

**water & sanitation**

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA



Presented by:

Fanus Fourie
Scientific Manager
Dir: Water Resources Planning Systems

Date

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Content

- Overview of Groundwater
- Groundwater Availability
- Groundwater Quality
- Definitions
- Concepts
- Planning Assistance (Guidelines, Tools, Maps)
- Assessment process
- Artificial Recharge

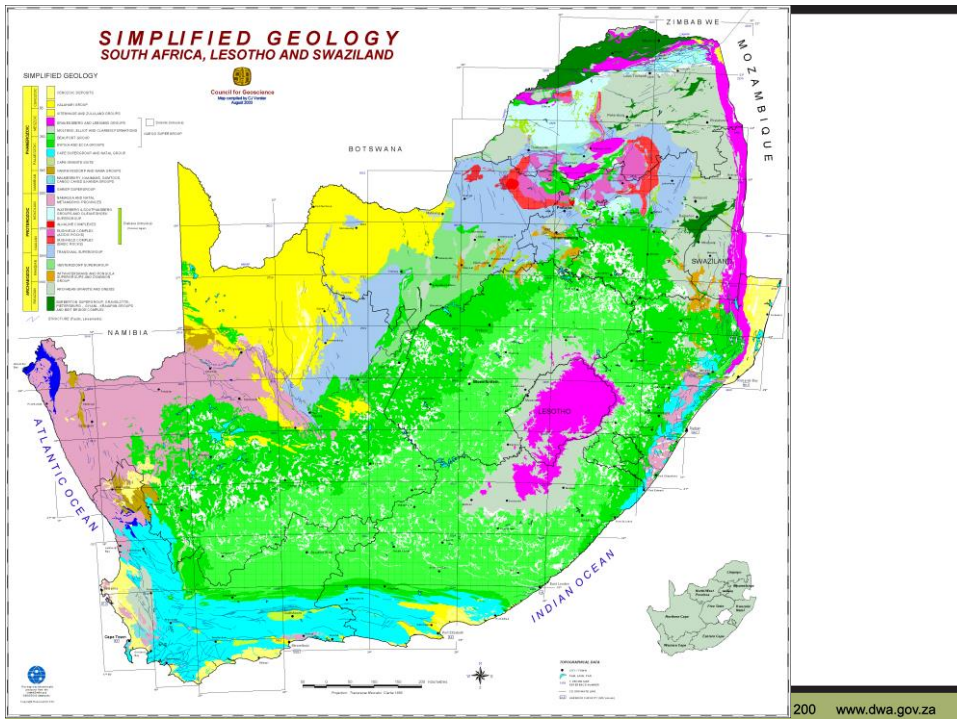
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Overview of Groundwater

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Aquifers Types

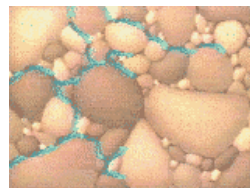
- Primary / Alluvial Aquifer (Intergranular)
- Secondary / Fracture Aquifer:
- Weather and Fractured Aquifer
- Dolomitic / Karst Aquifer

Primary / Alluvium Aquifer

- **Groundwater occurs in pore spaces that developed during deposition (alluvial)**
- Along rivers channels
- Coastline (dunes)
- Old Paleo Channels
- Inland sands

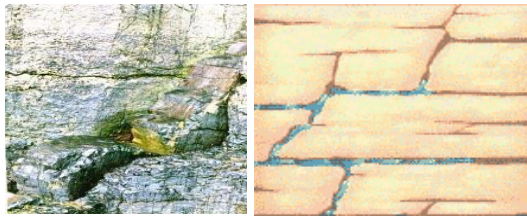
Eg.

- North of Richards Bay
- Kalahari
- Crocodile River
- Coastal areas



Secondary / Fracture Aquifer

- Results from solid rock that cracked upon deposition
- Most aquifers in RSA (80%+) are fracture aquifers,
- Karoo
- Crystalline



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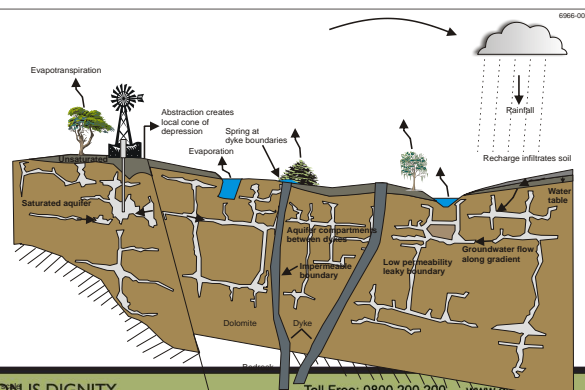
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Dolomitic / Karst Aquifer

- Dissolution of carbonate rocks
- Lots of water
- Fast movement
- Sinkholes

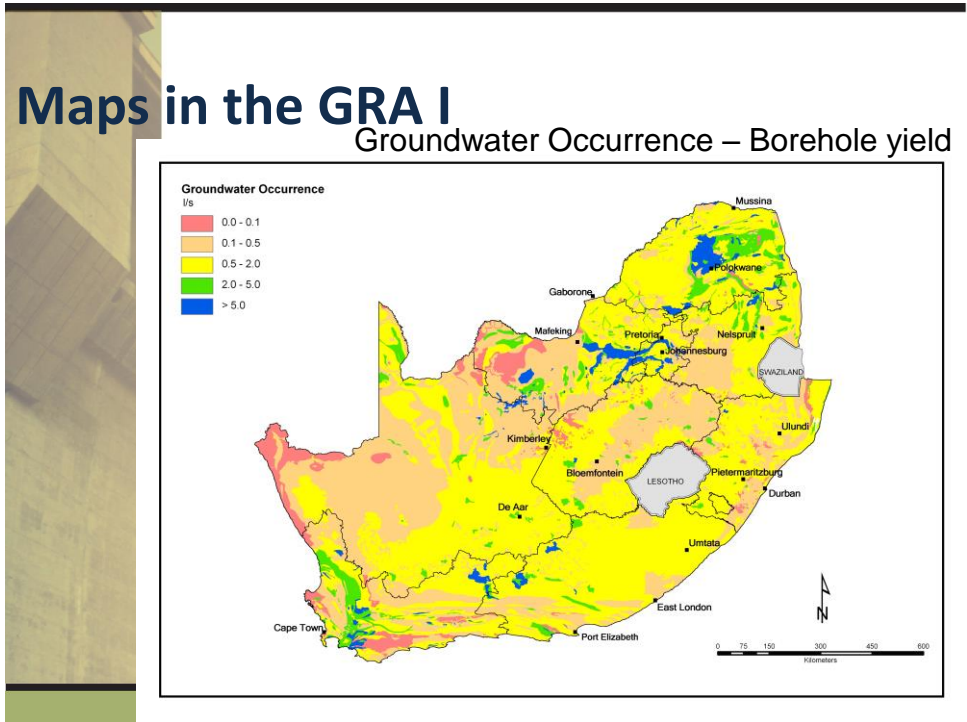
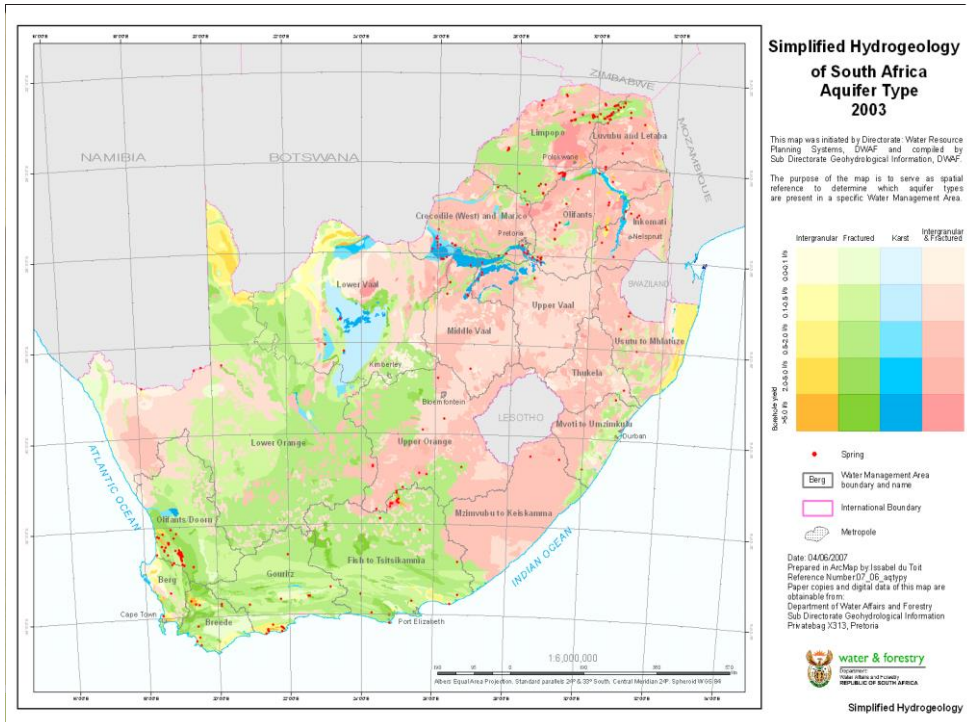
Eg:

- Ghaap
- NW



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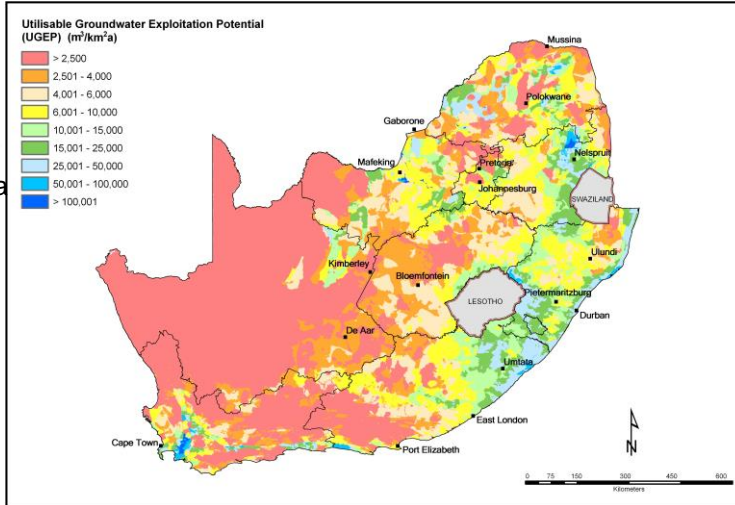


Maps in the GRA II

Utilisable Groundwater Exploitation Potential Aquifer Yield

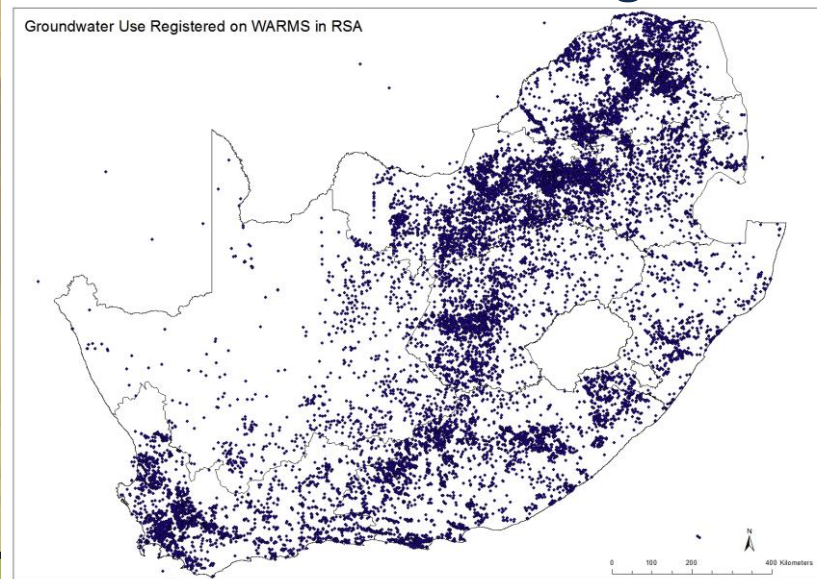
2 500 m³/km²/a
= 6.8 l/ha/d

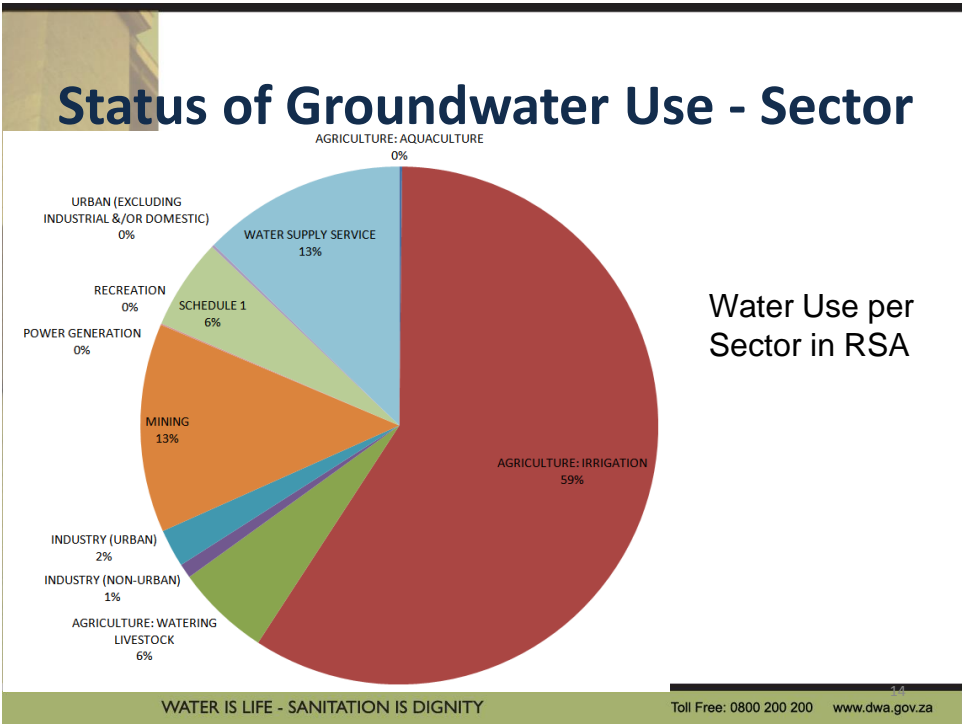
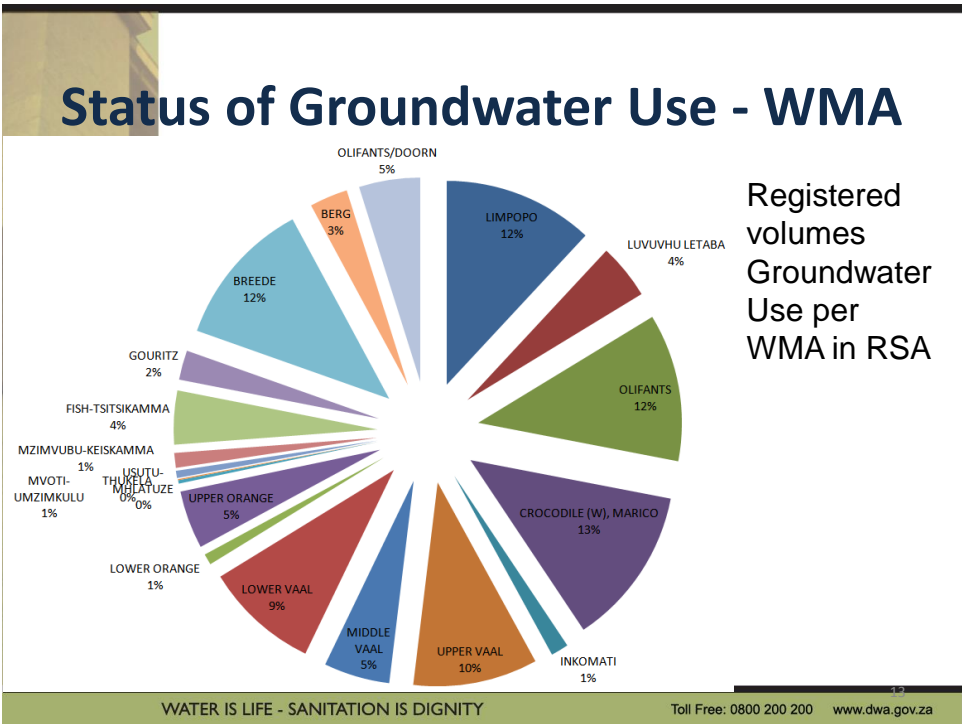
10 000 m³/km²/a
= 0.31 l/s/km²



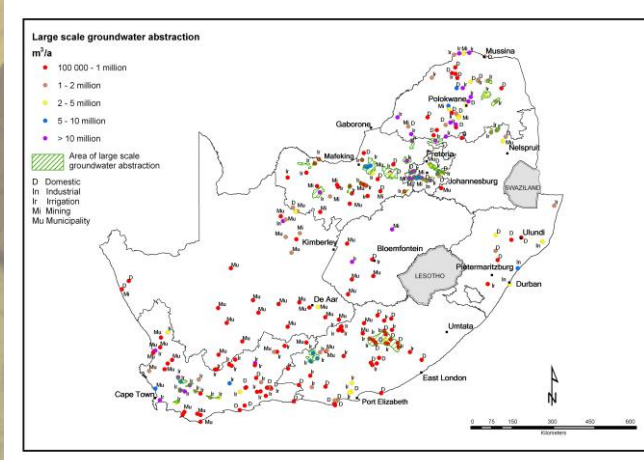
Groundwater Use - Registered

Groundwater Use Registered on WARMS in RSA





Groundwater Use - Large users

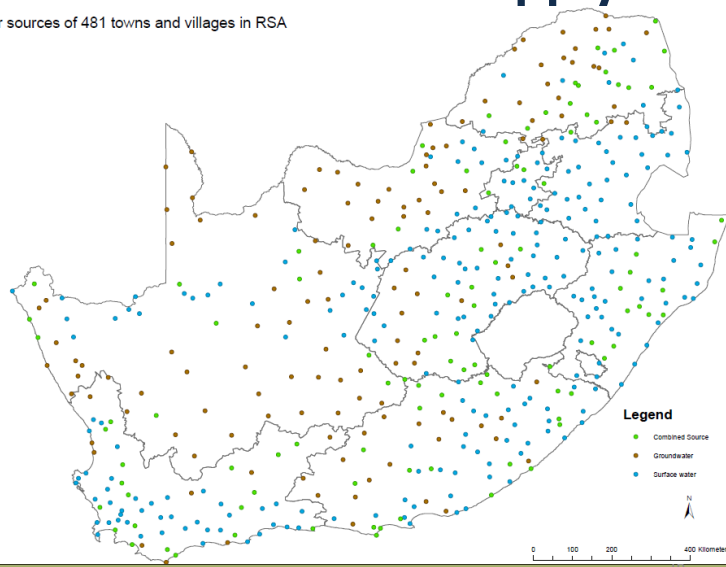


Pretoria
 • Fountains 1905
 • 60 ML/day or
 14,9 Million m³/a

Johannesburg
 • 11 ML/day

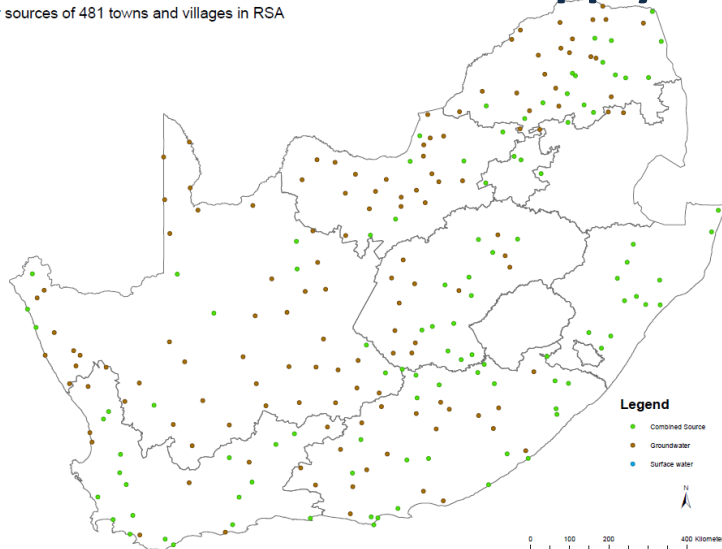
Groundwater Use – Water Supply

Water sources of 481 towns and villages in RSA



Groundwater Use – Water Supply

Water sources of 481 towns and villages in RSA



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Groundwater Use

Number of Towns and Villages (Sources water) – 23 297

	Urban	Rural	Total
Groundwater	22%	59%	53%
Combined	34%	34%	34%
Surface water	44%	7%	13%

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Groundwater Use

2000 – NWRS1 – 1 088 million m³

2004 – WR2005 – 1 771 million m³

2013 – WARMS – 2 123 million m³

2015 – WARMS – 2 723 million m³

Can be 3 500 million m³

Groundwater Use

Groundwater 2013 – WARMS – 2 123 million m³

Total water 2013 – WARMS – 16 965 million m³

= 12.5%

Total use ~ 14 700 million m³

= 16.1%

If Groundwater use is 3 000 million m³

= 20%

Available Groundwater

Available Groundwater - million m³

- Average Groundwater Resource Potential – 47 727
- Average Groundwater Exploitation Potential – 19 073
- Potable Groundwater Exploitation Potential – 14 802
- Utilisable Groundwater Exploitation Potential –
Normal – 10 345 Dry – 7 530

Groundwater Quality

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Groundwater Quality

Question?

Why is groundwater handled different than surface water?

Are we drink surface water without purifying to drinking water standards ?

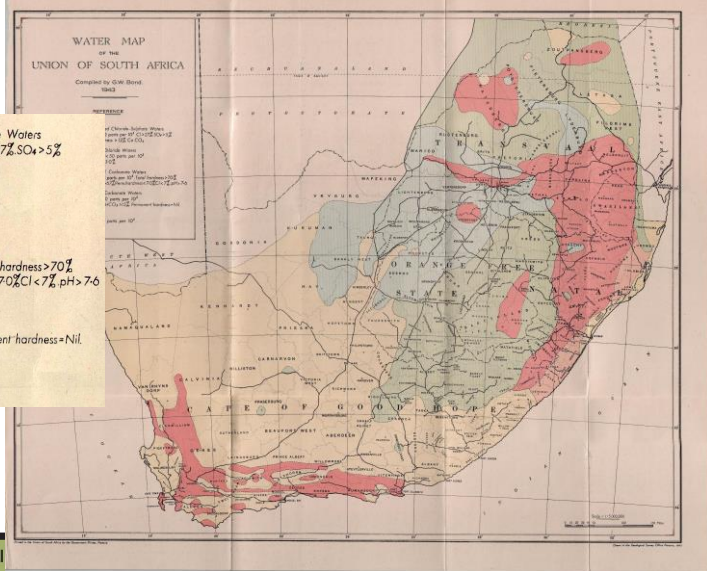
But the quality of groundwater must be at drinking water standard otherwise it is unusable?

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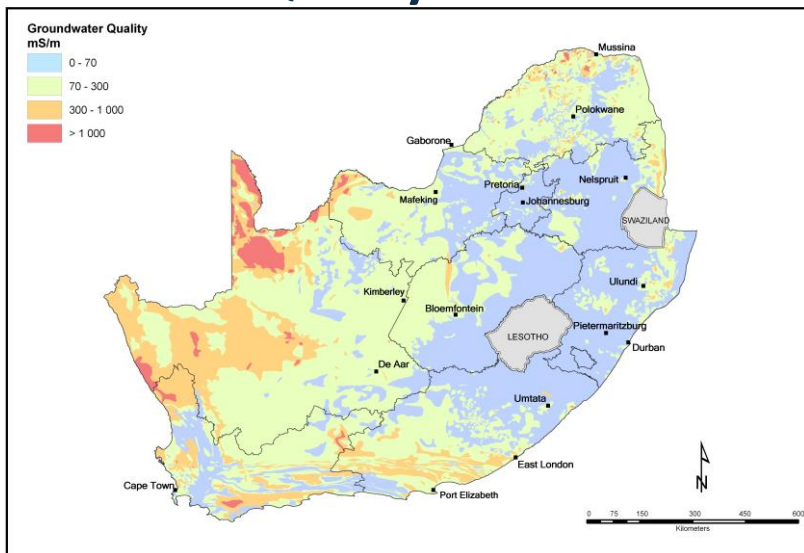
Groundwater Quality 1943

- GROUPS**
- A** Highly mineralised Chloride Sulphate Waters
Total solids > 100 parts per 10⁶. Cl > 27%. SO₄ > 5%.
Permanent hardness > 12%. Ca CO₃
 - B** Slightly saline Chloride Waters
Total solids > 30 < 50 parts per 10⁶.
Cl > 27%. SO₄ < 3.0%
 - C** Temporary hard Carbonate Waters
Total solids < 80 parts per 10⁶. Total hardness > 70%.
Temp. hardness > 67%. Perm. hardness < 7.0%. Cl < 7%. pH > 7.6
 - D** Alkaline Soda Carbonate Waters
Total solids < 100 parts per 10⁶.
Na₂CO₃ or NaHCO₃ > 15%. Permanent hardness = Nil.
 - E** Pure Waters
Total solids < 15 parts per 10⁶.
pH < 7.1.

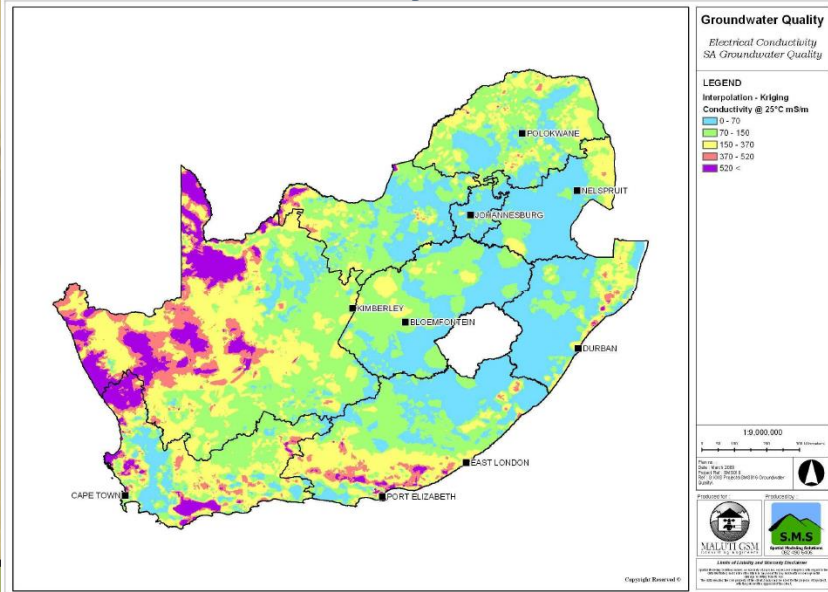


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Groundwater Quality - GRA I



Groundwater Quality – WRC 2011



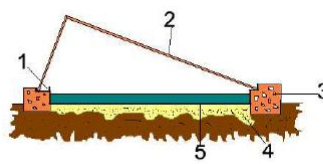
Groundwater Quality - Desalination

High cost?

High technology driven ?

Solar Stills
= 3.5 liter/m²/day
= Low maintenance

Solar electricity-operated reverse osmosis plant
= 15m³/day



Legend:

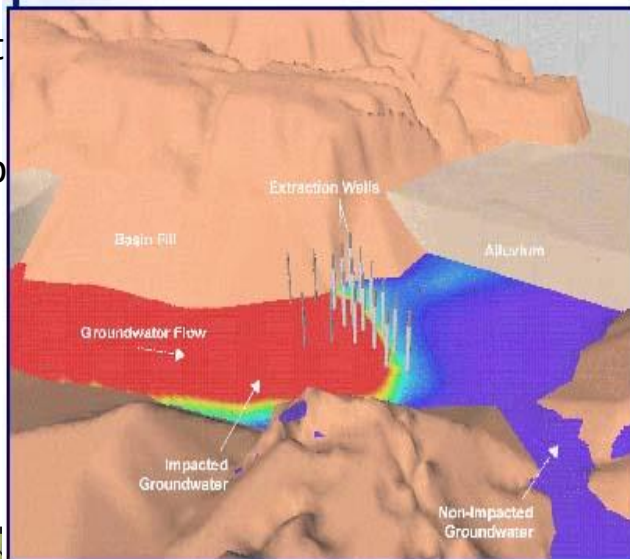
- 1 – lip channel
- 2 – glass / perspex cover
- 3 – containment
- 4 – foundation
- 5 – feed water reservoir



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Remediation Methods

- Containment
- Withdrawal
- In-situ Rehab



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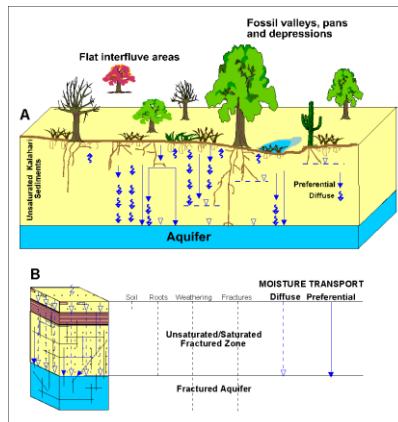
Definitions / Concepts

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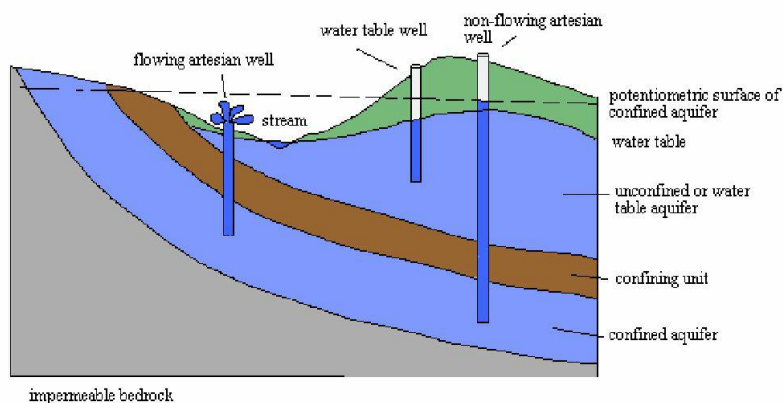
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GEOHYDROLOGICAL TERMS

- Water that infiltrate and replenish gw is recharge
- Saturated portion in the subsurface is groundwater whose upper limit is defined by the water table.
- Groundwater moves very slowly

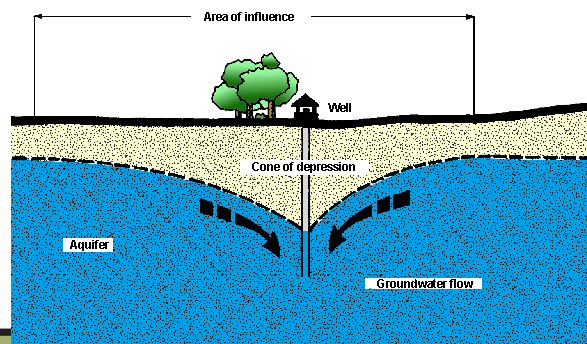


GEOHYDROLOGICAL TERMS (2)



GEOHYDROLOGICAL TERMS (3)

- Cone of depression: is an area around a pumping borehole where water level is significantly lowered due to pumping



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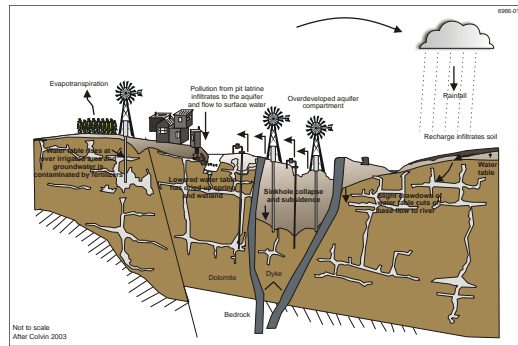
GEOHYDROLOGICAL TERMS (4)

- Sustainable yield: **safe amount of water that can be abstracted without causing damage to the system**
- Transmissivity: **ability of the aquifer to transmit water**
- Storativity: **aquifer's ability to release water**
- Aquifer: **a saturated and permeable underground geological unit that can transmit or produce water of significant quantities**

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Effect of over-exploitation

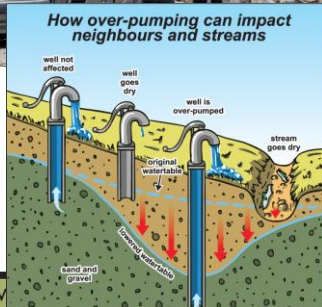


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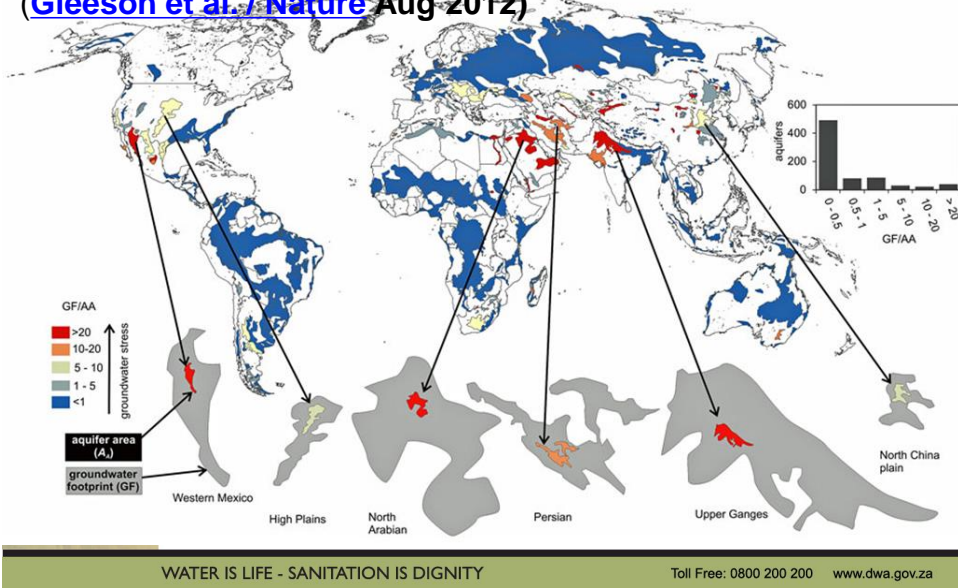
Over Abstraction

Lorca earthquake 'caused by groundwater extraction'



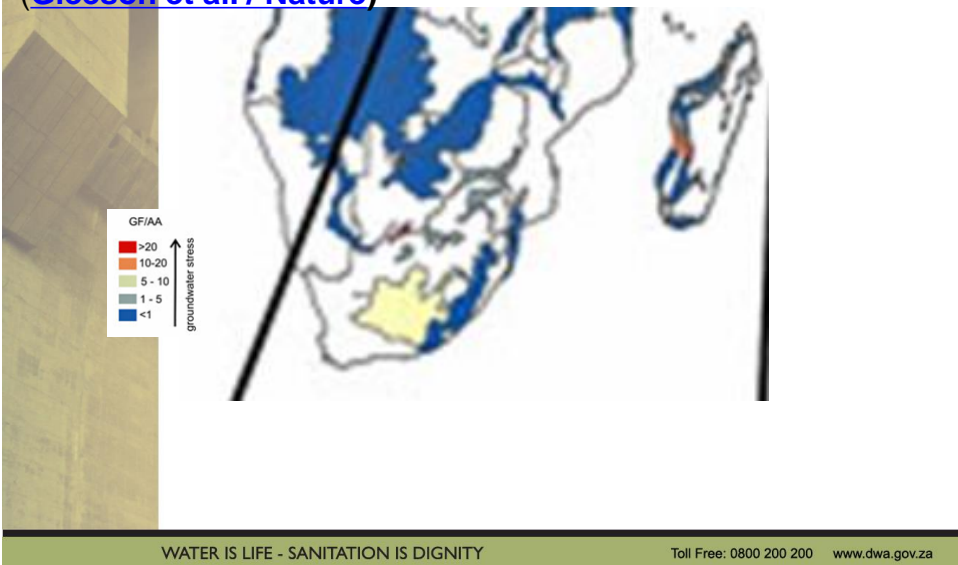
Over abstraction - Groundwater Footprint

([Gleeson et al. / Nature](#) Aug-2012)

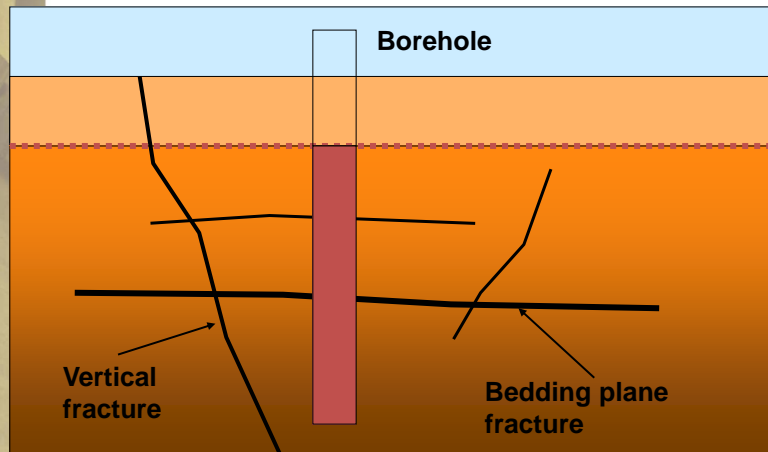


Over abstraction - Groundwater Footprint

([Gleeson et al. / Nature](#))



GROUNDWATER OCCURENCE



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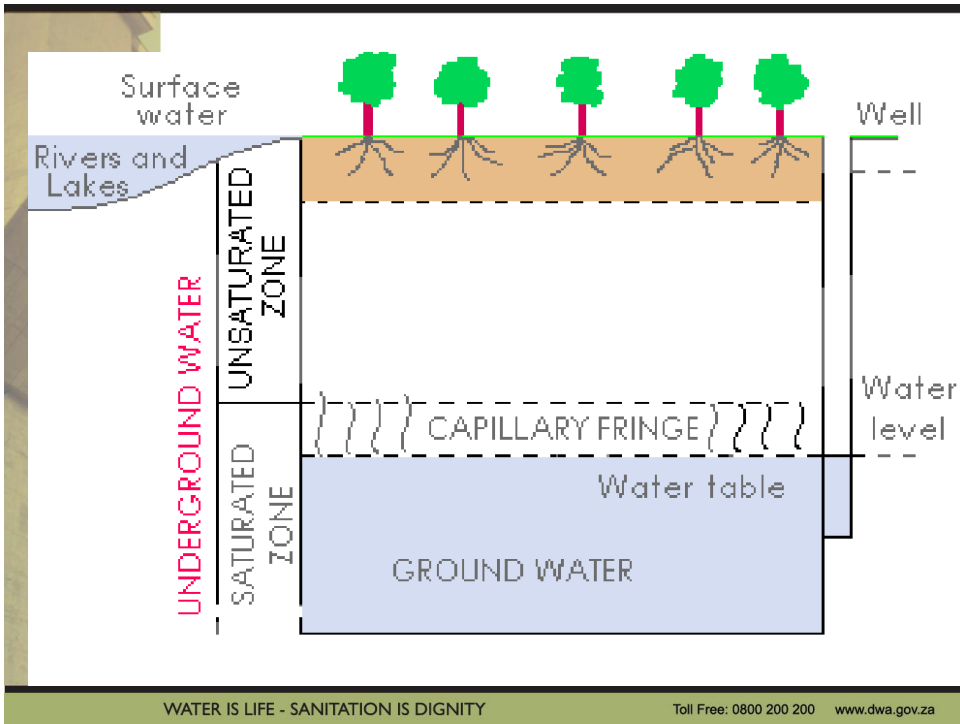
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GROUNDWATER OCCURRENCE

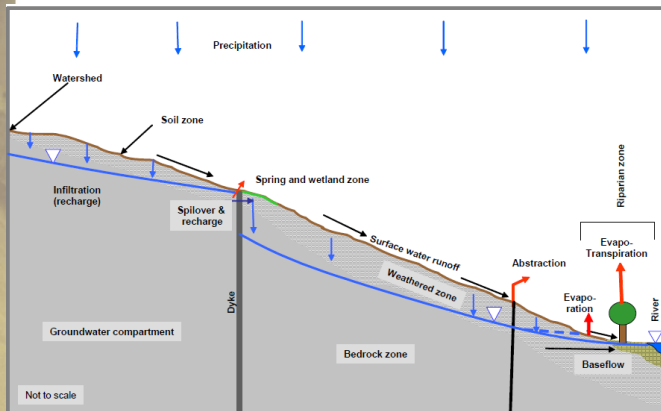
- Is subsurface water groundwater?
 - Soil water (soil moisture) supports vegetation: occurs near surface
 - Interflow occurs within the unsaturated zone (vadose zone): source of low flows
 - Groundwater is below water table
 - Baseflow is that part of groundwater that support low flows in rivers (or streams)
 - Water in capillary fringe occurs above water table
 - Hence not all water below surface is groundwater

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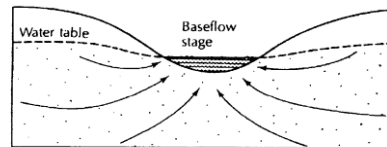
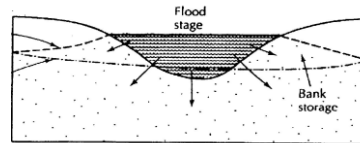


Groundwater Flow



SURFACE WATER G/WATER INTERACTION

- During high flow conditions, surface water leaks into groundwater (influent stream)
- During low flow, groundwater seeps into streams (effluent stream)



Information Sources and Examples

Information sources

- Your groundwater section Region Office
- National Office
- Groundwater data: National Groundwater Database (NGDB) + Groundwater Resources Information Project (GRIP)
- Groundwater quality: WMS
- GH Reports + WRC
- Maps
- georequests@dwaf.gov.za

Available Data / Info / Maps

- 1: 500 000 Hydrogeological Maps (GRA1 maps)
- UGEP map (Utilisable Groundwater Exploitation Potential Aquifer Yield map)
- Groundwater Occurrence map
- Recharge map
- Rainfall (SA Weather Service or WR2005)
- Geology maps (Council of Geoscience)
- Structure Geology maps (Council of Geoscience)
- Reconciliation Strategies (DWS Website)
- Aerial photo (Land Survey: Director General)
- Airborne Geophysics (Council of Geoscience)
- Water use volumes (WARMS – DWS)
- Borehole data (National Groundwater Archive – NGA – DWS website)
- Groundwater Quality (DWS)

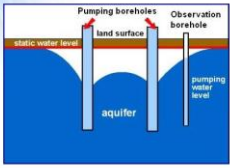
Internet-Groundwater-Dictionary

Aquifer Testing

Definition
 Aquifer testing involves the withdrawal of measured quantities of water from or the addition of water to, a [borehole\(s\)](#); and the measurement of resulting changes in [head](#) in the aquifer both during and after the period of [abstraction](#) or addition.

Description
 The process whereby an aquifer is subjected to pumping from a borehole under controlled test conditions in order to determine the hydraulic parameters of the [groundwater](#) system through its response to the stress of abstraction.

Why is aquifer testing important?
 The purpose of aquifer testing is to determine the hydraulic parameters of the [aquifer system](#) which are used to quantify water [resources](#) and facilitate resource management.



The diagram illustrates the process of aquifer testing. It shows a cross-section of the ground with a land surface and an underlying aquifer. A horizontal line represents the static water level. A pumping borehole is shown on the left, and an observation borehole is on the right. The pumping borehole is connected to a pump, which causes the water level in the aquifer to drop, creating a pumping water level. The observation borehole is used to measure the resulting changes in head in the aquifer.

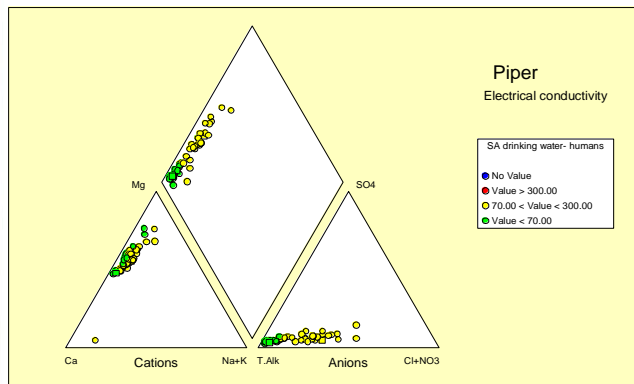
Drilling Rig



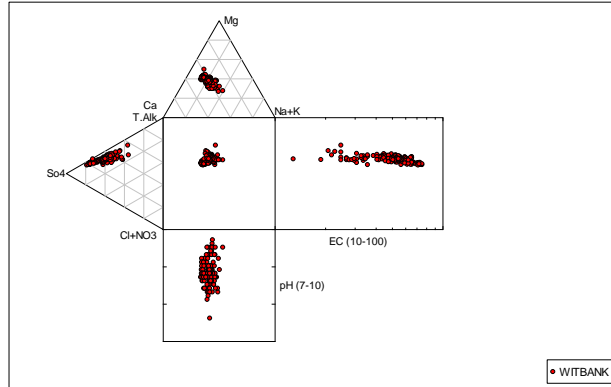
Borehole rock chips



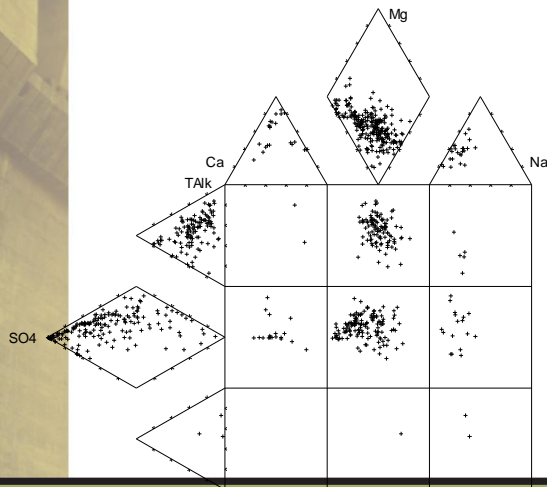
Piper plot



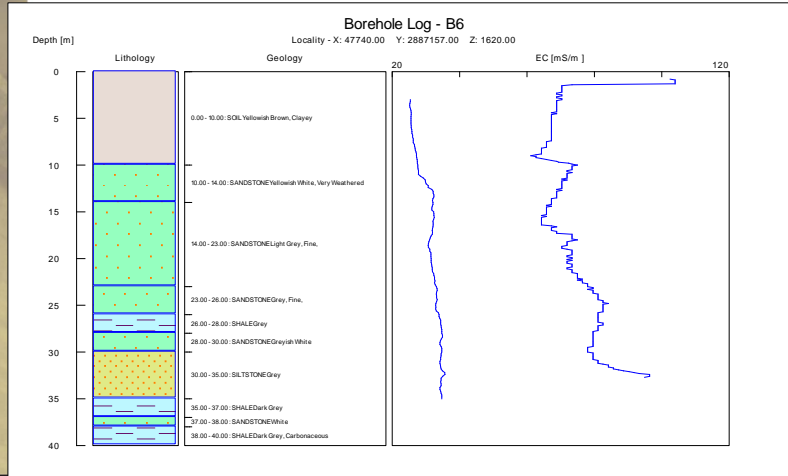
Durov plot



Expanded Durov plot



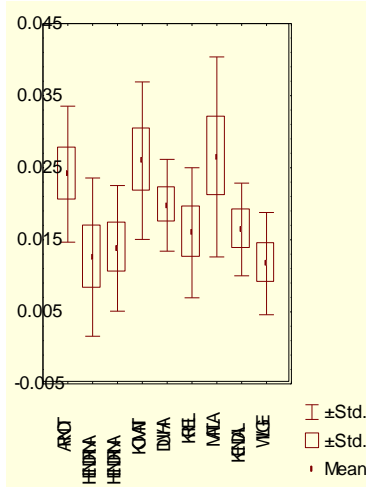
Borehole log



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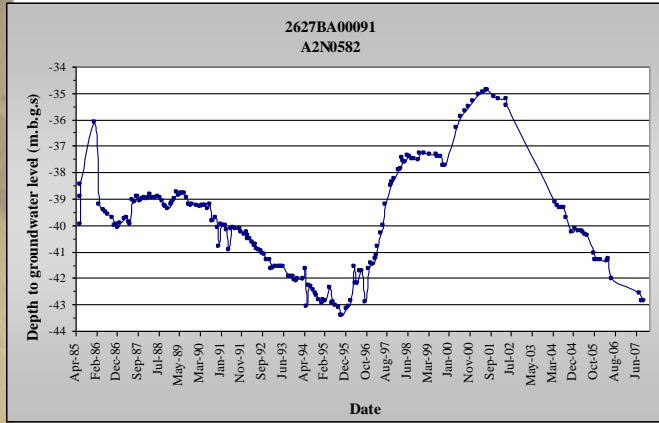
Box and whisker plot



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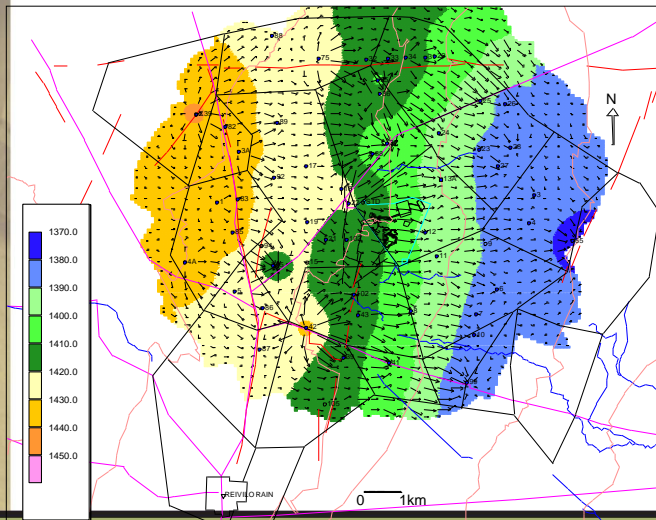
Water Level



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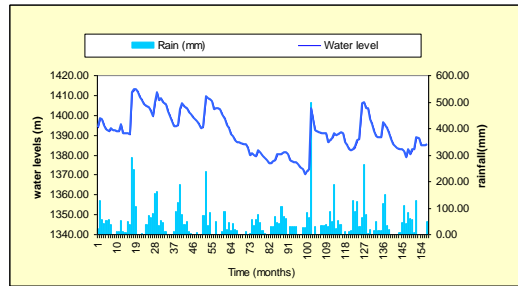
Groundwater flow vectors



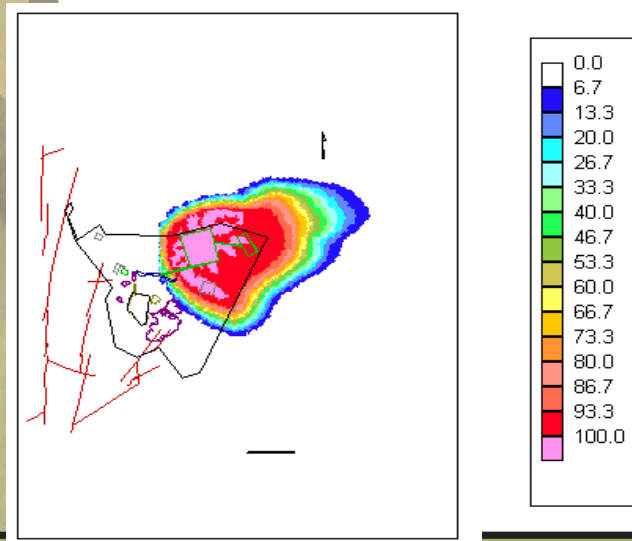
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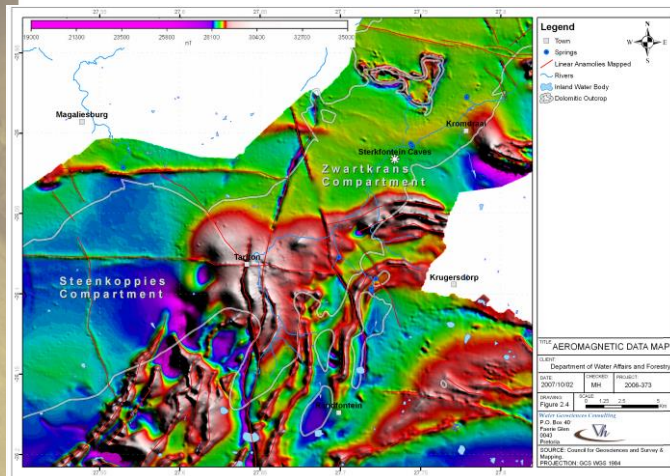
Rain vs Water level



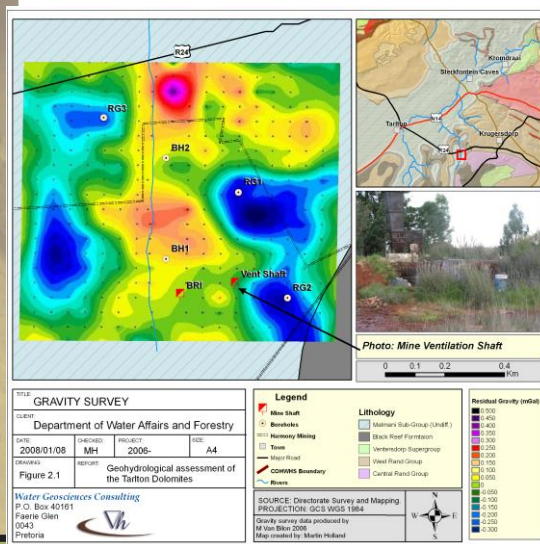
Pollution plume



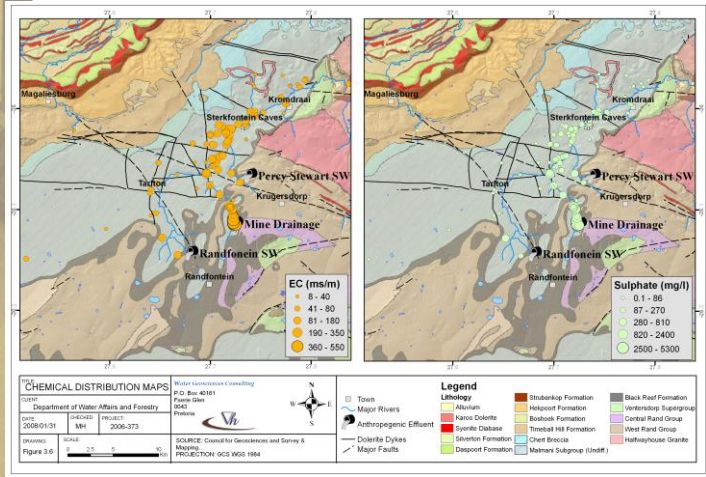
Aeromagnetic Map



Gravity Map



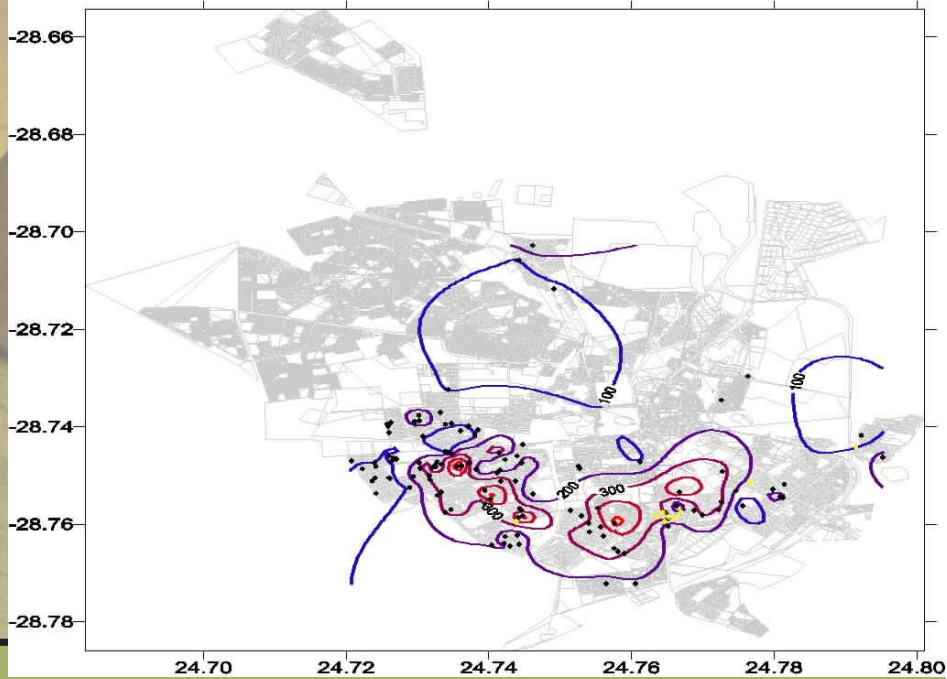
Water Quality Map



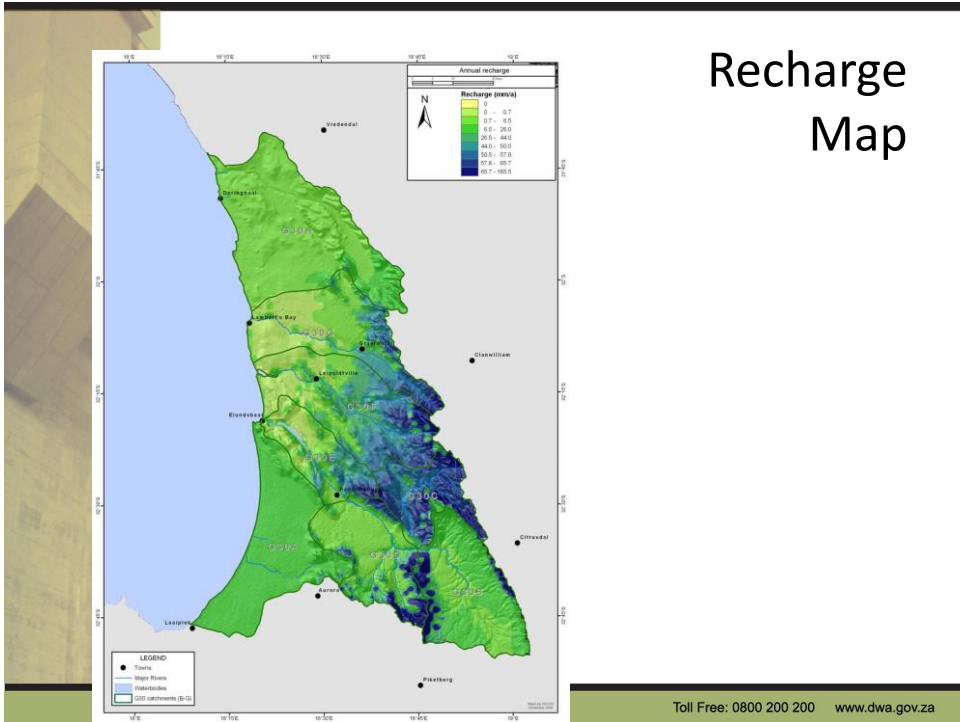
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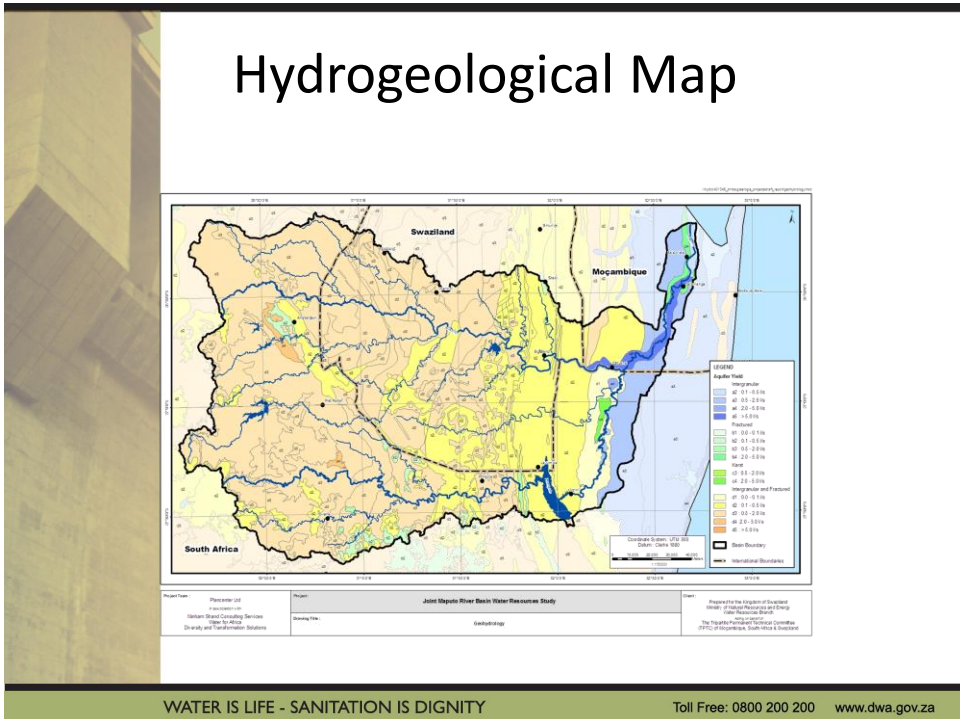
Ca of the Groundwater of Kimberley



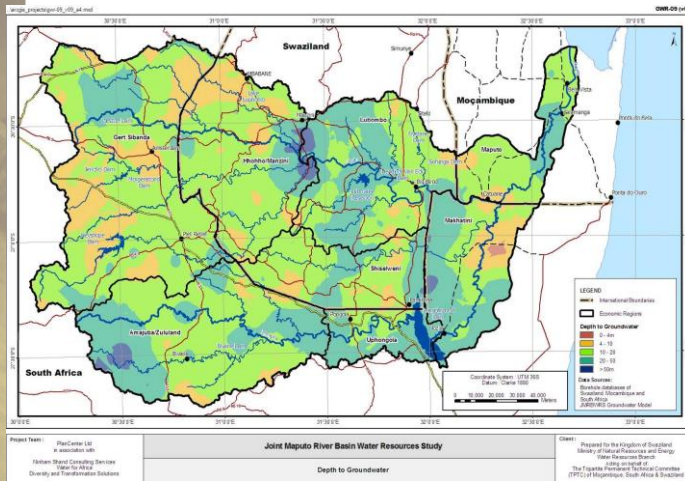
Recharge Map



Hydrogeological Map



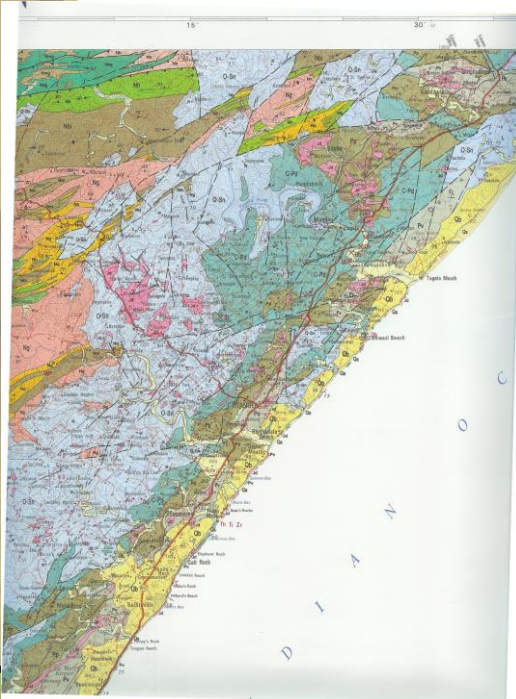
Depth to Groundwater



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Geology Map



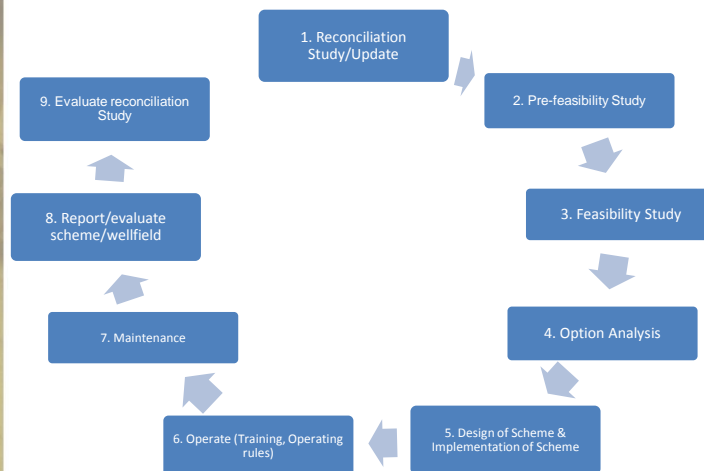
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Planning process

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Planning life cycle

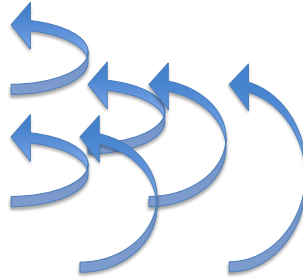


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Development Process

- Conceptualisation
- Reconnaissance
- Pre-feasibility
- Feasibility
- Design
- Construction
- Operation



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Level of Study	Product / Decision	Data collection	Confidence	Scale
Conceptualisation	Inception / Planning Report	Expert evaluation of existing data	50 %	1:500 000 to 1:250 000
Reconnaissance	ID Target Areas Recommendation for and prioritisation of monitoring	Primarily desktop work with limited fieldwork and data collection, as required, (e.g. Hydrocensus) 1 st order water balance model	60 %	~ 1:250 000
Pre-feasibility	Environmental monitoring and assessment ID Target Sites	Geological and ecological mapping Installation of monitoring infrastructure and ongoing monitoring of relevant processes Re-calibrate water balance model	70 %	1:100 000 to 1: 50 000
Feasibility	Exploration Yield estimation License & EIA application Feasibility Report	Site survey, borehole siting Drilling and testing of exploration boreholes Regional groundwater modeling Invest in collecting all relevant input for design purposes	80 %	1: 50 000 to 1: 10 000
Options Analysis	Options Analysis Report	Comparison of different options for water supply, based on feasibility studies	80 %	
Design *	Wellfield design and implementation Operating rules	Design all components of the scheme Wellfield model	90 %	1: 1 000 to 1:10 000
Operation & Maintenance *	Operation & Maintenance	Ongoing monitoring	95 %	

200 www.dwa.gov.za

Development Process

- Incremental Development
 - Plan and design whole scheme
 - Construct initial part of scheme
 - Add elements, when required

Project life cycle



Methodology: Free State

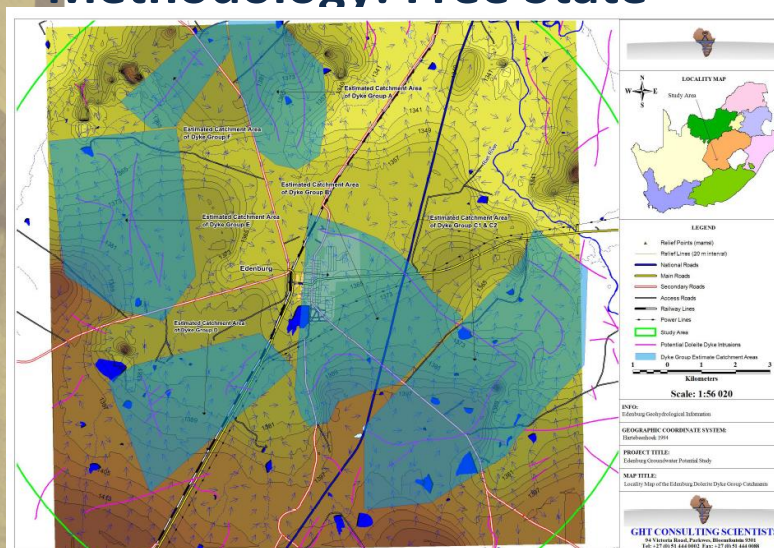
GROUNDWATER POTENTIAL DESKTOP STUDY

- Existing geohydrological data;
- Hydrocensus
- Aerial photo interpretations
- Aerial magnetic interpretations
- Geophysical field survey
- GIS map compilation
- Determination of high groundwater abstraction areas
- Recharge volume estimation
- Compilation of a Geohydrological Potential Report

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Methodology: Free State



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Methodology: Vaal Gamagara

GROUNDWATER POTENTIAL & DEVELOPMENT SCHEME

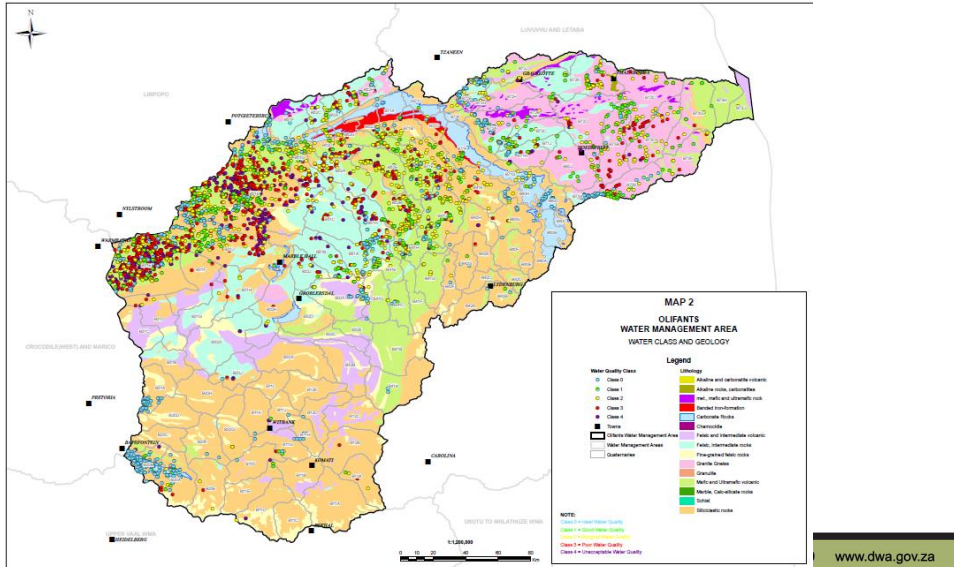
- Detail desktop study: Collation & updating Existing geohydrological data;
- Land Owner Engagement process
- Hydrocensus: Id & verification of use & sampling
- High resolution airborne geophysical surveys: magnetic & TDEM
- Detail remote sensing & assessment of airborne geophysical data
- Ground geophysical field survey: magnetic & gravity
- Test pumping existing boreholes
- Drilling of exploration/test boreholes
- Groundwater sampling on newly drilled boreholes

Methodology: Vaal Gamagara

GROUNDWATER POTENTIAL & DEVELOPMENT SCHEME

- Aquifer test pumping exploration boreholes:
 - Short term test: SDT & 24h CDT – bh yield capacity + aquifer sustainability
 - Long term test: 72h – aquifer sustainability + aquifer hydraulic parameters for modelling
- Conceptualizing of hydrogeological model
- Numerical 3D modelling: simulate aquifers + predict long term sustainability
+ test feasibility of implementing development
- Management recommendations: production design + buffer effect
- Compilation investigation report

What is wrong with this picture?



NB Data

- No Data!!!!!!
- Concentrated area
- Poor distribution
- Witbank & Middelburg – Coal - AMD?
- Steelpoort – Platinum mines?

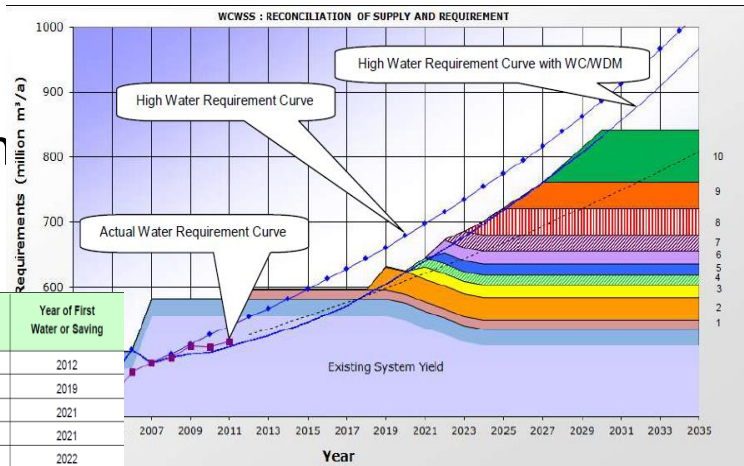
Planning Assistance

- Reconciliation Studies
- Conjunctive use
- Maps
- Guidelines
- Tools
- Methodologies
- Interventions

Reconciliation Studies

Western
Cape
Water
Supply
System

Th

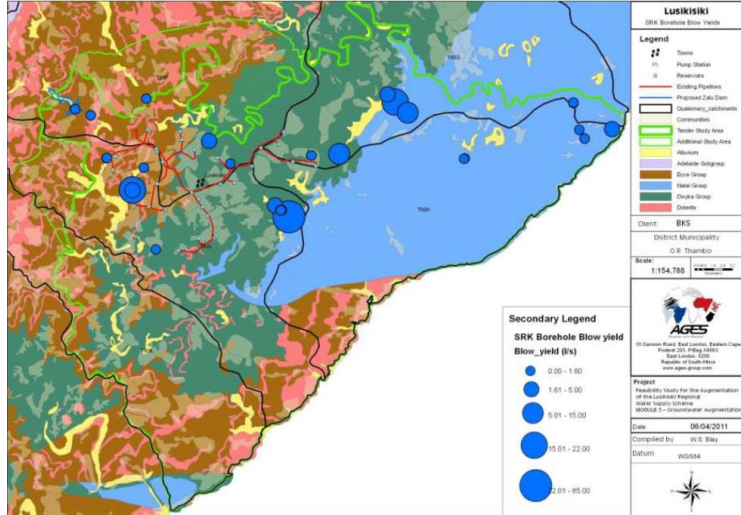


No	Intervention	Year of First Water or Saving
1	Optimise System Operation	2012
2	Voelvlei Phase 1	2019
3	Lourens	2021
4	DWA:ASR: West Coast	2021
5	Cape Flats Aquifer	2022
6	TMG Scheme 1	2022
7	Raise Lower Steenbras	2023
8	Re-use Generic 1	2024
9	Re-use Generic 2	2026
10	Desalination	2028

Conjunctive Use

Lusikisiki
Water scheme

Bulk water
infrastructure
Surface and
groundwater



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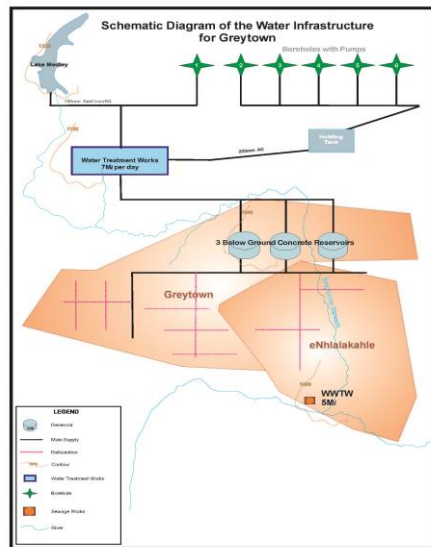
Toll Free: 0800 200 200 www.dwa.gov.za

Conjunctive Use

Example:

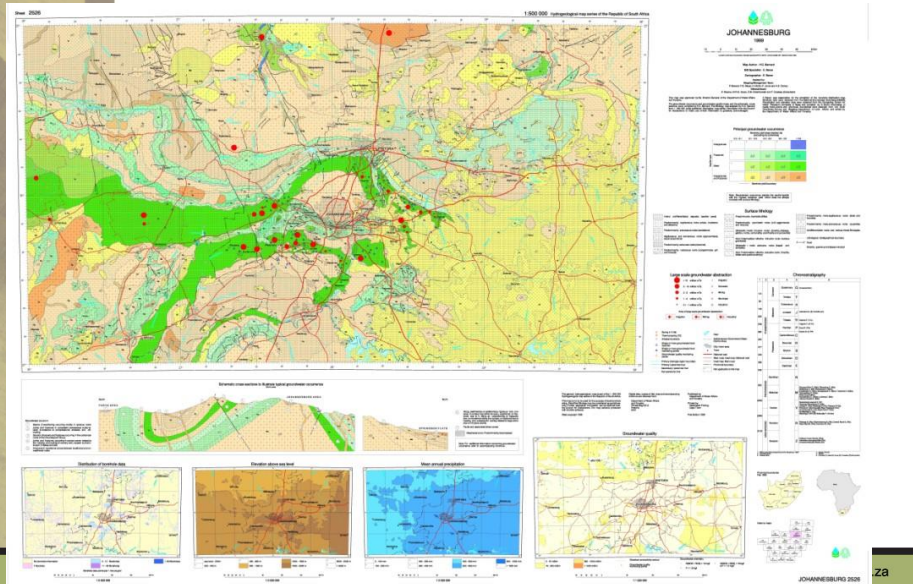
Greytown - KZN
Water scheme

Dam + boreholes



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Maps of GRA I



DWS Website

<http://www.dwa.gov.za/projects.aspx>

<http://www.dwa.gov.za/groundwater/>

Groundwater Home	Groundwater Offices	Data Management	NGIS	International Projects	NGS	Information Products	Documents	Forms	Groundwater Dictionary	Contacts	Links
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DOCUMENTS

► **Groundwater Resource Assessment II**

In late 2003, the Department of Water and Sanitation (DWS) of South Africa initiated the Groundwater Phase 2 Project, which is aimed at the quantification of the groundwater resources of South Africa on a national scale. The project has been carried out by a consortium of consultants comprising SRK Consulting, GEOS, WSM and CSIR (SGWC) in close collaboration with key DWS personnel and was completed in June 2005. Algorithms have been developed for the estimation of storage, recharge, base flow and the impact of the reserve and present groundwater used has been recorded. The results, in addition to methodology, include several valuable datasets and maps and will provide input to various levels of planning and management of water resources once reviewed and verified. The data, information and paper copies of technical reports can be obtained from georequests@dws.gov.za.

► **Geohydrological Reports**

Geohydrological Reports are available at <http://www.dwa.gov.za/ghrreport>. Users will be able to search the system. Alternatively mail your requests to georequests@dws.gov.za.

► **Order details**

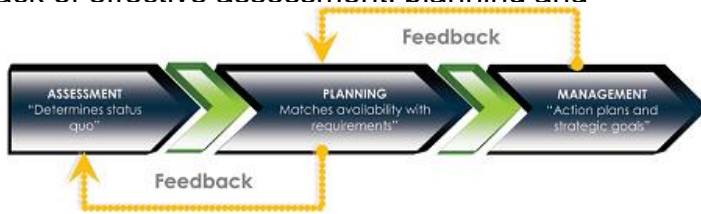
Directorate: Surface and Groundwater Information
Private Bag X313
Pretoria
0001
Fax: +27 12 336 6904
E-mail:
ngaur@dws.gov.za

DWA Guideline

“A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa”

•DWA website at www.dwa.gov.za/groundwater/documents.aspx.

•A lack of effective assessment, planning and management on significant the



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Toll Free: 0800 200 200 www.dwa.gov.za

DWA Guideline

A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa



water & forestry

Department of Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

March 2008

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NORAD Toolkit

Consists of a collection of documents, software and maps

Aimed at improving the management of groundwater at municipal level in South Africa

<http://www.dwa.gov.za/Groundwater/NORADtoolkit.aspx>

- A Framework for Groundwater Management of Community Water Supply,
- Decision Making Framework for Municipalities,
- Groundwater Monitoring for Pump Operators,
- Guidelines for Protecting Boreholes and Wells,
- Guidelines for Protecting Springs,
- Guidelines for Protecting Groundwater from Contamination,
- Implementing a Rural Groundwater. Management System

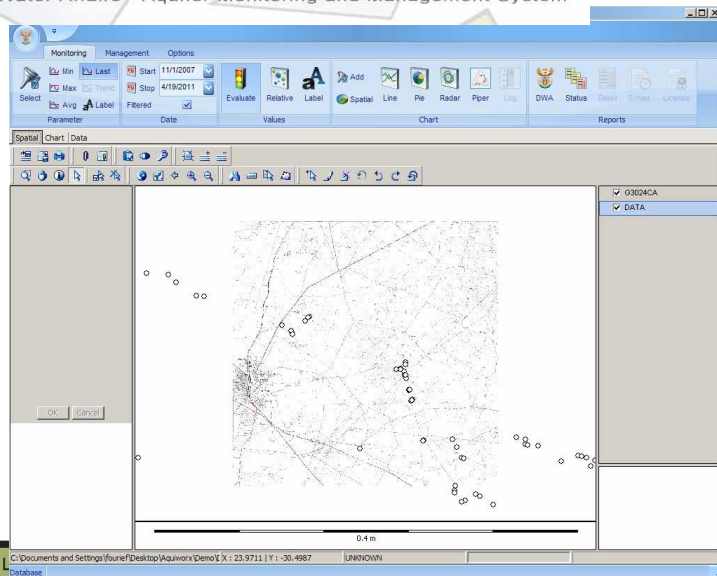
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AQUIWORX

Department of Water Affairs - Aquifer Monitoring and Management System

Groundwater
Management
Tools
or
WISH



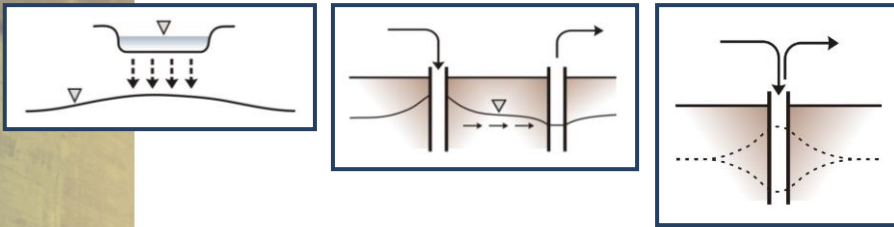
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Database

Artificial Recharge

- Artificial recharge is the process whereby surface water is transferred underground to be stored in an aquifer

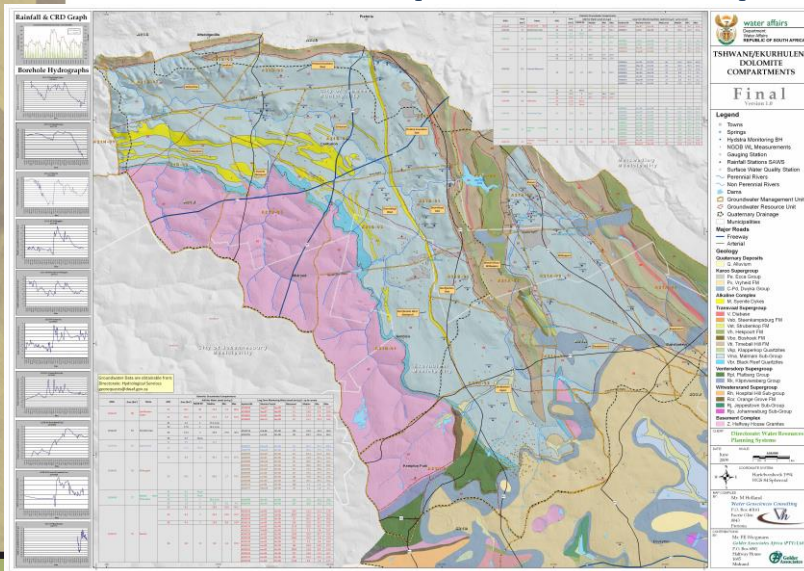
www.artificialrecharge.co.za



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Dolomitic Compartment Maps



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WRC WATER COMMUNITY

Events >>

Start Date	Title
2014/10/13	Short course on adaptive strategies for water use and demand management
2014/11/03	Gender, Water and Development Conference 3-7 November 2014, East London, South Africa
2014/11/05	SANCOLD Annual Conference 2014

NEWS & MEDIA

Latest News >>

Standing on the shoulders of South African giants – Dr Inga Jacobs
Science and Technology's new members of the National Advisory Council on Innovation appointed
Addressing sanitation services in South Africa

Press Release >>

Gender Water & Development Conference Announces -New dates
Media advisory: Water and Sanitation Summit

Hot Topics >>

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Institutions

Institutional Capacity

- Water management institutions must be structured and mandated in such a way that groundwater development and management can be optimally achieved. The challenge is adequate institutional functioning and support.
- Public – private partnerships must be established to manage aquifer system and well field

Institutions: Water Supply Models

Victoria West:

- Farmer is WSP. Supply water to reservoir from private well field.

De Aar:

- Buy farm/property with groundwater (buy of registered water right)

Kenhardt:

- Incentives for groundwater from farm (servitude, land management)

Bloem Water:

- Operate municipal well field and develop own groundwater (Private Service Provider)

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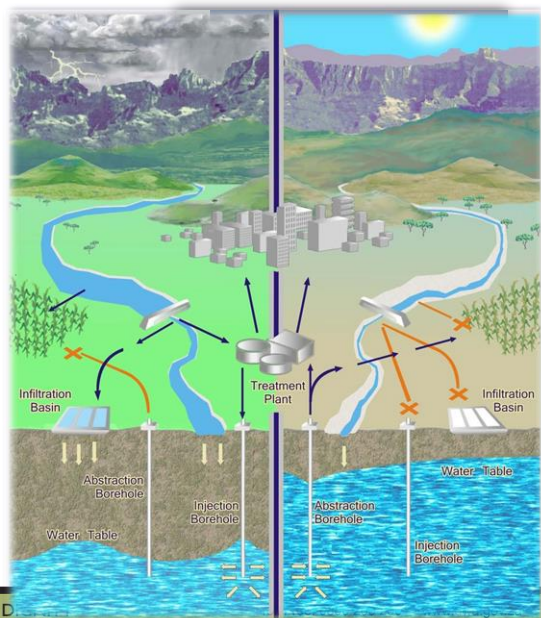
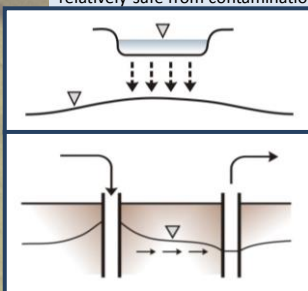
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What is artificial recharge?

Artificial recharge is the **process** whereby surface **water** is **transferred underground** to be stored in an **aquifer**.

The most common methods used involve **injecting** water into boreholes and transferring water into spreading **basins** where it infiltrates the subsurface.

Underground water storage is an efficient way to store water because it is **not** vulnerable to **evaporation losses** and it is relatively safe from contamination.



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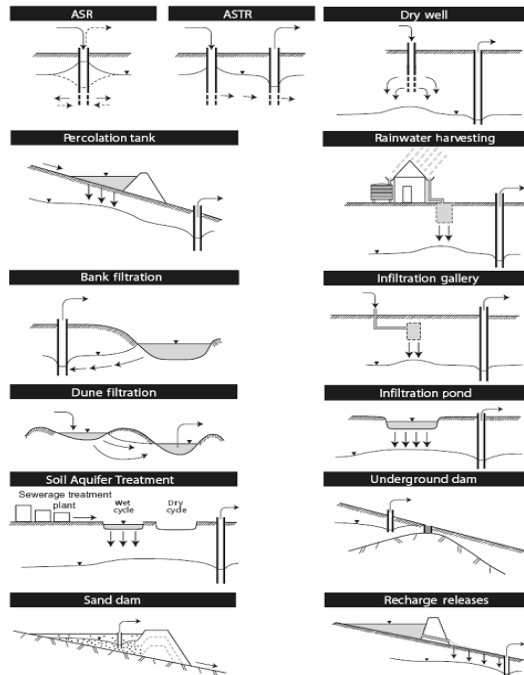
Benefits

- The on-going enhancing of aquifer yields using **treated waste water** and **storm water** (Atlantis) and treated waste water only (Polokwane);
- Enhancing aquifer yields by **transferring** groundwater from one aquifer to another (Williston);
- Enhancing aquifer yields through **opportunistic** artificial recharge whenever surface water is available (Kharkams in Namaqualand and Omdel in Namibia);
- Enhancing the **security of supply** by large-scale sub-surface **water banking** from treated dam water for long-term and seasonal storage, and for emergency requirements (Windhoek), and
- Improving water **quality** (Atlantis and Kharkams).

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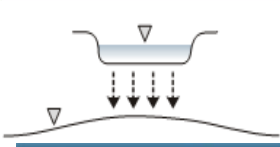
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Types of Artificial Recharge



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v.za




Infiltration Basins

Basins constructed in sand or gravel aquifers. Surface water is diverted to the basins and allowed to infiltrate through an unsaturated zone to the underlying unconfined aquifer.

Atlantis Water Resource Management Scheme

Hidden Treasure of Water Conservation and Artificial Recharge



- Atlantis Water Resource Management Scheme (AWRMS) has successfully recharged and recycled water since 1993.
- On average, the site recharges more than 2.7 million m³ per year to the town's water supply i.e. approximately 25 - 30% of Atlantis' groundwater supply is engineered through artificial recharge.
- Approximately 4000 m³/day of higher salinity industrial wastewater is treated and discharged into the coastal basin down-drift of the landfill close to the sea. This prevents seawater intruding into the aquifer.

Artificial Recharge Basins
Treated water is directed to basins for artificial recharge into the aquifer.

Wastewater Treatment Plant (WWT)
Wastewater is treated and recycled for use in the resort.

Desalination
Seawater is desalinated and treated for use in the resort.

Storage Reservoirs
Treated water is stored in reservoirs for use in the resort.

Distribution and Delivery Plant
Treated water is distributed to various parts of the resort.

Thank you