

Under the Patronage of **HRH Prince Faisal bin Bandar bin Abdulaziz**
Governor of Riyadh Region

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture



رؤية
2030
الجمهورية العربية السعودية
Kingdom of Saudi Arabia

منتدى المياه السعودي
saudi water forum **SWF 2022**
Water Sustainability.. A Responsibility for All

Integrated Solutions for Water Scarcity – Artificial Aquifers

Dr. Ashraf Melki
Head of Hydrology Department
TDS Company for Water and Environment

ORGANIZING PARTNERS



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TECHNICAL ADVISOR



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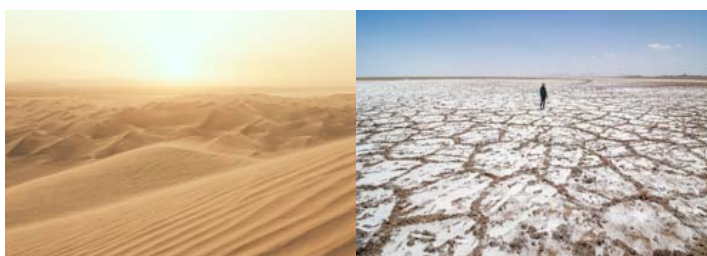
شركة حلول التقنية والتطوير
Technical Development Solutions

Contents

1. Challenges of water resources in the Kingdom of Saudi Arabia
2. Integrated solutions for water scarcity: Artificial recharge
3. Conclusion

1. Challenges of water resources in the Kingdom of Saudi Arabia

❖ Arid climate conditions



Low precipitation
(103mm/year)

High PET
(2.43 m/year in Jaddah)

❖ Sediment transport for dams



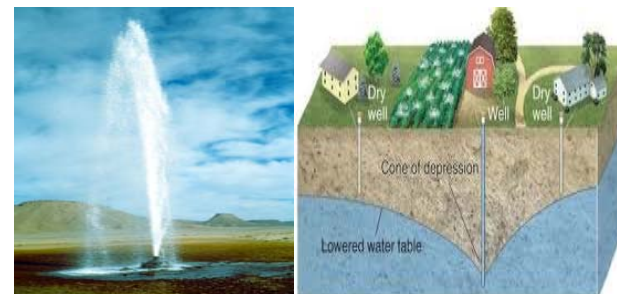
Exp: Thamed dam

❖ High cost of desalination



Exp: Ras Al-Khair desalination plant
(SR15.67 billion)

❖ Groundwater depletion



Artesian wells

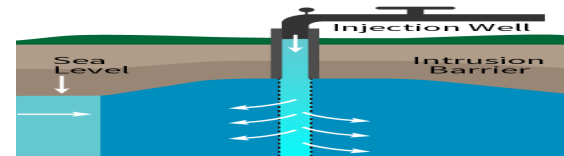
High drawdown
Exp: Manjour aquifer

➡ Artificial recharge is suggested as an adequate solution for water sustainability.

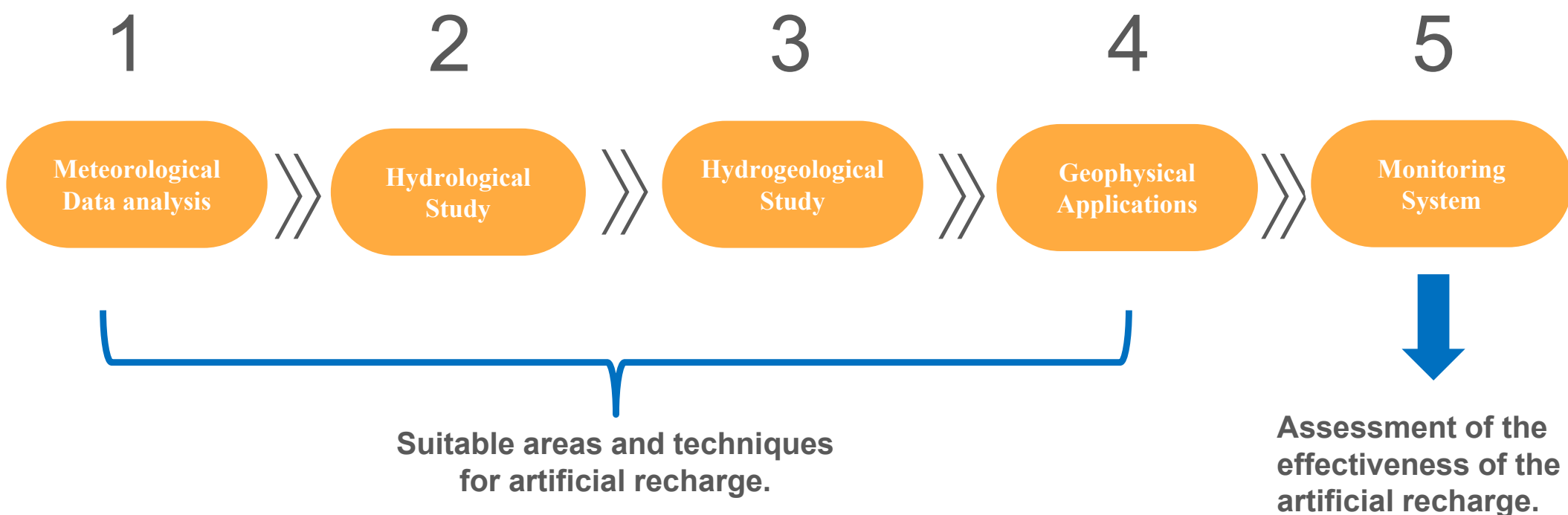
2. Integrated solutions for water scarcity: Artificial recharge

Artificial recharge is the practice of increasing the amount of water that enters an aquifer through human-controlled.

- Rainwater
- Treated wastewater
- Desalinated water
- Infiltration devices
- Injection devices



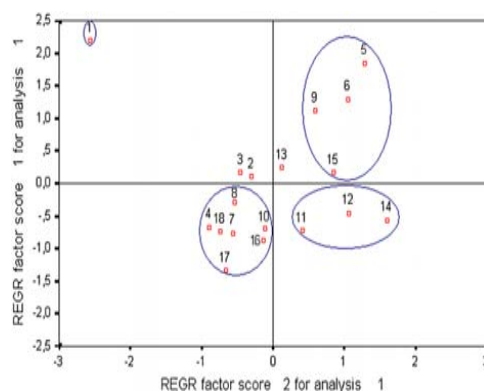
2. Integrated solutions for water scarcity: Artificial recharge



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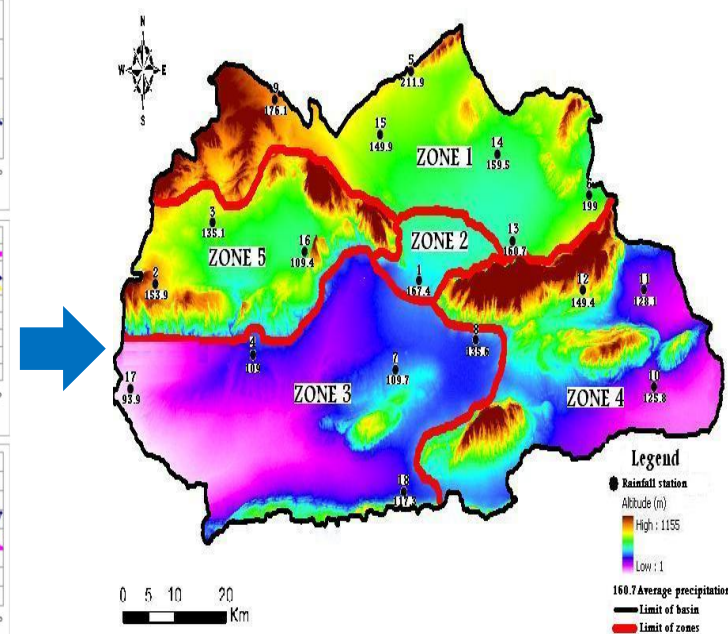
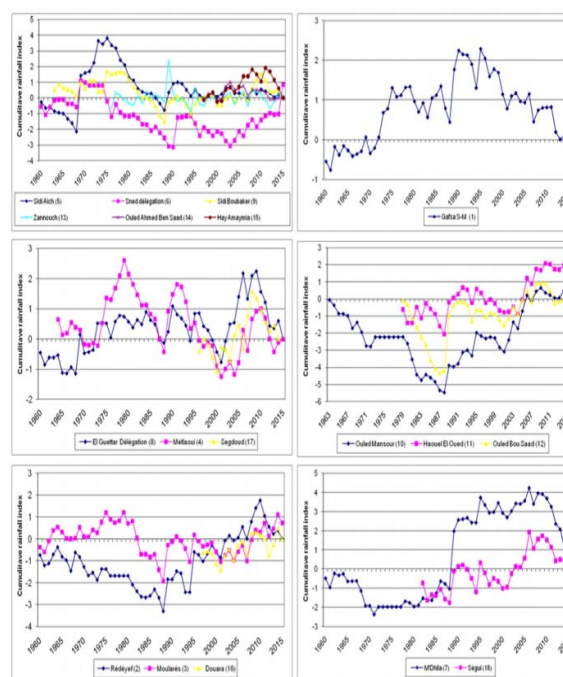
Meteorological Data Analysis

Principal Component Analysis.



Spatial analysis of rainfall variation.

Cumulative Rainfall Index.

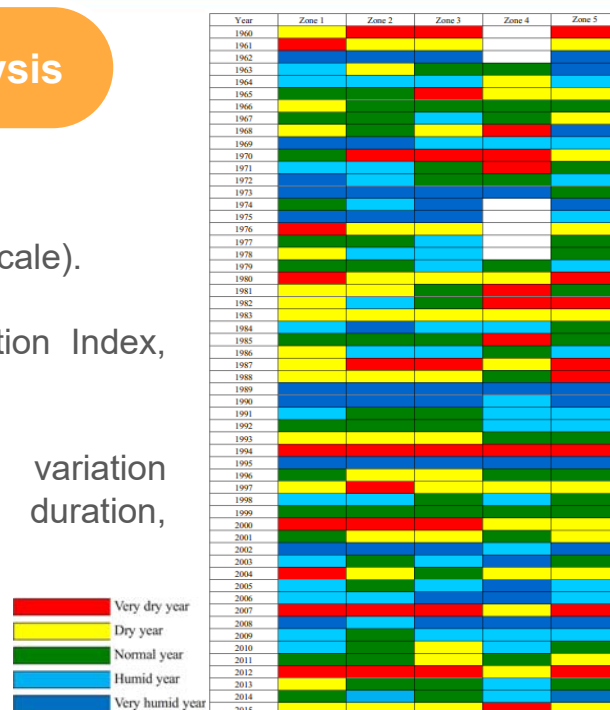


Spatial variation of rainfall under an arid climate. Case Gafsa region, Tunisia (Melki et al., 2018).

2. Integrated solutions for water scarcity: Artificial recharge

Meteorological Data Analysis

- Scales (yearly, monthly and daily scale).
- Statistical tests (Standard Deviation Index, Deciles distribution, Frequency...).
- Characteristics of temporal variation (class of the year, frequency, duration, severity and extension).



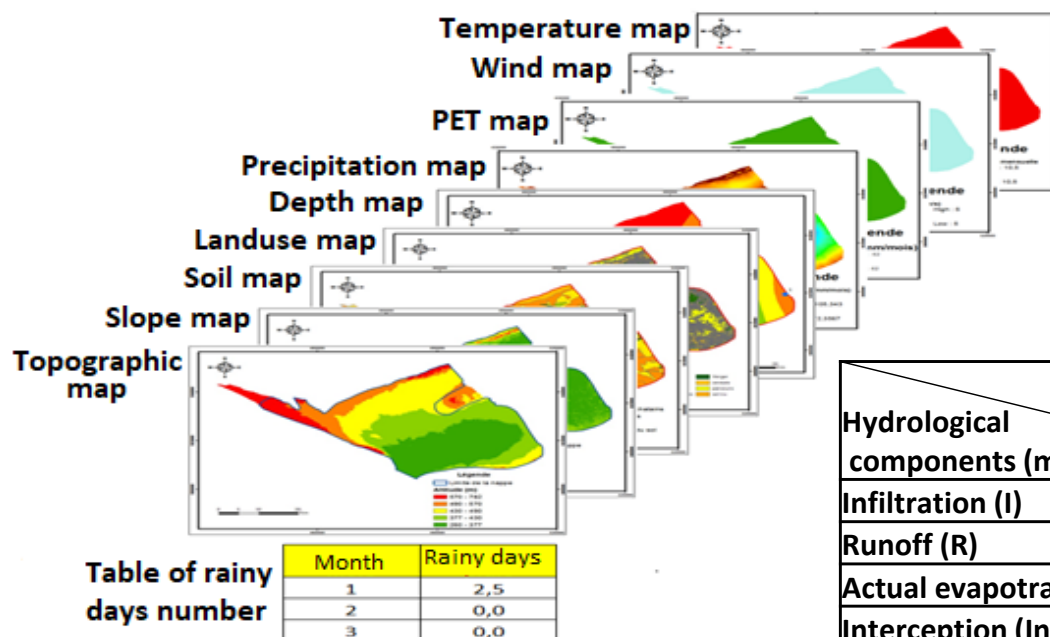
Daily rainfall mm/day	Frequency %				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
0.1-5	46.4	75.8	55.2	40.1	55.5
5-10	21.6	12.2	21.7	27.6	20.3
10-15	12.7	5.7	8.8	13.5	11.4
15-20	7.6	2.8	6.1	5.5	4.4
20-25	4.0	1.2	2.9	4.4	3.3
25-30	2.4	0.9	1.7	2.6	1.8
30-35	1.9	0.5	1.0	2.3	1.1
35-40	1.1	0.2	0.9	0.7	0.6
40-45	0.6	0.1	0.3	1.2	0.9
45-50	0.1	0.1	0.3	0.5	0.2
> 50	1.6	0.5	1.1	1.6	0.5

Temporal variability of rainfall under an arid climate. Case Gafsa region, Tunisia (Melki et al., 2018).

Hydrological study

Estimation of hydrological components By WetSpass-M model

(Water and Energy Transfer between Soil, Plant and Atmosphere under quasi-Steady State)



This model is calibrated based on the actual evapotranspiration estimated over a period of 50 years to adapt to the arid climate of the studied region (Melki et al., 2017).

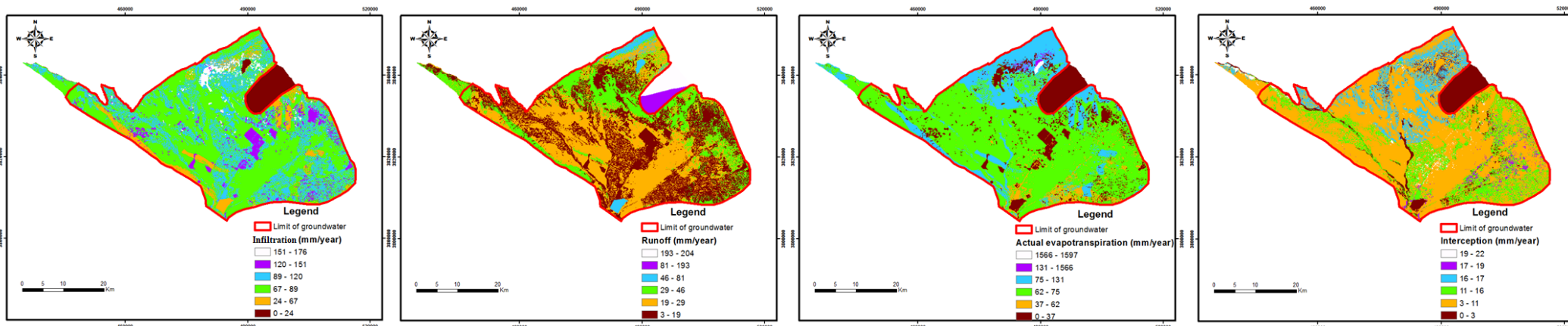
Year	Very dry	Dry	Normal	Humid	Very humid
Hydrological components (mm)					
Infiltration (I)	40.8	63.4	81.3	101.4	141.4
Runoff (R)	10.8	14.0	22.7	30.6	80.1
Actual evapotranspiration (AET)	52.5	60.2	71.8	71.6	107.9
Interception (In)	4.9	6.4	9.9	11.9	16.9

$$P = I_n (5\%) + R (15.4\%) + AET (36.8\%) + I (42.8\%)$$

Rates of the different hydrological components in Northern Gafsa Aquifer, Tunisia (Melki et al., 2019).

2. Integrated solutions for water scarcity: Artificial recharge

Hydrological study



Spatial distribution of the different hydrological components under an arid climate.
Case Northern Gafsa Aquifer, Tunisia (Melki et al., 2017).

2. Integrated solutions for water scarcity: Artificial recharge

Hydrological study

- Discharge Keeper is an optical flow measurement for natural water streams, irrigation and wastewater channels.
- Key Features :
 - Camera-based measurement system for acquisition of the surface velocity profile and the water level for direct calculation of the discharge.
 - Non-intrusive measurement method using only one sensor (camera).

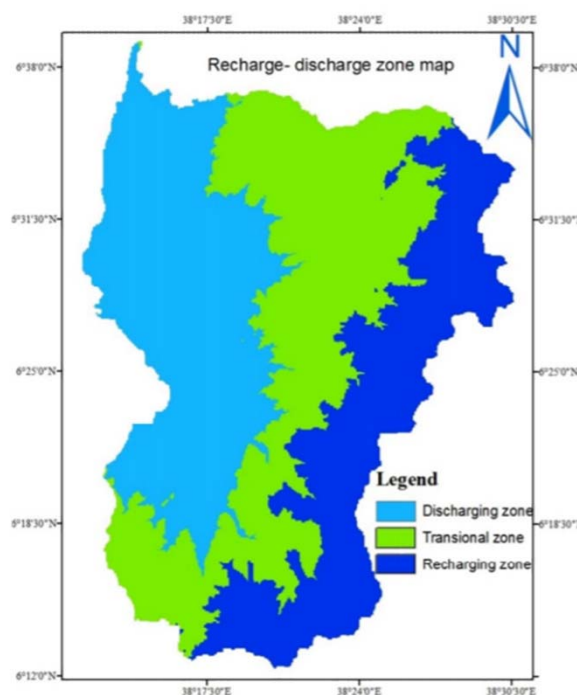


Example of recorded data by Discharge Keeper
in Wadi Naqab UAE (03/01/2022).

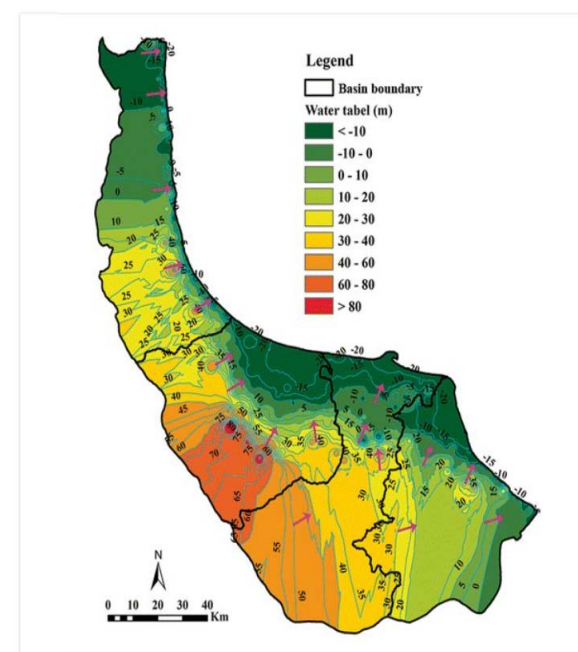
2. Integrated solutions for water scarcity: Artificial recharge

Hydrogeological Study

- Recharge , Discharge zone and flow Direction.
- Over exploitation zones.
- Groundwater quality.
- Sea intrusion zones.



Groundwater recharge, discharge and transition zones.(Genet et al., 2017).



Piezometric map showing direction of groundwater flow.(Mohamed Javad et al.,2018).

2. Integrated solutions for water scarcity: Artificial recharge

Geophysical Applications

Seismoelectric (SE)

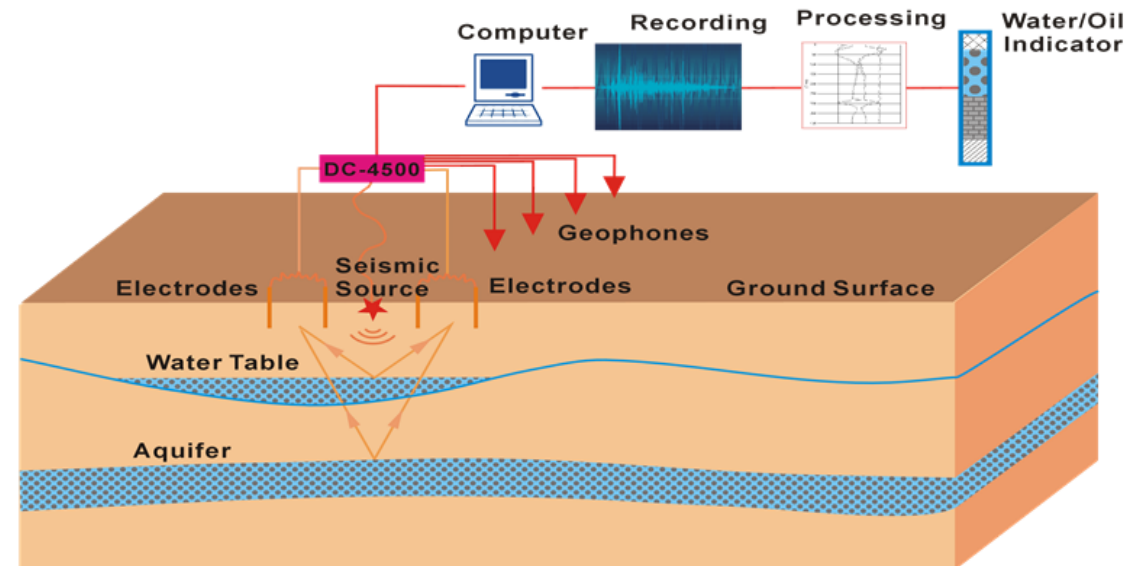
Principle:

New technology based on the seismoelectric effect to measure the electric potential signal at ground surface with a seismic source for detecting subsurface water properties.

Benefits:

- Rock porosity.
- Permeability.
- Fluid contents and their saturation.

DC-4500 Field & House Workflow



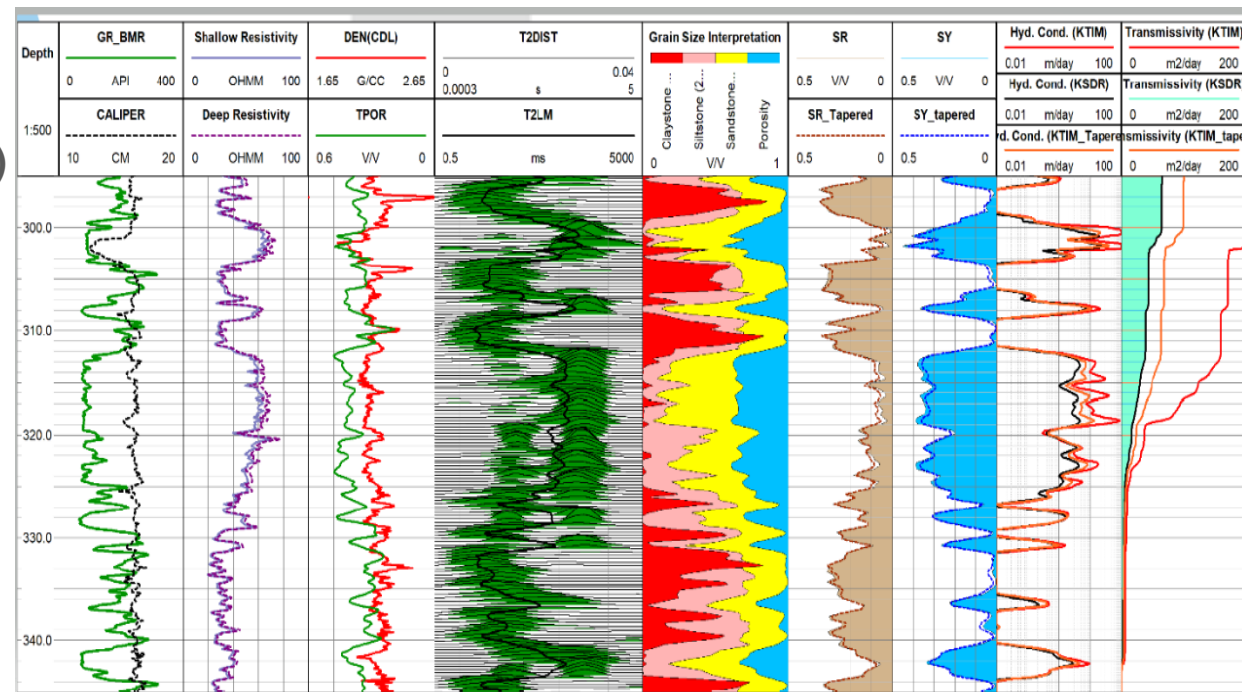
2. Integrated solutions for water scarcity: Artificial recharge

Geophysical Applications

Borehole Magnetic Resonance (BMR)

BMR Benefits:

- Lithology identification.
- Identify the storage properties:
 1. Porosity.
 2. Specific storage.
 3. Specific yield and specific retention.
- Flow properties:
 1. Transmissivity.
 2. Hydraulic conductivity.

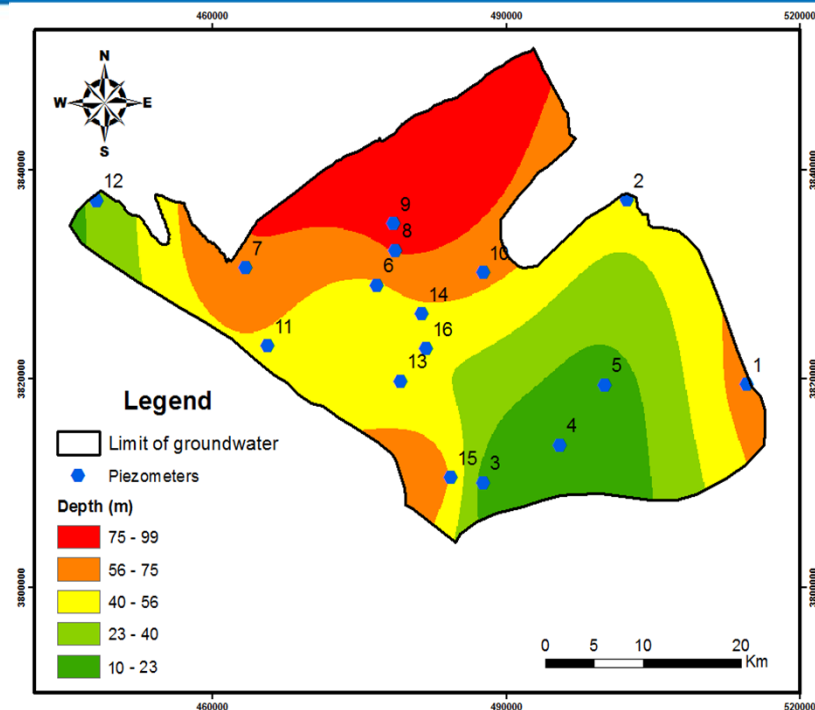


Borehole data obtained from the well logging.

2. Integrated solutions for water scarcity: Artificial recharge

Monitoring System

- ❑ Selection of representative monitoring wells.

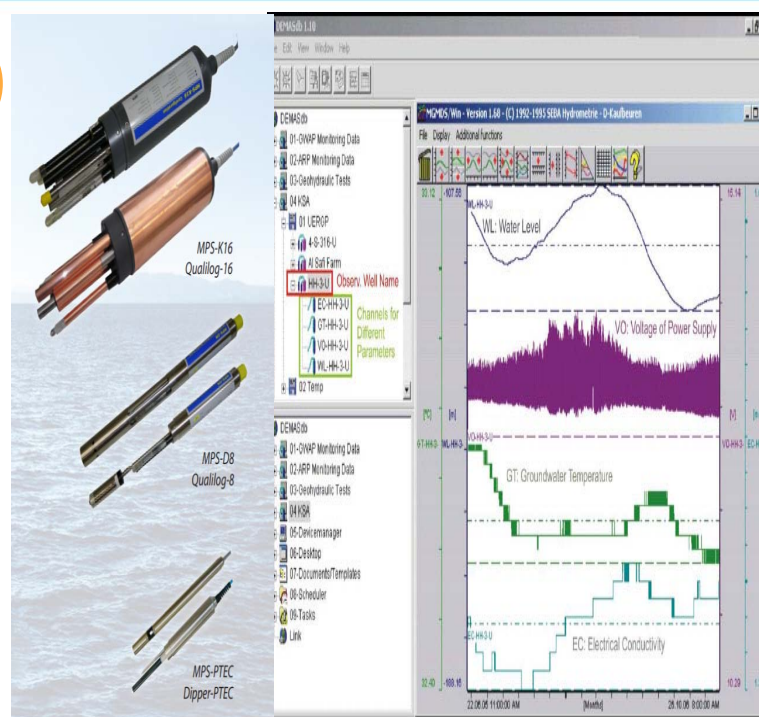


Observation wells distribution in Northern Gafsa Aquifer.

2. Integrated solutions for water scarcity: Artificial recharge

Monitoring System

- Installation of multi-parameter sensors.



Water quality monitoring

Multiparameter measuring systems for ground and surface water

- Water level
- Temperature
- Conductivity
- Total dissolved solids (TDS)
- Salinity
- Density
- Dissolved oxygen
- oxygen saturation
- pH value
- Redoxpotential
- Ammonia
- Nitrate
- Chloride
- Ammonium
- Sodium
- Calcium
- Fluoride
- Potassium
- Chlorophyll a
- Cyanobacteria
- Rhodamine WT
- Turbidity
- total suspended solids (TSS)



B24_MPS-Wasserqualitätsmonitoring_e 05.06.2020

Examples of sensors output.

3- Conclusion

- Worldwide demand for freshwater.
- Artificial recharge = water sustainability.
- Integration of several studies and applications = effective artificial recharge.

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