GW (Mm³/a)
D34D	6.73	0.002	0.12	0.122	0.235	3.50	A	6.369
D34E	5.90	0.002	0.12	0.122	0.478	8.11	A/B	5.302
D34F	7.69	0.004	0.12	0.124	0.398	5.17	A/B	7.168
D34G	10.96	0.003	0.36	0.363	1.331	12.15	B	9.268
D35A	3.07	0.001	0.84	0.841	0.380	12.37	B	1.851
D35B	3.11	0.001	0.72	0.721	0.186	5.98	A/B	2.201
D35C	11.06	0.004	2.28	2.284	0.709	6.41	A/B	8.065
D35D	6.82	0.002	1.20	1.202	0.235	3.45	A	5.379
D35E	3.67	0.001	0.72	0.721	0.505	13.77	B	2.441
D35F	6.62	0.002	1.56	1.562	0.484	7.30	A/B	4.578
D35G	6.40	0.002	0.84	0.842	2.073	32.39	C	3.484
D35H	6.07	0.002	1.08	1.082	0.292	4.82	A	4.696
D35J	19.14	0.003	1.80	1.803	1.264	6.60	A/B	16.071
D35K	8.19	0.002	1.08	1.082	0.909	11.09	B	6.203