water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DETERMINATION REVIEW AND IMPLEMENTATION OF THE RESERVE IN THE OLIFANTS/LETABA SYSTEM

Skills Transfer and Capacity Building S1

18 February 2016

Purpose of meeting: Skills Transfer and Capacity Building Session for the Groundwater component of the DWS Project: "The Determination, Review and Implementation of the Reserve in the Olifants/Letaba System" (WP10940)

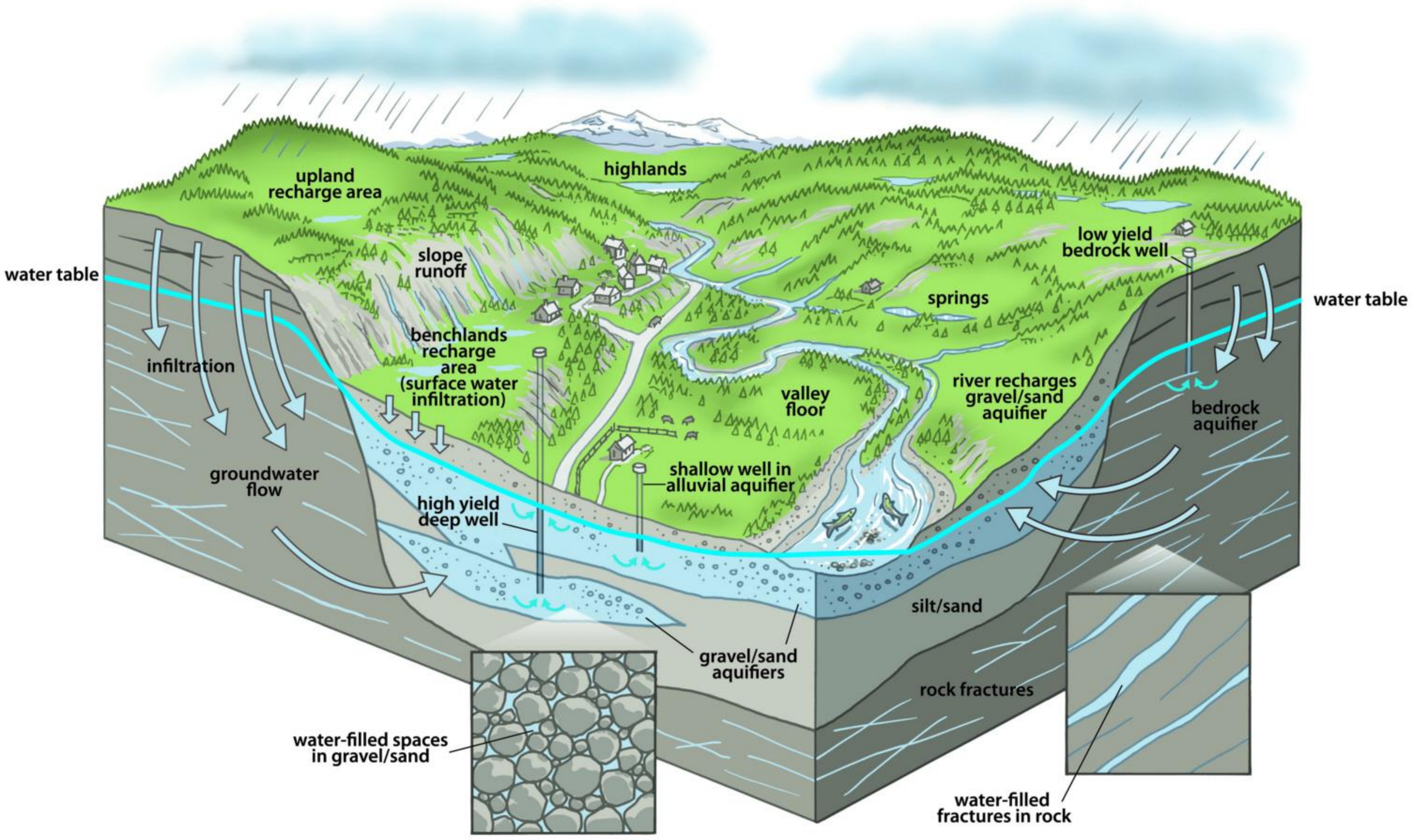
Agenda items:

Welcome and Introductions.	All present
Morning's Programme.	E van Wyk
Groundwater and the Reserve Concept.	E van Wyk
Basic Information Required and Sources.	E van Wyk
Procedure followed for Gwater.	E van Wyk
Application to Olifants/Letaba System.	E van Wyk
Practicals.	All present
General/Discussions.	All present
Closure	

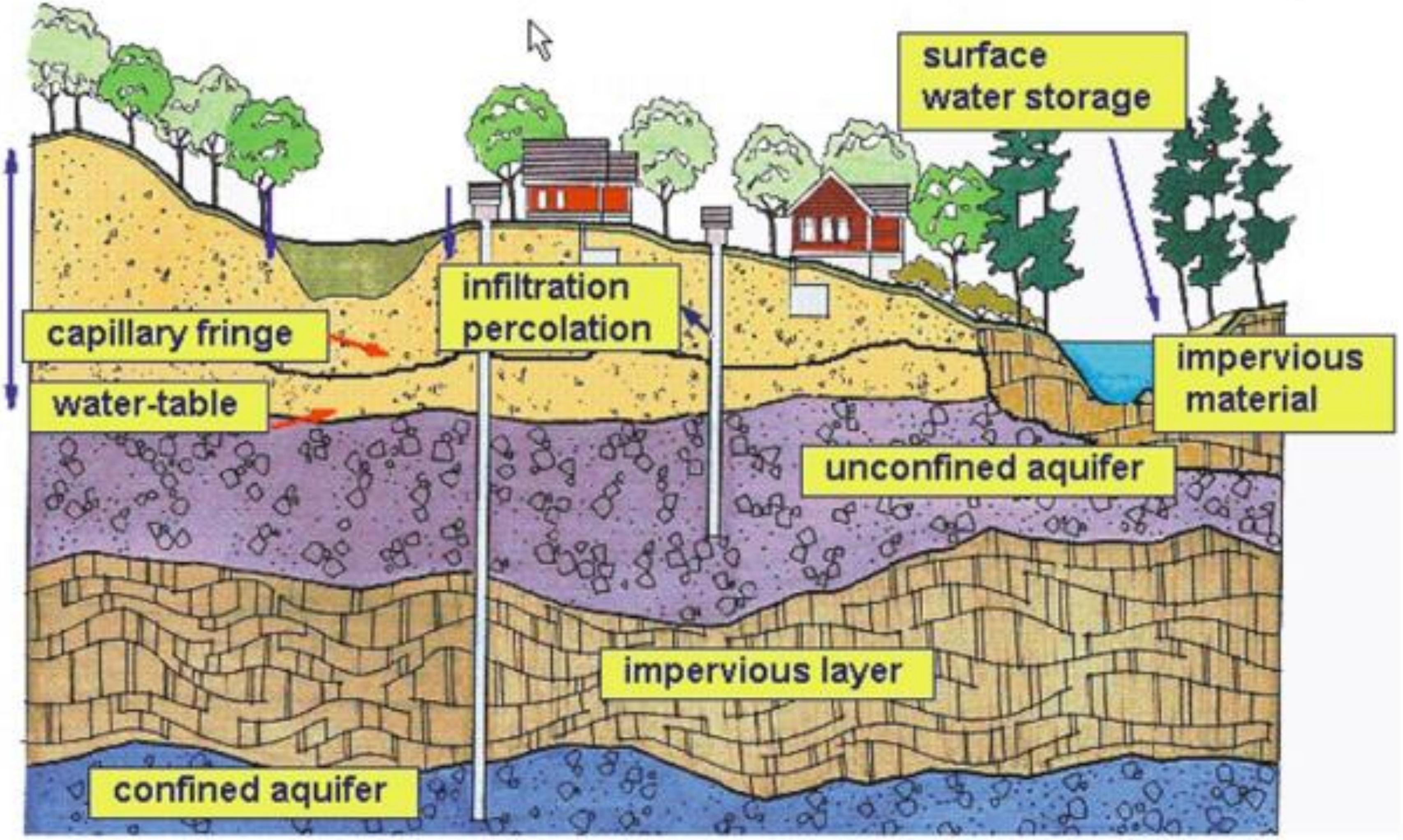
Light Lunch

3a - GROUNDWATER CHARACTERISTICS

Groundwater:……… Occurrences (ii) (after watershed-watch.org)



Groundwater:……… Occurrences (i) (after landfood.ubc)

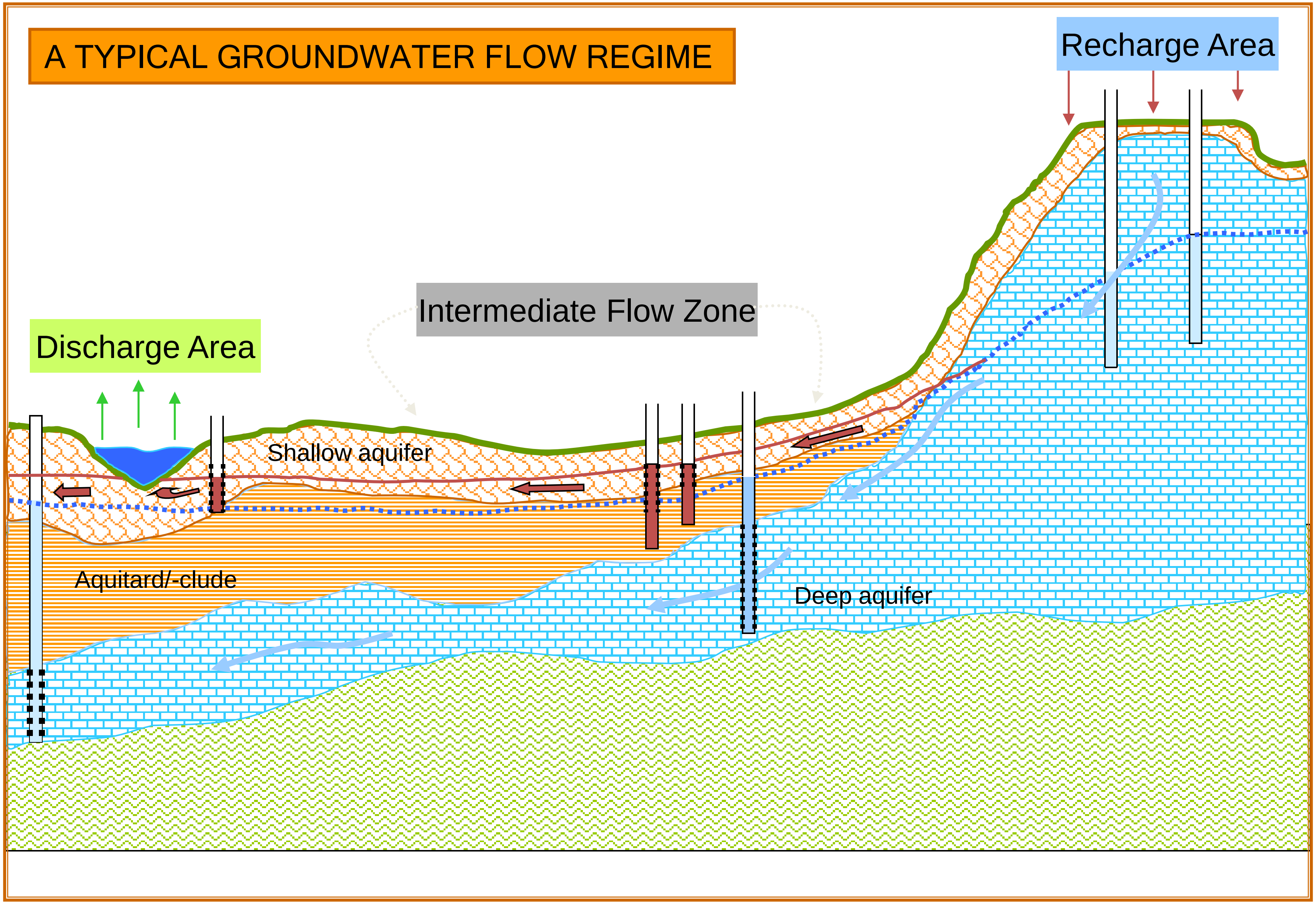


- GROUNDWATER RESOURCES:

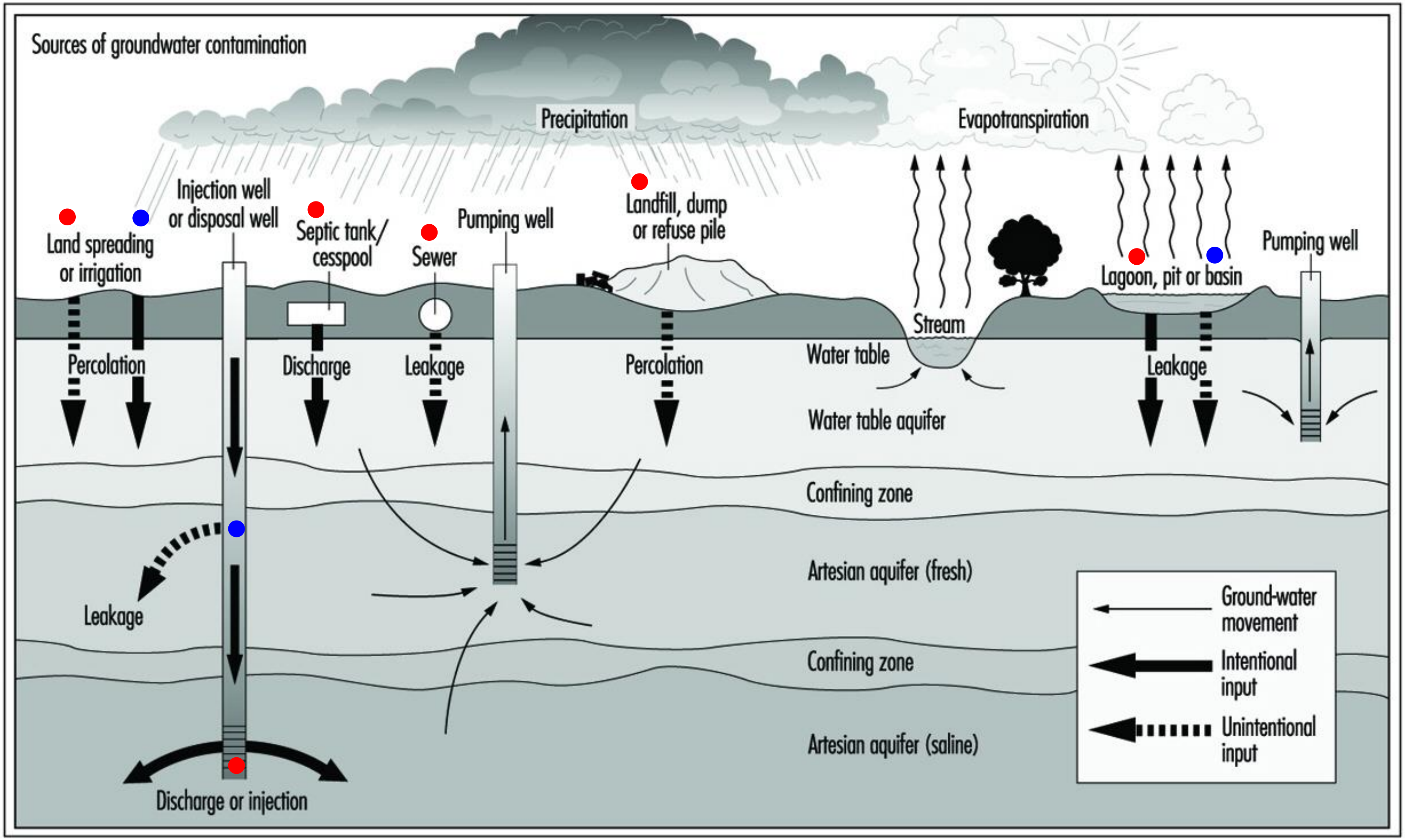
  Groundwater occurs in a wide spectrum of geological formations and all four different aquifer classifications are present, viz.:

  - Intergranular (primary) aquifers (shallow soft rock, alongside rivers/spruits);
  - Fractured and weathered (secondary) aquifers (hard rock, alongside drainages and country wide);
  - Fractured (secondary) aquifers (solid, hard rock – country wide);
  - Karst (dolomite) aquifers.

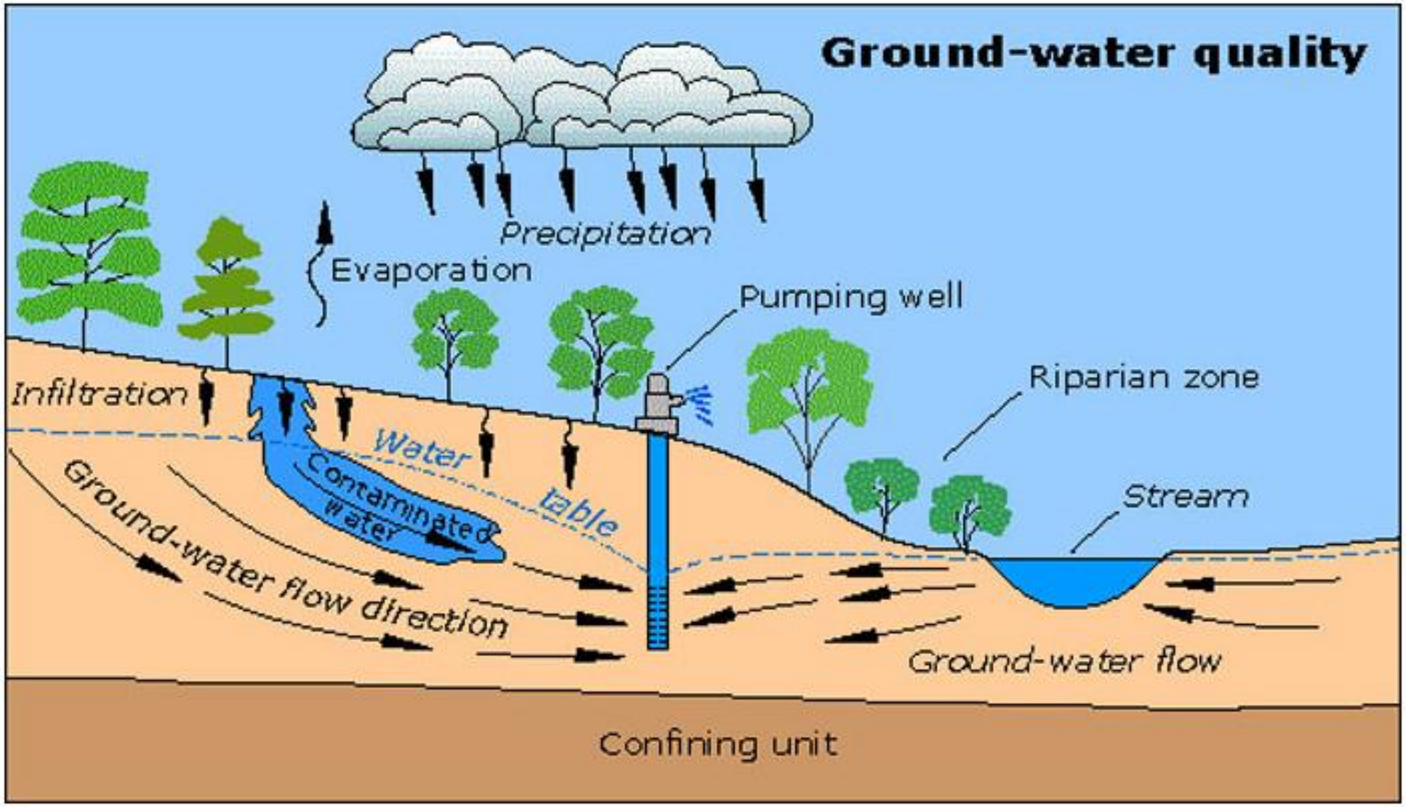
- SIGNIFICANT AQUIFER SYSTEMS:
  - Dolomite Water Areas:
    - High yielding aquifers with a high rate of recharge, but also highly vulnerable to pollution and unbalanced recharge – abstraction scenario's; and
    - Having their own catchment demarcation due to unique boundary conditions.
  - Alluvium Aquifer Systems:
    - Along river channels;
    - Swater-Gwater Interactions.
  - Hard Rock Aquifer Systems:
    - Regional geological formations such granites, quartzites, sandstones & mudrock;
    - Represents the Fractured & Weathered and Fractured Aquifer Systems in SA.


A TYPICAL GROUNDWATER FLOW REGIME
Recharge Area
Intermediate Flow Zone
Discharge Area
Shallow aquifer
Aquitard/-clude
Deep aquifer

Groundwater:……… Flow paths/water sources link to Gwater (iloenncyclopaedia.org)



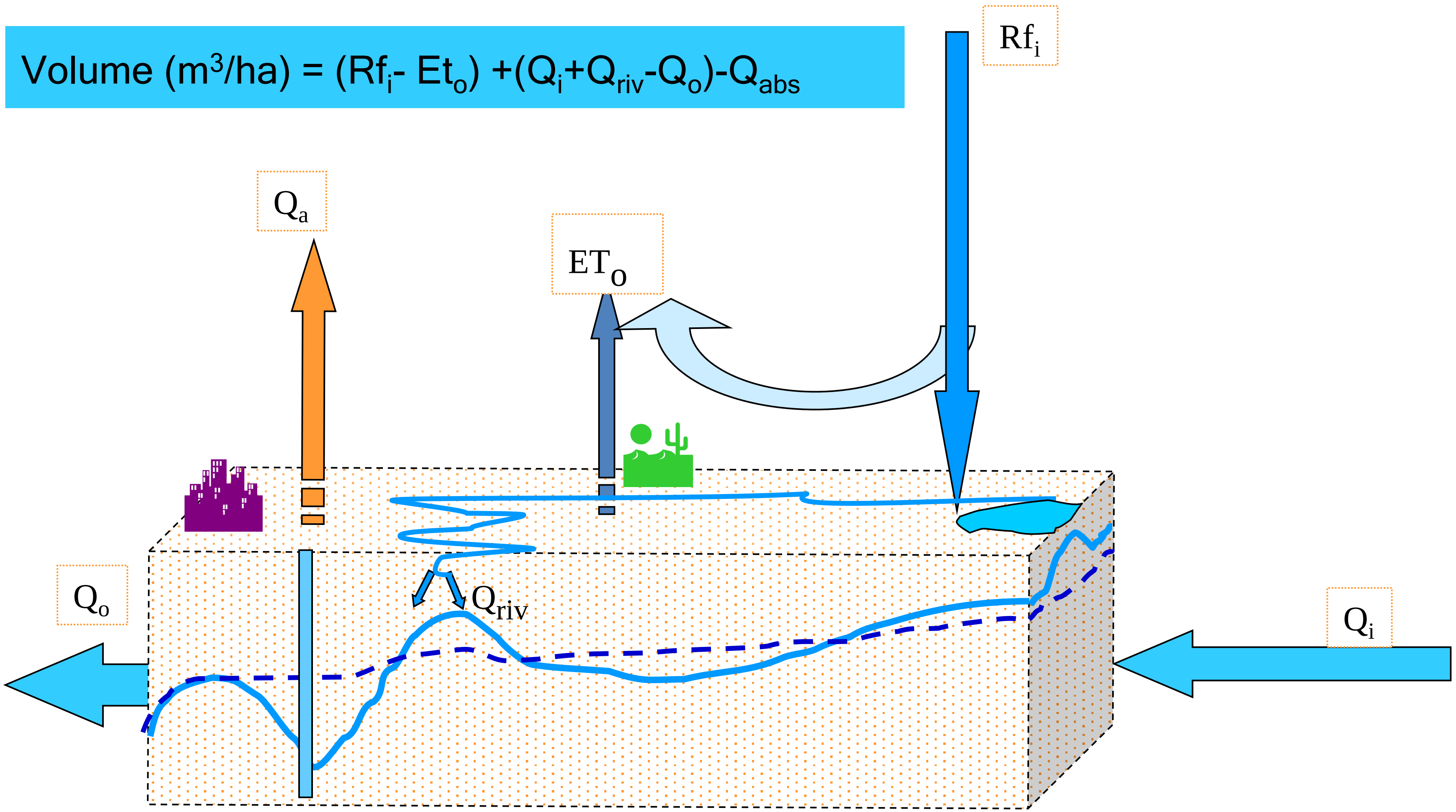
Groundwater: Impacts – pollution / baseflow reduction (ii) (after citeatthecrossroads.net)



⇨ Showing impact of land use pollution (PCD's, land fill sites, stock kraals, leaking sewer systems, etc.) ; and
⇨ Showing impact of high Gwater abstraction on river flow (reducing baseflow in drainage).

3b + 4 -- GROUNDWATER BEHAVIOUR

$$\text{Volume } (m^3/ha) = (Rf_i - Et_o) + (Q_i + Q_{riv} - Q_o) - Q_{abs}$$



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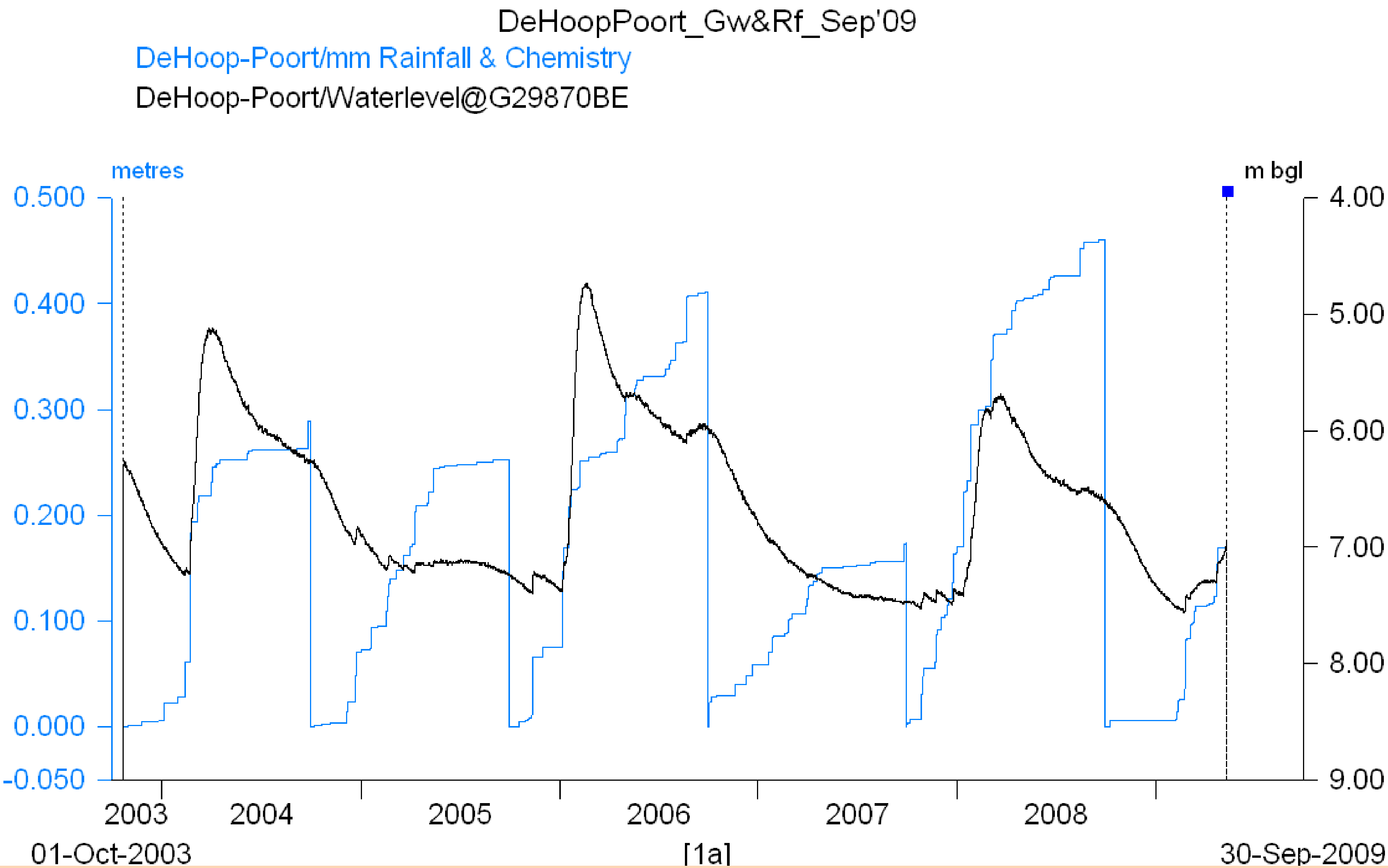
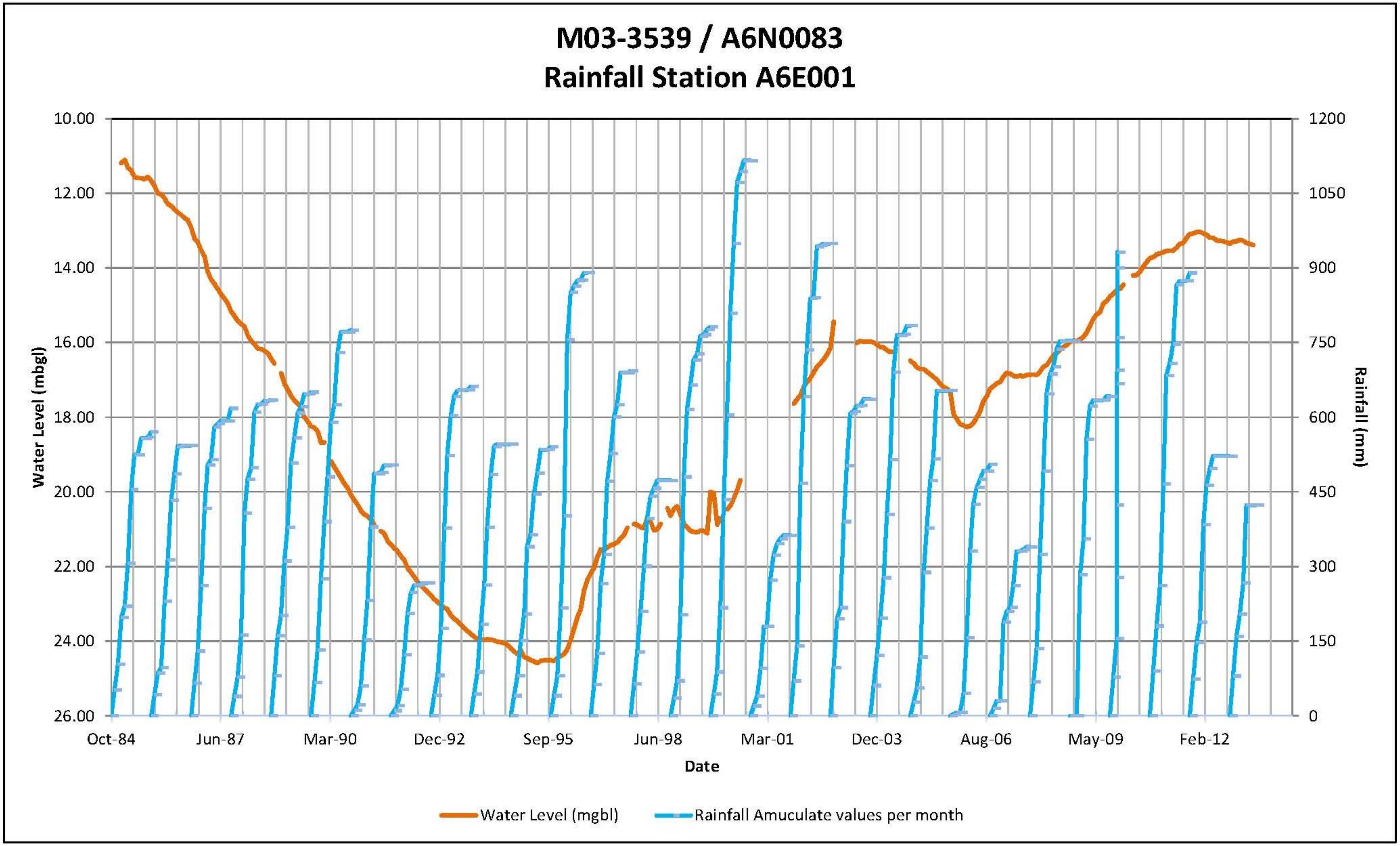


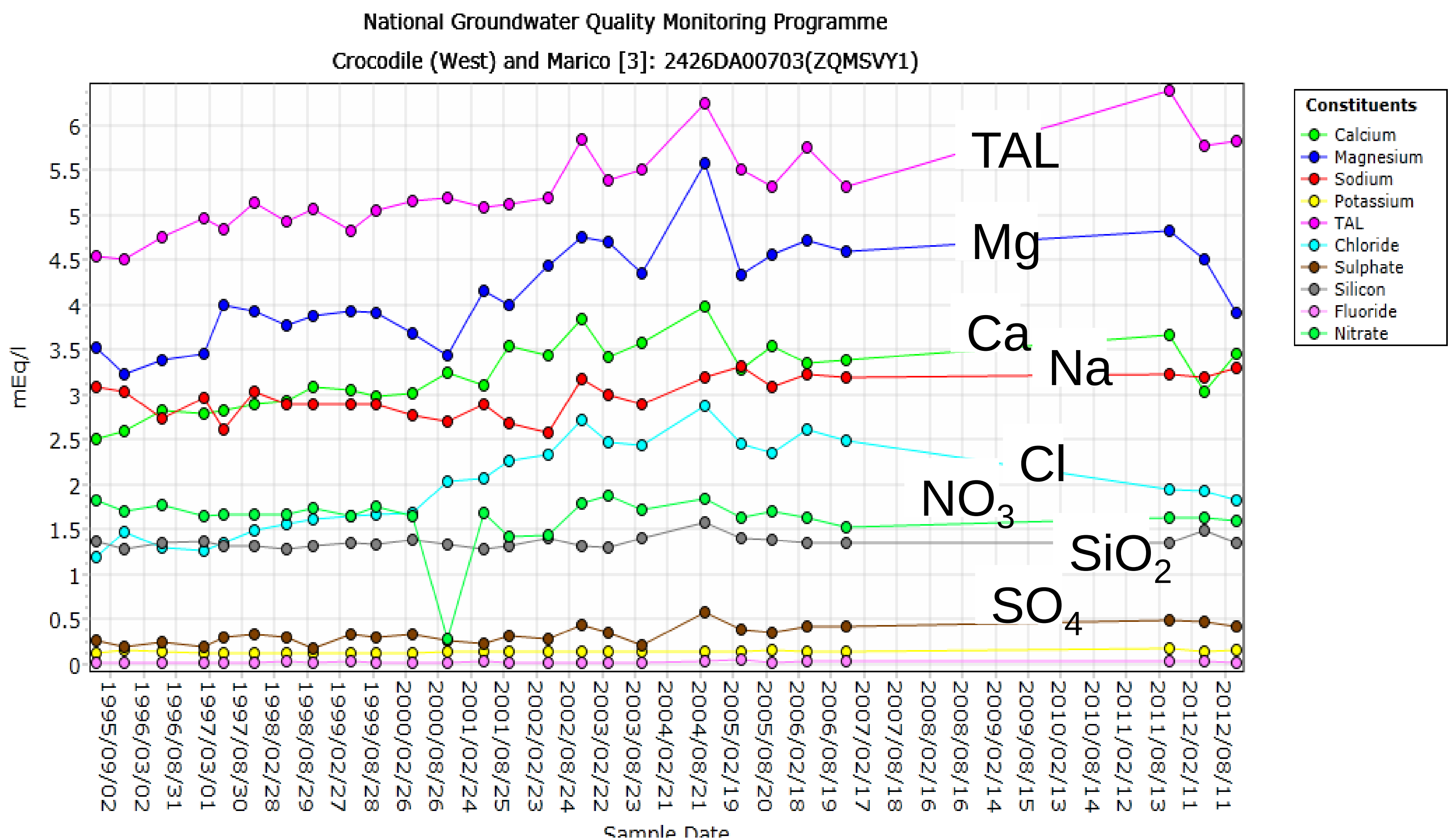
Show the high variability in annual groundwater recharge events, i.e. rainfall depth VS water levels



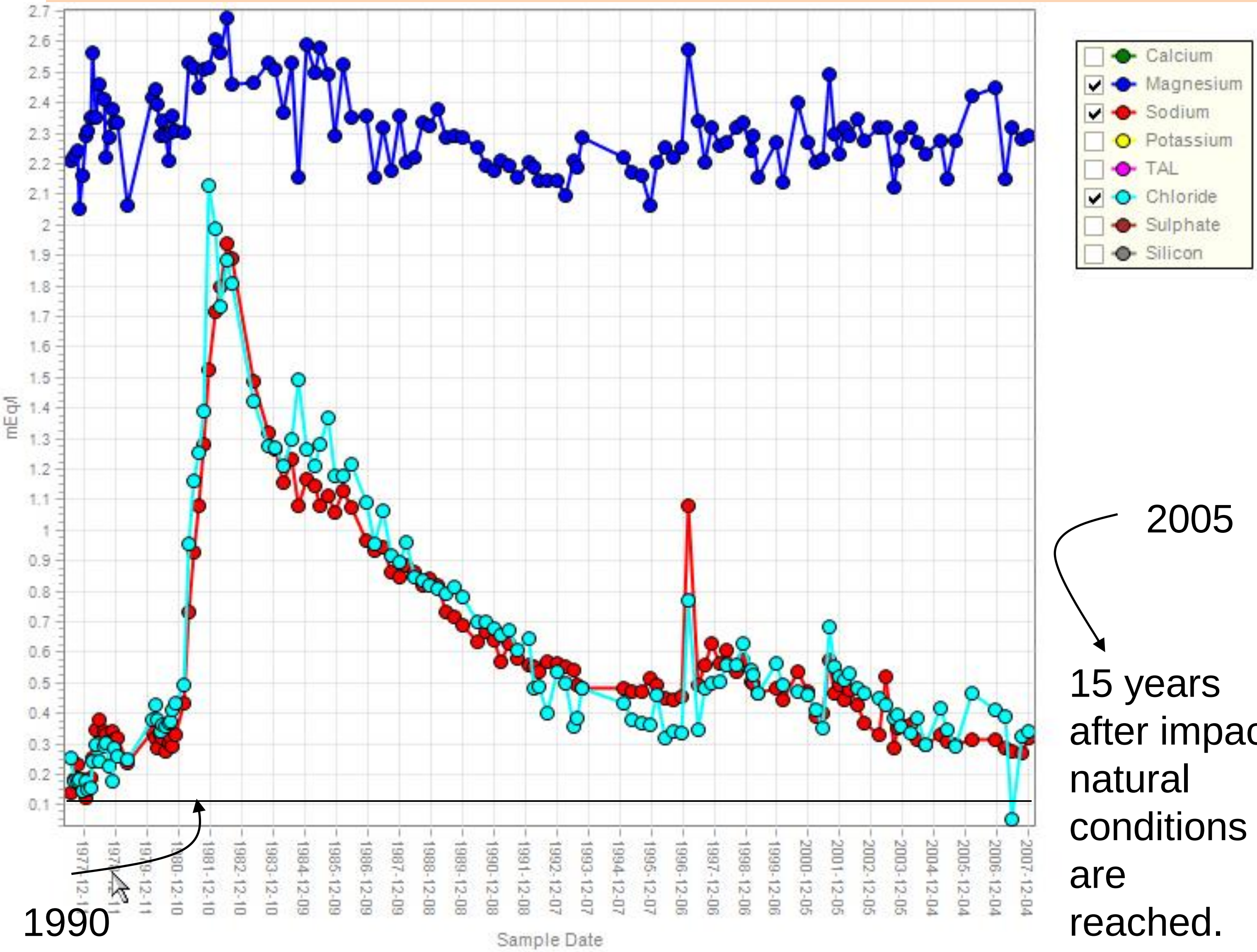
Long-term variation in aquifer saturation levels … What is the reference water level for RQO's?

DETERMINATION REVIEW AND IMPLEMENTATION OF THE RESERVE IN THE OLIFANTS/LETABA SYSTEM

Long-term variation in groundwater quality showing slightly rising trend for TAL, Mg, Ca Na & Cl.



Time series showing the imp-act of local pollution (in this case NaCl dumped into a redundant quarry) ~5km's upstream of an dolomite eye. Fully flushed after ~15 years.



2005

15 years after impact natural conditions are reached.

DETERMINATION REVIEW AND IMPLEMENTATION OF THE RESERVE IN THE OLIFANTS/LETABA SYSTEM

Borehole situatated next to a local drainage system where acid mine water started to decant.

4-5 -- GROUNDWATER RESOURCES DIRECTED MEASURES

- Reserve Concept:
  - A component of the Resource Quality Measures (NWA, Act No. 36 of 1998):
    - Classification, Reserve and Resource Quality Objectives.
    - Determine Quality/Quantity of surplus groundwater above the Reserve for the water resource.
  - Basic Human Needs:
    - Water supply (25l/c/d) from local resources (aquifers, rainfall storage and natural streams).
  - Ecological Protection for:
    - Wetlands, Springs/Eyes and Baseflow Status (e.g. Gwater in-stream flow requirements).
- Groundwater Reserve – 2 Important Aspects
  - Groundwater Storage (volume):
    - Depleting aquifer saturation levels (e.g. shallow water users, flows at springs and base flow).
  - Groundwater Quality (human, ecology and aquatic uses):
    - Deterioration of aquifer water quality (e.g. land use pollution, an activity generating ARD, poor water quality intrusions, i.e. up coning of deep saline water or lateral seawater movement).

Significant Groundwater Resources in South Africa

- **Aquifer Types** Classification (Hydrogeology: Mapping Gwater Resources)
  - Karst/dolomite aquifers (Wolkberg Dolomites)
  - Fractured Karoo, Waterberg Group and Bushveld Igneous Complex aquifers
  - Intergranular Alluvial aquifers (major river channels)
  - Intergranular and fractured aquifers ()

- **Borehole Yield Class** and **Aquifer Rating** (Hydrogeology: Assessment)

Borehole Yield Class (l/s)	Aquifer Rating
0.0 to 0.5 l/s	Insignificant
>0.5 to 2.0 l/s	Minor
>2.0 to 5.0 l/s	Moderate
>5.0 l/s	Significant

- Delineation of **Major Dolomite Resources** (Olifants-Letaba System))
  - Delmas Dolomites
  - Wolkberg Dolomites.

- Data Requirements / Availability

a) Groundwater Recharge (% of MAP – m^3 in GRU)

- Vegter (1995);
- Gwater Exploitation Potential (2003);
- GRA II (2005); and
- **Specialist Reports (post 2005)**.

b) Groundwater Quality (Compliance: I – 95%, II – 75% & III - <75%).

- NGA data base;
- **Specialist Reports**; and
- **National Gwater Quality Monitoring Programme**.

c) Groundwater Use (Mm^3/a in IUA)

- Vegter (1995);
- GRA II (2005);
- **WARMS** (2008, **2014 or later**); or
- **Specialist Reports**.

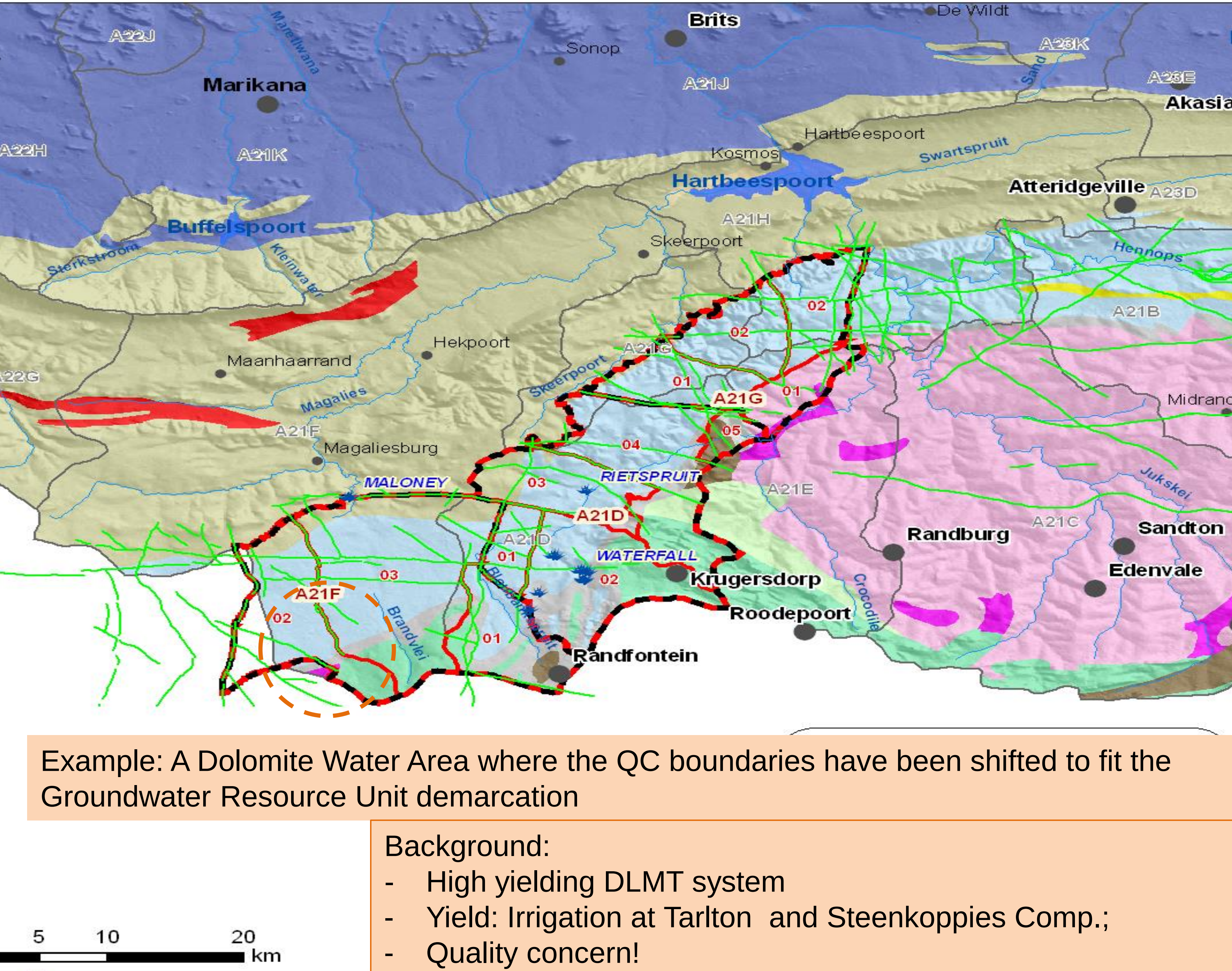
- Basic Information Required: ....
  - Scale of Assessment: A Groundwater Management/Resource Unit…….GwRU
    - Areas of similar hydrogeological (physical/ecological) properties, grouped together to simplify the process;
    - Olifants/Letaba: Quaternary Catchment Level, several QC's grouped into one GwRU.
  - Scope of Information Required………..GRDM based (possible information source):
    - Reference Conditions for GwRU's: Initial natural conditions (reports and time series information)…♦;
    - Water Uses Criteria: All the abstraction volumes (hydrocensus, plus WARMS dataset)…...........♦;
      - Strategic, common, multiple, conflicting vs non-conflicting and natural discharges.
    - Present Status of GwRU's: Water resources monitoring data (CMA's, DWS, water users)……….. ♦;
    - Indicate the degree of vulnerability of GwRU's: Ecological dependency, contamination vulnerability, over-exploitation risk and current degree of impact (viz. degree of infrastructure developments, mining, industries, villages, agric. (GIS/Land Use assessment)……………………♦.
  - Reference Conditions:
    - Aquifer Saturation Level (Water Levels)………………….historical water level dataset; and
    - Water Quality Status………..focussing on TDS, NO_3, SO_4 and F for example, but any other macro/micro/trace metal constituent should be considered as well.

- Hydrogeological Characteristics

  Aquifer systems occurs as groundwater units due boundaries formed by geological features (specifically dolomite water areas):

  - Geological/Hydrogeological Characteristics: e.g. 1:500k Mapping as Baseline.
  - Flow Regimes: Aquifer boundaries based on geological features (dykes/faults).
  - CMA-Water Users Association Boundaries: For management requirements.
  - Quaternary Boundaries: Normally aquifer boundaries can be inline with QC;s, however, in the case of large dolomite water areas, the QC boundaries are changed.
  - Groundwater Management Units (GMU's) : Several dolomite compartments (or GRU's) may be grouped together as Groundwater Management Units, based on surface water drainages and hydrogeological considerations.
  - Groundwater Resource Units (GRU's): **A groundwater body, which represents a hydrogeological homogenous zone, that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit.** A compartmentalised dolomite water areas is a good example of a GRU.

  - The application of GRU's are mainly used in the cases of large dolomite water areas where due to their unique compartmentalisation, the surface water boundaries are not complying to the actual groundwater flow patterns and may cause problems especially between two different WUA's. In such cases, the areas should be mapped and highlighted and specifically explained for further applications of the RDM and WUL procedures.



Example: A Dolomite Water Area where the QC boundaries have been shifted to fit the Groundwater Resource Unit demarcation

Background:

- High yielding DLMT system
- Yield: Irrigation at Tarlton and Steenkoppies Comp.;
- Quality concern!

➢ Groundwater Resource Classification Criteria (example)

The classification used is based on quantity and quality of groundwater as follows:

- **Quantity - Stress Index**

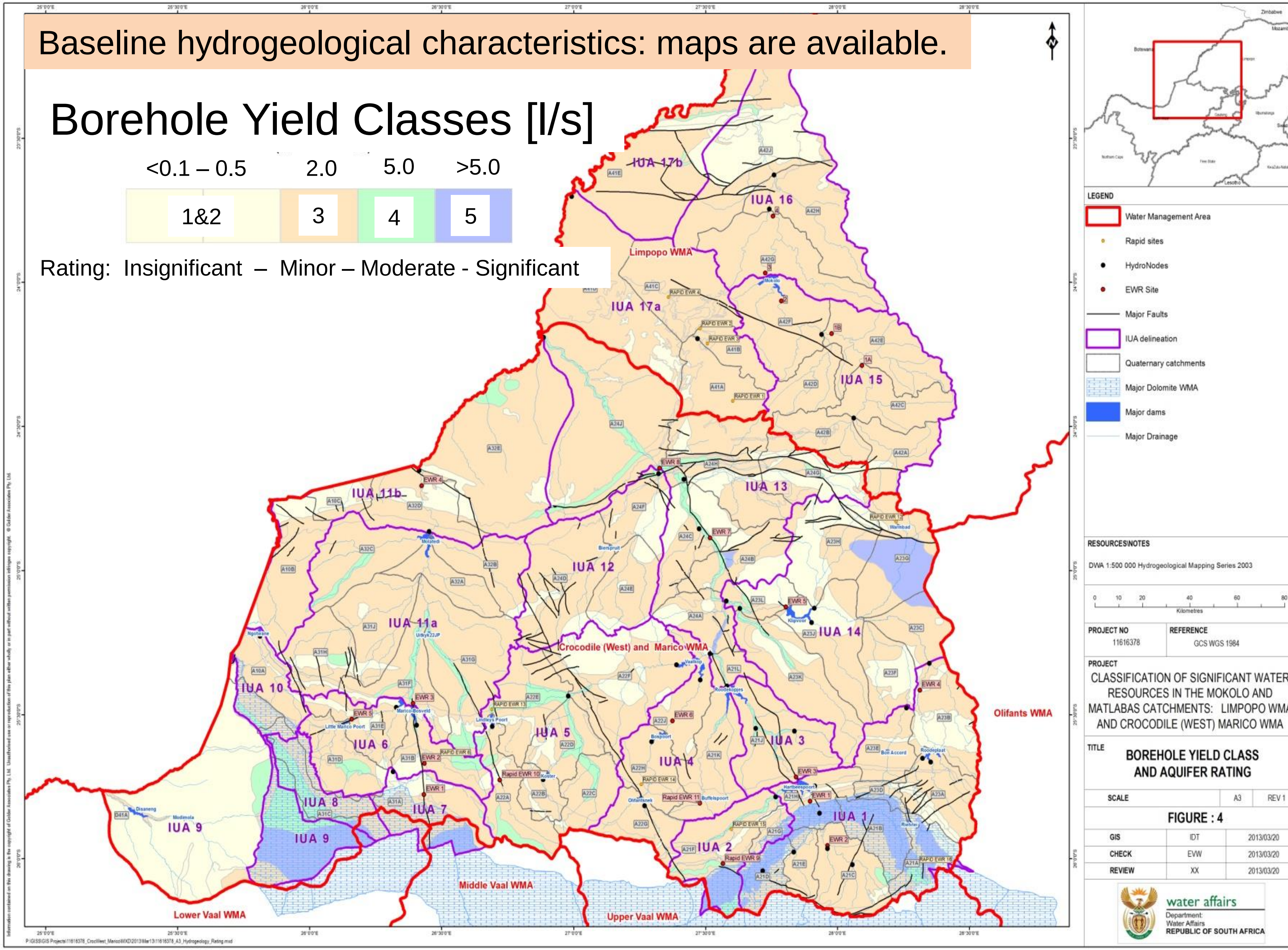
Present category	Description	Compliance (spatial/Temporal)
I	Minimally used	≤20%
II	Moderately used	20% - 65%
III	Heavily used	>65%

- **Quality - Hydrochemistry (SAWQG Vol.1 – Domestic Use)**

Present category	Description	Compliance (spatial/temporal)
I	DWA Class 0 or 1 natural background	95%
II	DWA Class 2 (95% compliance) or natural background (75% compliance)	75%
III	DWA class 3 or 4 or natural background (<75% compliance)	<75%

This evaluation represents the first step into evaluation of the Reserve Determination (guide to address the status (Ql) and availability (Qn) of water from the water resource.

Baseline hydrogeological characteristics: maps are available.



- Datasets applied:

a) Gwater Recharge: (Vegter$_{1995}$, GRA II$_{2005}$, Specialist Studies)

Table : Recharge estimation (example only)

Q-Catchment	QC's	MAP (mm)	Area (km²)	GRA II		Vegter (1995)	Specialist report Mm³	Applied Re est. Mm³	Recharge %
				(Wet) Mm3	(Dry) Mm³	Mean Mm³			
1	A41A	625.3	692	19.85	14.33	18.81	-	17.66	4.1
	A41B	586.6	358	8.60	6.14	8.85	-	7.86	3.7
2	A41C	511.7	1111	16.41	11.44	11.84	-	13.23	2.3
	A41D	491.6	1913	20.51	14.12	15.51	-	16.71	1.8
3	A41E	438.2	1940	14.99	9.96	12.80	11.9	12.41	1.5

Data set applied – Highlights the difficulty with Groundwater Uses numbers, a major obstacle with Reserve Determinations as cases exists where the groundwater use is completely overriding the available annual recharge.

Only updated data source through WARMS (Groundwater use).

Table: Groundwater Use per IUA (example only, but look at the differences)

QC	GRA II (2005)	Warms (2008)	Warms (2013)
1	1.56	20.345	22.990
2	0.83	11.575	12.475
3	1.52	1.166	0.923
4	1.93	11.533	11.860
5	5.27	0.774	0.872
6	3.95	3.226	3.387
7	12.77	5.094	4.982

Data set applied.

c) NGA (Groundwater Quality).

Table : Groundwater quality (mean values) (All units in mg/l, EC in mS/m)

QC	Para-meter	pH	EC	Ca	Mg	Na	K	SO_4	Cl	NO_3 as N	F	Compliance (% of samples within Class I)	Present Category
1	Nr	190	190	189	189	189	189	189	189	187	189	31 %	III
	Mean	7.5	214	125	79	202	7.4	126	439	10.5	1.6		
2	Nr	81	82	78	78	78	69	78	78	54	78	32 %	II
	Mean	7.6	221	91	52	200	13	150	298	9.0	1.2		

The source of the poorer water quality needs to be assessed during the RDM assessment – if due to natural (geological) conditions, the use will be influenced accordingly, but if the source is related to anthropogenic activities, the reserve quality needs to be addressed through management protocols (RQO's)

Methodology: Classification and Management Class …. Reserve Indicators

Table : Calculation of Stress Index's and Water Use and Quality Classes

QC	Area (Km^2)	Recharge Mm^3	Ground-water Use Mm^3/a	Stress Index (SI)	Present Category (SI)	Present Category (Impact) ❖	Proposed Category	In terms of Reserve Status
1	1095	33.96	25.50	75%	III	II	II	Potential impact on Reserve possible.
2	3224	99.33	105.50	106%	III	III	II	Over-utilised, impact on Reserve noted, i.e. borehole running dry.
3	1207	26.40	0.13	1%	I	I	[1]III	Natural conditions, QI needs protection
4	2869	30.95	2.21	7%	I	II	[1]III	Natural conditions, QI needs protection

[1]III Poor groundwater quality status due to natural (mostly geological) conditions. Resource is minimally used (<20%) due to the poor groundwater quality. Very little water is used for water supply, thus Reserve Status in natural condition.

❖ Team's hands-on assessment of the present water use/status category obtained through physical observations and special research programmes.

6 - GROUNDWATER RESOURCES DIRECTED MEASURES:
Examples of procedures followed

Grouping of aquifer systems/quaternary catchments to grouped to present GRU's. Reference back to the quaternary catchments should not be ignored towards the final product.

Table 4-1: Groundwater Resource Units

Resource Unit	Affected Quaternary[2]	Area (km^2)	Water User Association
1	B11A - L, B12A - E	7108	KLEIN OLIFANTS
2	B20A - J	4094	UPPER OLIFANTS
3	B20A- B	261	UPPER OLIFANTS
4	B31A- D, F - J, B32G – J	5611	ILANGA
5	B32A – F	2976	LOSKOP VALLEY
6	B32D	133	LOSKOP VALLEY
7	B41A- K, B42A- H	7134	TUBATSE
8	B31E, F, J	2519	ILANGA
9	B51E, G, B52A	2588	GREAT SIKHUKHUNI
10	B31H, J	180	ILANGA
11	B51A - C, E, G, H, B52A, B, D, E, G, J	5339	GREAT SIKHUKHUNI
12	B51E	54	GREAT SIKHUKHUNI
13	B60A, E, F, G, H	1151	MOGABA
14	B71A, B, D, E, F	1479	KLASIRIE IRR BOARD
15	B52A, D, G, J, B60A - D, H, B71A, C, D, F, G, B72F	1599	MOGABA, KLASIRIE IRR BOARD, GREAT SIKHUKHUNI
16	B60B - D, H, J	1100	MOGABA
17	B51E, F, G, B52A, C, F, H	1425	GREAT SIKHUKHUNI
18	B71C, D, F, G, H, J, B72A - K, B73A - J	9974	KLASIRIE IRR BOARD

Description of assessment for a resource unit:

Resource Unit 9

Resource Unit 9 has an aerial extent of 2 588 km^2 and consists of quaternaries B51E, G, B52A. This resource unit is comprised of the northern portion of the Springbok Flats area and forms part of the Great Sikhukhuni WUA. Figure 4-3i shows RU9. Quaternary catchment B51E forms an endoeric area.

Classification

- Abstraction is calculated at 12.2 Mm^3/a in this northern part of the Springbok Flats. Recharge is estimated at 42 Mm^3/a (3% of MAP). The stress index is 0.29, which is a PSC level C - Moderate levels of stress;
- Approximately 85% of the groundwater users are registered.
- The water resource category is Poor and similar to RU8 is due to the high groundwater abstraction and water quality reflecting elevated salt levels that appear to be due to the high evaporation rates in this area. TDS concentrations range from marginal to unacceptable in the central parts of this resource unit.

Resource quality objectives

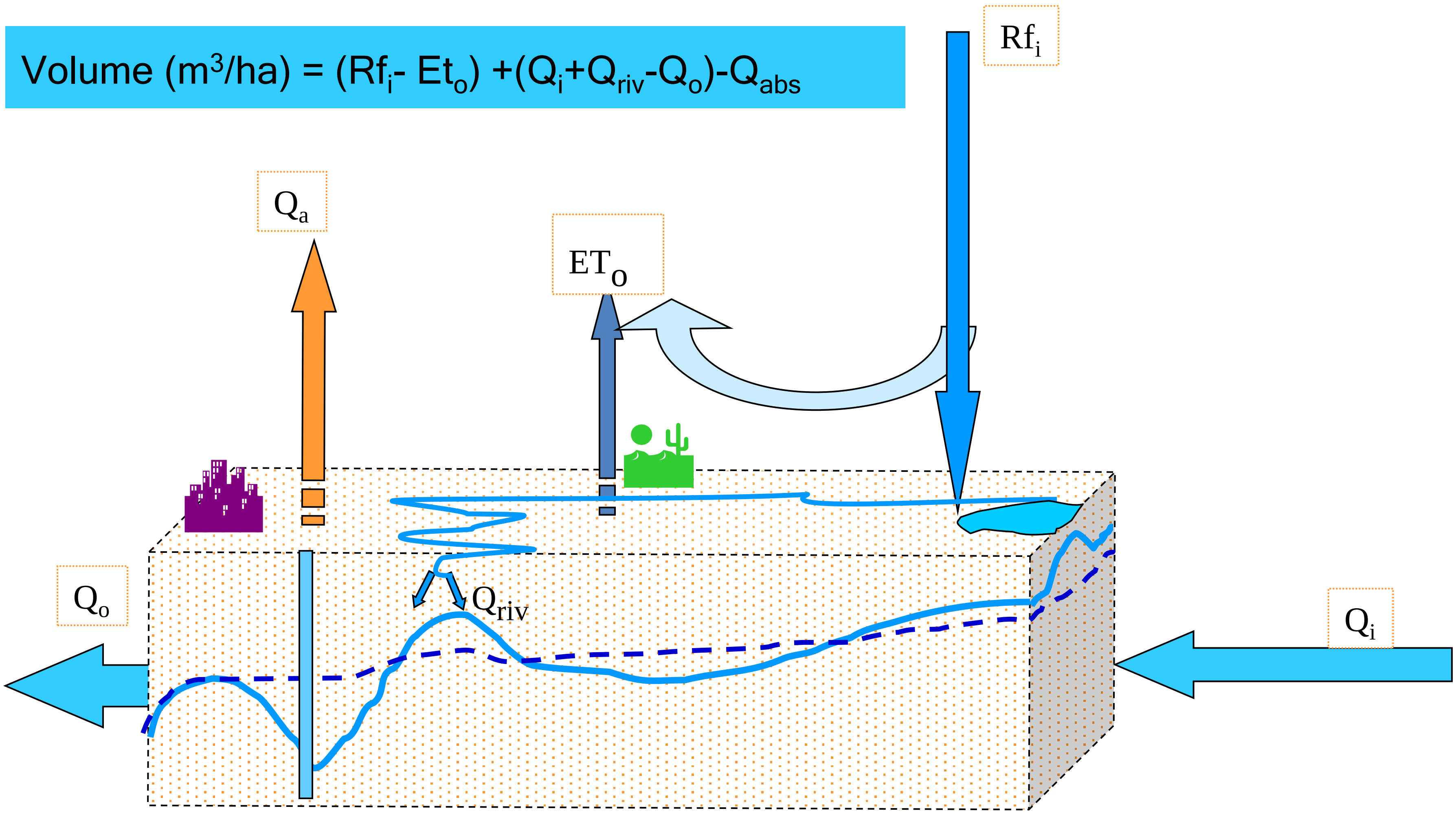
- Similar conditions to RU8 exist and RQO's prescribed related to groundwater level monitoring and maintaining water quality.
- An understanding the source of the elevated nitrate and TDS concentrations will be needed to manage this aquifer; and
- The flow rate of a spring to the south west of the RU must be monitored.

GAPS ANALYSIS (6)

Grouping of QC's based on potential/observed impact of surface water resources

Quaternary catchment	Groundwater utilisation status	Impact on surface water Resources	Comments
B20C	Under-Utilised	High	Provide protection of surface water resource in RQO's
B41F	Under-Utilised	High	Provide protection of surface water resource in RQO's
B41G	Under-Utilised	High	Provide protection of surface water resource in RQO's
B42A	Under-Utilised	High	Provide protection of surface water resource in RQO's
B42B	Under-Utilised	High	Provide protection of surface water resource in RQO's
B42D	Under-Utilised	High	Provide protection of surface water resource in RQO's
B42F	Under-Utilised	High	Provide protection of surface water resource in RQO's
B60E	Over-Utilised	High	Cat III, secure reserve and apply RQO's to Cat II
B71C	Under-Utilised	High	Provide protection of surface water resource in RQO's
B71D	Under-Utilised	High	Provide protection of surface water resource in RQO's
B71F	Under-Utilised	High	Provide protection of surface water resource in RQO's
B71G	Under-Utilised	High	Provide protection of surface water resource in RQO's
B72G	Data not available	High	To be further investigated
B73A	Under-Utilised	High	Provide protection of surface water resource in RQO's
B60A	Data not available	High	To be further investigated
B60B	Under-Utilised	High	Provide protection of surface water resource in RQO's
B60C	Data not available	High	To be further investigated
B60D	Under-Utilised	High	Provide protection of surface water resource in RQO's
B81A	Under-Utilised	High	Provide protection of surface water resource in RQO's
B81B	Under-Utilised	High	Provide protection of surface water resource in RQO's
B81D	Heavily-Utilised	High	Cat III, secure Reserve and apply RQO's to Cat II

Volume (m^3/ha) = $(Rf_i - Et_o) + (Q_i + Q_{riv} - Q_o) - Q_{abs}$



6 - GROUNDWATER RESOURCES DIRECTED MEASURES:
Application o/t Gwater Allocation Algorithm

- Quantification o/t Groundwater Component o/t Reserve:

$$Gw_{allocate} = (Re + Gwin - Gwout) - (BHN + GwBf)$$

- Due to lack of deep aquifer flow data, $Gw_{in} = Gw_{out,}$ unless piezometric data is available to calculate flow across resource unit boundary, but this may require dedicated borehole sites and detailed measurements of abstraction rates.

- Re: Recharge Estimations

Table 4-2: Chloride concentrations and recharge estimate

RU	Cl_{gw} (Harmonic Mean)	MAP mm	Cl_p mg/l	D $mg/m^2/a$	$R = P(Cl_p + D) / Cl_{gw}$	% Recharge
1	82	667	1.2	0.1	10.5	1.6
2	6	650	1.2	0.1	140.8	21.7
3	3	600	1.2	0.1	240.5	40.1
4	7	550	1.2	0.1	97.4	17.7
5	184	625	1.2	0.1	4.4	0.7
6	13	600	1.2	0.1	60.3	10.0
7	12	700	1.2	0.1	77.5	11.1
8	18	550	1.2	0.1	40.6	7.4
9	22	533	1.2	0.1	31.5	5.9
10	13	500	1.2	0.1	50.3	10.0
11	4	550	1.2	0.1	178.8	32.5
12	7	533	1.2	0.1	97.3	18.2
13	12	700	1.2	0.1	74.0	10.6
14	39	575	1.2	0.1	19.1	3.3
15	22	733	1.2	0.1	42.6	5.8
16	11	683	1.2	0.1	79.7	11.7
17	10	600	1.2	0.1	77.6	12.9
18	41	682	1.2	0.1	21.6	3.2

Table 4-3: Final Recharge estimates

RU	Vegter & GRA2	Chloride	Expert Opinion	Average	Final Estimate	Lithology
	% recharge					
1	7	1.6	5	13	5	Karoo (Ecca), Loskop & Wilge
2	9	21.7	5	11	5	Karoo (Dwyka, Ecca), Pretoria Group
3	11	40.1	10	19	12	Delmas Dolomite
4	5	17.7	4	8	5	Dwyka, Loskop & Wilge, Rooiberg, Rashoop Granophyre and Lebowa Granite Suite
5	6	0.7	8	13	8	Loskop & Wilge, Rooiberg , Pretoria Group,
6	6	10.0	10	8	10	Groblersdal Dolomite
7	6	11.1	7	8	8	Rustenberg layered suite, Pretoria Group
8	4	7.4	4	4	4	Springbok Flats, Karoo, basalts
9	3	5.9	3	3	3	Springbok Flats, Karoo, basalts
10	4	10.0	10	8	10	Marble Hall Dolomite
11	3	32.5	4	4	4	Rashoop Granophyre and Lebowa Granite Suite, Pretoria Group, Rustenberg Layered Suite
12	3	18.2	10	10	10	Zebedelia Dolomite
13	7	10.6	8	8	8	Pretoria Group
14	6	3.3	7	5	5	Rustenberg layered suite, Pretoria Group
15	6	5.8	10	7	10	Escarpment Dolomite
16	8	11.7	5	8	8	Granite-Nelspruit, Dalmein, Hebron, Halfway House, Goudplaats, and unnamed intrusivess
17	3	12.9	4	6	4	Granite-Mpageni, RV, Z
18	6	3.2	4	5	5	Granites and intrusives-Z, R, Zg, Rro, Karoo (Ptru), Jl, Jj (Letaba)

- Gw_{Bf} : Baseflow Estimations:
  - An expert hydrologist is to provide the baseflow requirements for the reserve determination.
  - Sources of Information:
    - Literature/Map Reviews
    - Topography-Groundwater Elevation Difference Maps
    - Use of Baseflow Index (>0.2) as indicator of baseflow separation assessment;
    - Darcy's Law (Q=TiW);
    - EWR estimates (Intermediate to Comprehensive Assessment);

Table 4-5: Final Baseflow estimates

RU	Total Area (km^2)	Total BF (Ave) $^3Mm^3/a$	IFR Site (Maint Low Flow) Mm^3/a	Darcy Flux Mm^3/a	Final BF_Estimate Mm^3/a
1	7104.54	73.01	15.17	0.53	26.83
2	4096.10	59.41	31.45		31.45
3	260.84	3.33		8.35	3.33
4	5618.14	28.32	4.01	17.37	18.43
5	2978.08	35.44	50.05	17.90	50.05
6	133.24	0.46			0.46
7	7136.29	108.07	30.18		30.18
8	2522.45	0.00			0.00
9	2590.64	0.03			0.03
10	180.10	0.17		2.04	0.17
11	5341.91	0.62		1.06	0.62
12	54.55	0.00			0.00
13	1151.49	42.19			42.19
14	1479.66	11.17	35.85		11.17
15	1600.51	100.29			100.29
16	1100.57	80.27	107.27		80.27
17	1439.16	0.35			0.35
18	9974.09	71.40	361.02		71.39

BHN: Population at 25 l/c/d

Table 4-6: Basic Human Needs requirements

RU	Population (2008^4)	BHN requirement (Mm^3/a)
1	435 657	3.99
2	382 988	3.50
3	95 925	0.88
4	556 303	5.09
5	53 510	0.49
6	1 721	0.02
7	224 999	2.06
8	46 066	0.42
9	78 748	0.72
10	10 801	0.10
11	584 453	5.35
12	673	0.01
13	9 794	0.09
14	106 398	0.97
15	67 981	0.62
16	21 852	0.20
17	128 093	1.17
18	283 170	2.59

Reserve Calculations: Using the GRDM Assessment Sheet and provides a Status Category on quaternary catchment level

Table 4-8: GRDM Assessment Sheet (WRU)

WRU	Total area	Effective Area	Recharge	Average Baseflow Estimates	Maintenance Low Flow Quaternary	Final BF Estimates	BHN Adjustment	Reserve as % of RCH	Groundwater Allocation	Current Use	Stress Index for	Present Status Category	Water Resource Category
	km^2	km^2	MCM/a	MCM/a	MCM/a	MCM/a	MCM/a	%	MCM/a				
1	7108	7108	245.18	73.01	15 (BJ11)	26.83	3.99	12.57	196.82	17.55	0.07	B	Fair
2	4356	4094	137.23	59.41	31 (B20J)	31.45	3.50	25.47	48.12	54.15	0.39	C	Fair
3	895	261	20.84	3.33		3.33	0.88	20.19	-18.55	35.18	1.69	F	Poor
4	6749	5611	170.21	28.32	4 (B32G)	18.43	5.09	13.82	112.14	34.55	0.20	B	Good
5	3110	2976	160.07	35.44	50 (B32D)	50.05	0.49	31.57	98.44	11.10	0.07	B	Good
6	521	133	8.00	0.46	50 (B32D)	0.46	0.02	5.95	6.72	0.80	0.10	B	Good
7	7134	7134	387.51	108.07	14 (B41J), 30 (B41K)	30.18	2.06	8.32	340.23	15.04	0.04	A	Fair
8	3400	2519	57.78	0.00		0.00	0.42	0.73	28.69	28.67	0.50	D	Poor
9	4084	2588	41.90	0.03	27 (B51G)	0.03	0.72	1.79	28.94	12.22	0.29	C	Poor
10	1992	180	10.00	0.17		0.17	0.10	2.64	6.21	3.52	0.35	C	Fair
11	8452	5339	116.43	0.62	27 (B51G)	0.62	5.35	5.13	99.35	11.12	0.10	B	Fair
12	2927	54	2.95	0.00		0.00	0.01	0.21	-0.05	3.00	1.02	F	Poor
13	1525	1151	73.29	42.19		42.19	0.09	57.69	23.06	7.96	0.11	B	Good
14	2122	1479	46.20	11.17	36 (B71B)	11.16	0.97	26.26	32.06	2.01	0.04	A	Natural
15	4481	1599	127.16	100.25		100.29	0.62	79.36	22.77	3.48	0.03	A	Natural
16	1700	1100	86.92	80.27	107 (B60J)	80.27	0	92.58	3.67	2.79	0.03	A	Natural
17	1867	1425	34.01	0.35	27 (B51G)	0.35	1	4.47	24.89	7.60	0.22	C	Fair
18	10790	9974	289.32	71.40	358 (B72D), 8 (B72K), 361 (B73H)	71.39	3	25.57	196.73	18.61	0.06	B	Fair
	Totals	54726	2015.02	614.48		467.18	28		1250.24	269.33			

- Compare $Gw_{allocat}$ with actual Gwater Use and estimate Water Resource Category. Tables are available in the GRDM guideline.

➢ CONCLUSIONS AND RECOMMENDATIONS (example of a WMA's assessment

- The reference conditions for the catchment were pre-1950's water level data and 1980's chemistry data. The chemical variables considered were TDS, NO_3 and SO_4. With the exception of nitrates (especially in the Springbok Flats area), the chemical constituents were largely at acceptable concentration levels.

- Based on the quantification of the reserve and available groundwater for additional use (GRDM Assessment Sheet Table 4-8) no further groundwater allocations can be made in:
  - Resource Unit 3 (Delmas Dolomite);
  - Resource Unit 8 (Southern Springbok Flats);
  - Resource Unit 12 (Zebedelia Dolomite);
  - Quaternaries B20A and B20B (Resource Unit 2-Upper Olifants);
  - Quaternary B31J (Resource Unit 4- Ilanga WUA) and;
  - Quaternary B31J (Resource Unit 10).

  This is due to over abstraction of groundwater.

- Currently approximately 269.3 Mm^3/a of groundwater is abstracted across the Olifants River catchment. The GRDM employed estimates an additional 1 250 Mm^3/a can be allocated for use without impacting on the current groundwater reserve requirement of 495 Mm^3/a.

Conclusions

- Groundwater Reserve determination is part of the (G)RDM Process, thus:
  - Classification:
    - Quantity: Application of the Stress Index (SI) Principle (I to III) on the groundwater resource unit (Quaternary Catchment) using rainfall values (CI method) and water use figures (WARMS, GRA II or Gwater Exploitation Potential); and
    - Quality: Compliance (%) to different Water Quality Classes (I to III).
  - Reserve Determination:
    - Quantity: Application of the $\text{Gwater}_{\text{allocate}}$ algorithm to calculate the surplus water after BHN and baseflow has been allocated to quaternary catchment; and
      - Compare with WARMS , GRA II or GEP values to set a Status Category for GRU/QC
    - Quality: High level (i.e. O Cat II due to the requirement of fresh/potable water for Reserve Component. Long-term trends are an important indicator of the health status of a Gwater Resource.
  - Resource Quality Objectives (a hydrogeological assessment process!)
    - Quantity: Based on the SI, cutbacks on water uses need to be assessed and implemented – easy to control with water level monitoring; and
    - Quality: Certain hydrochemical determinants are normally specified, but achieving spontaneous results is depending on various aspects (rainfall, level of deterioration and aquifer hydraulics), however, setting of determinant limits in WUL conditions and monitoring programmes the best way to implement.

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