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Water and Oil Do Mix!
A Discussion on How Leading-Edge Oil Field Technologies are Applied to Groundwater Applications

Water Tech Symposium

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About Schlumberger…

- Founded in France, early 1900's
- >80,000 people, 140 nationalities
- Real-time technologies and services for oil and gas companies
- Schlumberger Water Services - >350 employees
- Provide technologies and solutions engineered to support groundwater professionals at virtually every stage of their project.

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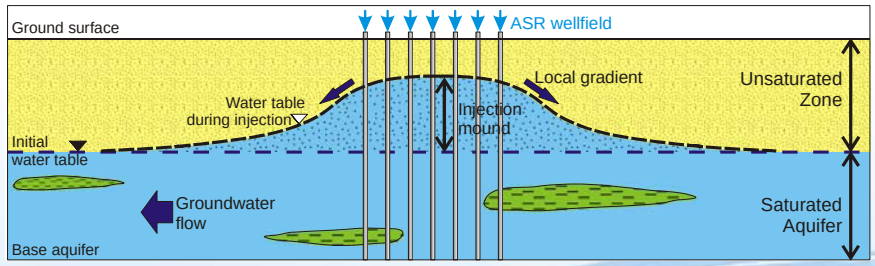
Outline

- How can oilfield technology be applied in the water industry to improve the aquifer characterization ?
- Can we bring the traditional ASR development processes to a new technical level - Improving success rate and improving implementation duration?
- Creating the strategic potable water supply with ASR technology in the UAE: Project overview
- New advanced hydrogeological workflows that integrate new acquisition technology from the field



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Technologies…

- Advanced Borehole Geophysics
  - Technologies from Schlumberger Oil Field Services.
- Petrel* and ECLIPSE*
  - Software solutions that solve subsurface challenges from seismic to simulation by uniting the subsurface domains of geophysics, geology, and reservoir engineering.
- Divers (Dataloggers)
- Satellite and Telemetry

*Mark of Schlumberger

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ASR Project in Arid Environments

Highlights:

- Implementation of Aquifer Storage and Recovery (ASR) to improve water supply in the United Arab Emirates
- The environmental Agency of Abu Dhabi supervised the technical aspects of the ASR project
- Compilation of geological and hydrological data for conceptual model development
- Monitoring changes in response to hydraulic pumping tests or groundwater injection
- Advanced groundwater simulation to determine ASR feasibility

Rolf Herrmann Schlumberger Water Services
Abu Dhabi, United Arab Emirates

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ASR Objectives and Conditions

- Locate, Evaluate and Test an Aquifer(s) for Strategic Storage of Fresh Water with a Storage Capacity of 36 Billion Gallon (136 Million m^3)
- Phased Approach with clear Milestones:
  - Phase-1: Feasibility Study & Engineering Design (6 months)
  - Phase-2: Pilot Field Test (12 months)
  - Phase-3: Execution

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ASR vs. Surface Tank Storage

Freshwater = 1.5 * 3 km

Pressure = 4 * 8 km

Protected Area

Storage Capacity: 4 - 6 BG

Construction: 2 years

No. of Wells: 50-100

Recovery Rate: 10 MG/D

Efficiency: 80 - 90 %

Equivalent to No. of Surface Tanks: 200

(each 24MG)

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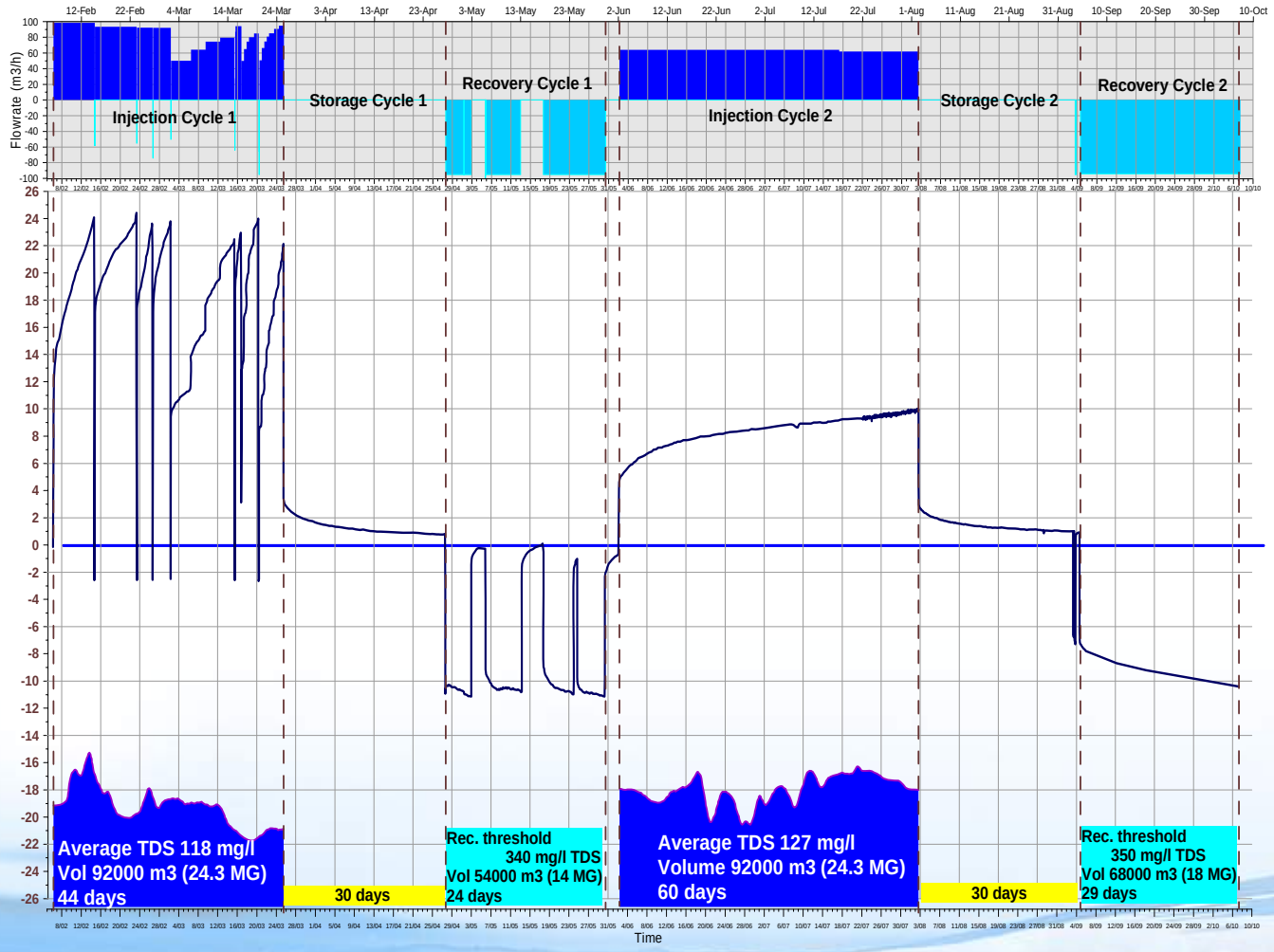
ASR Pilot Test Cycles



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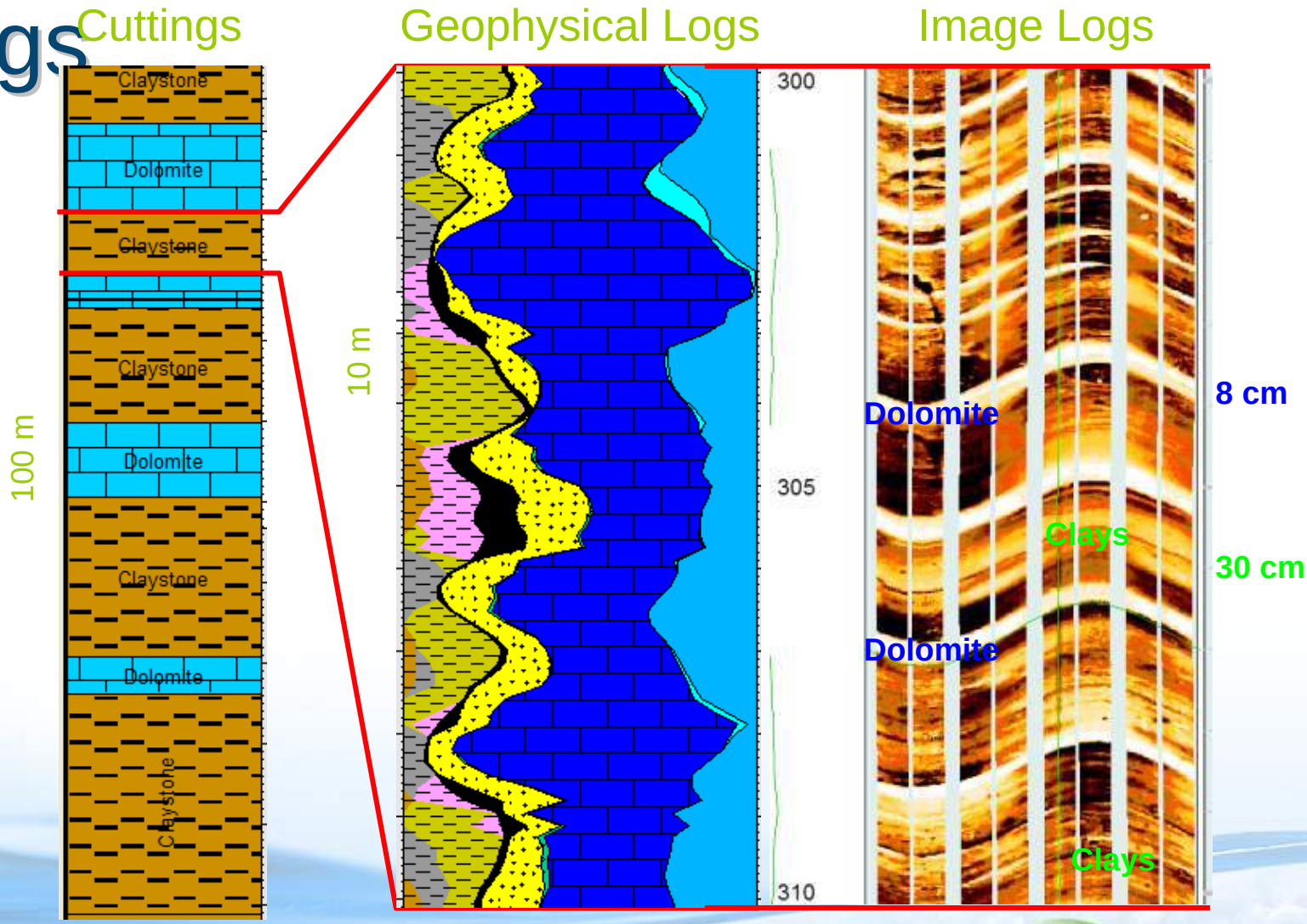
Increase Vertical Resolution with Logs



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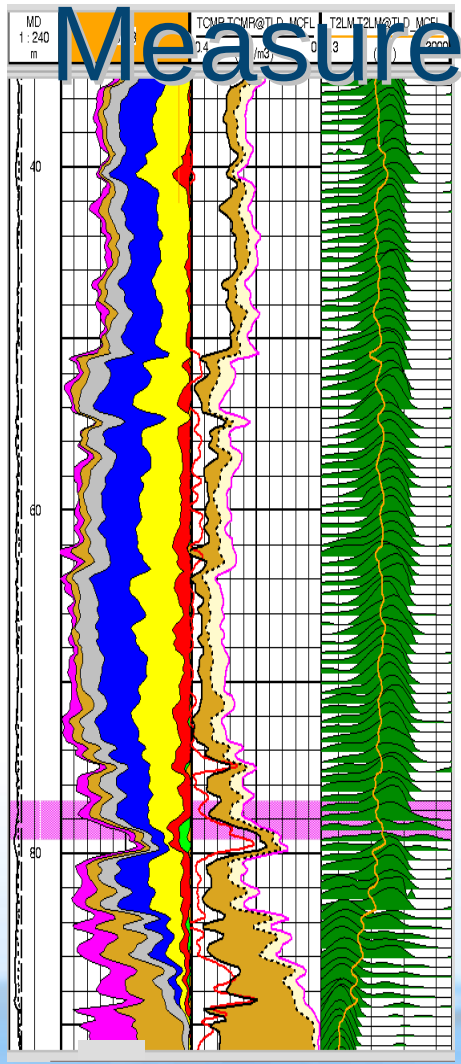
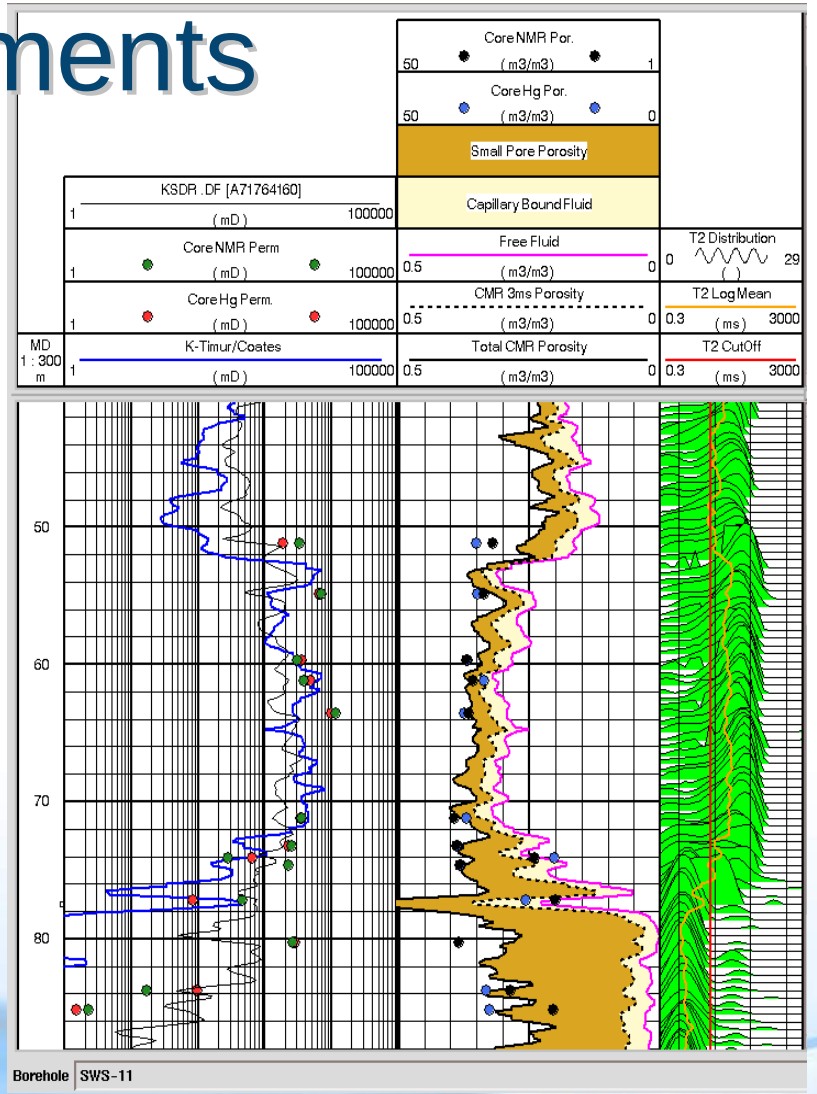
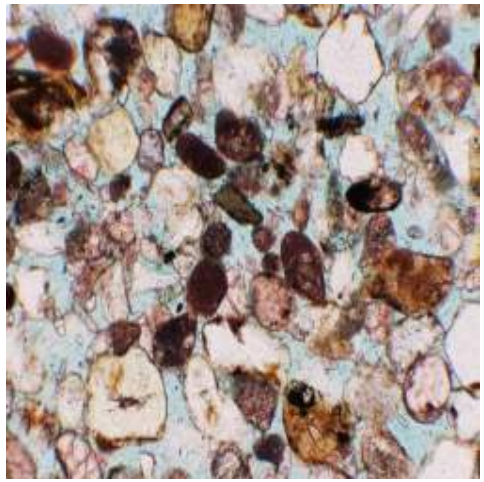
CMR Compared to Core Measurements

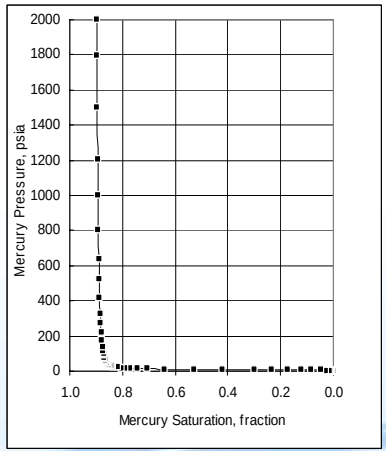


CMR Pore Size Distribution





Thin Section



Capillary Pressure

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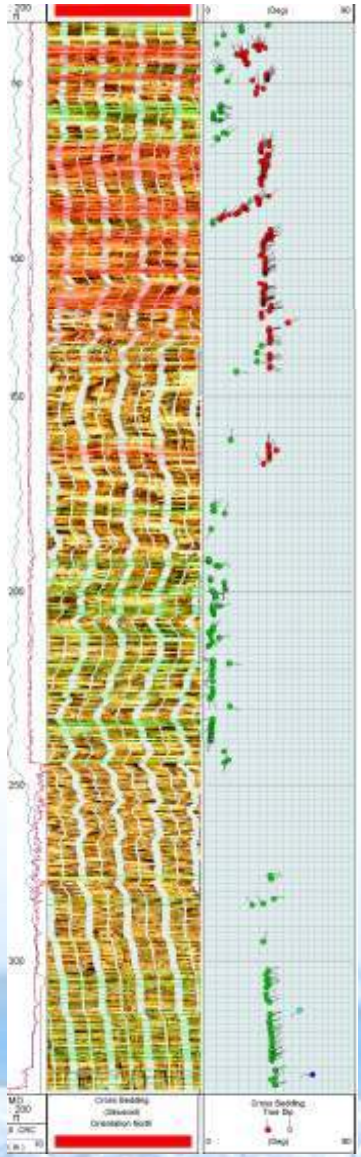
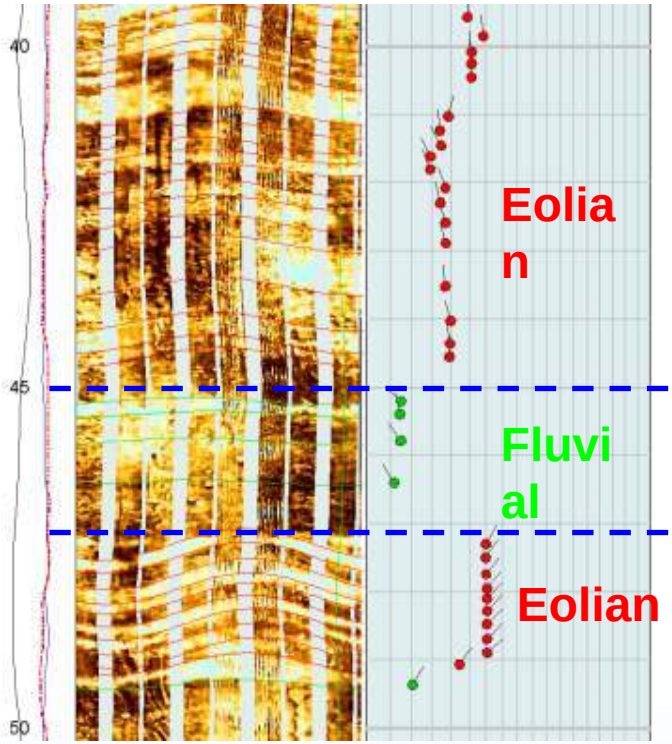
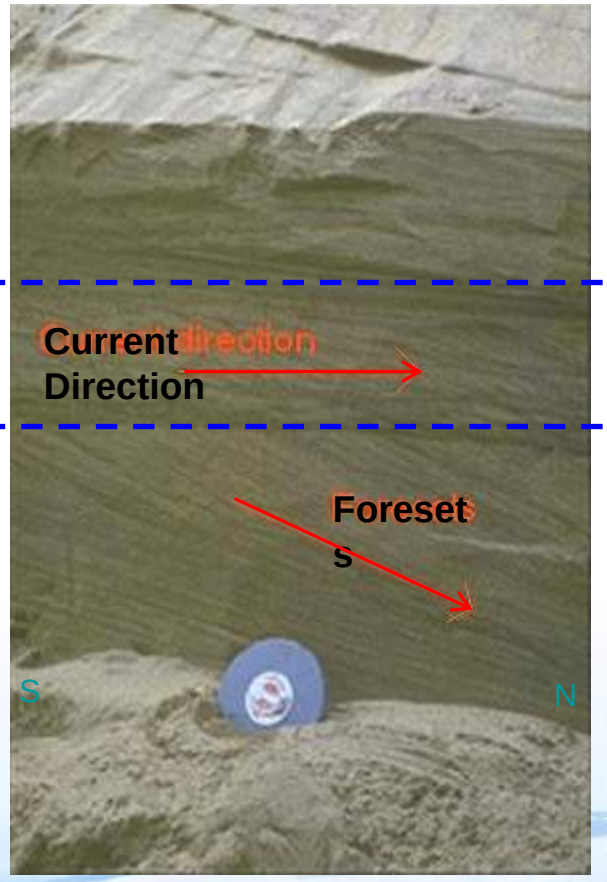
Sedimentary Interpretation







Preferred Groundwater Flow Direction =
Perpendicular to Sedimentary Dip
condX, condY, condZ - anisotropy

dip= E15-30, F8, azimuth=NNW

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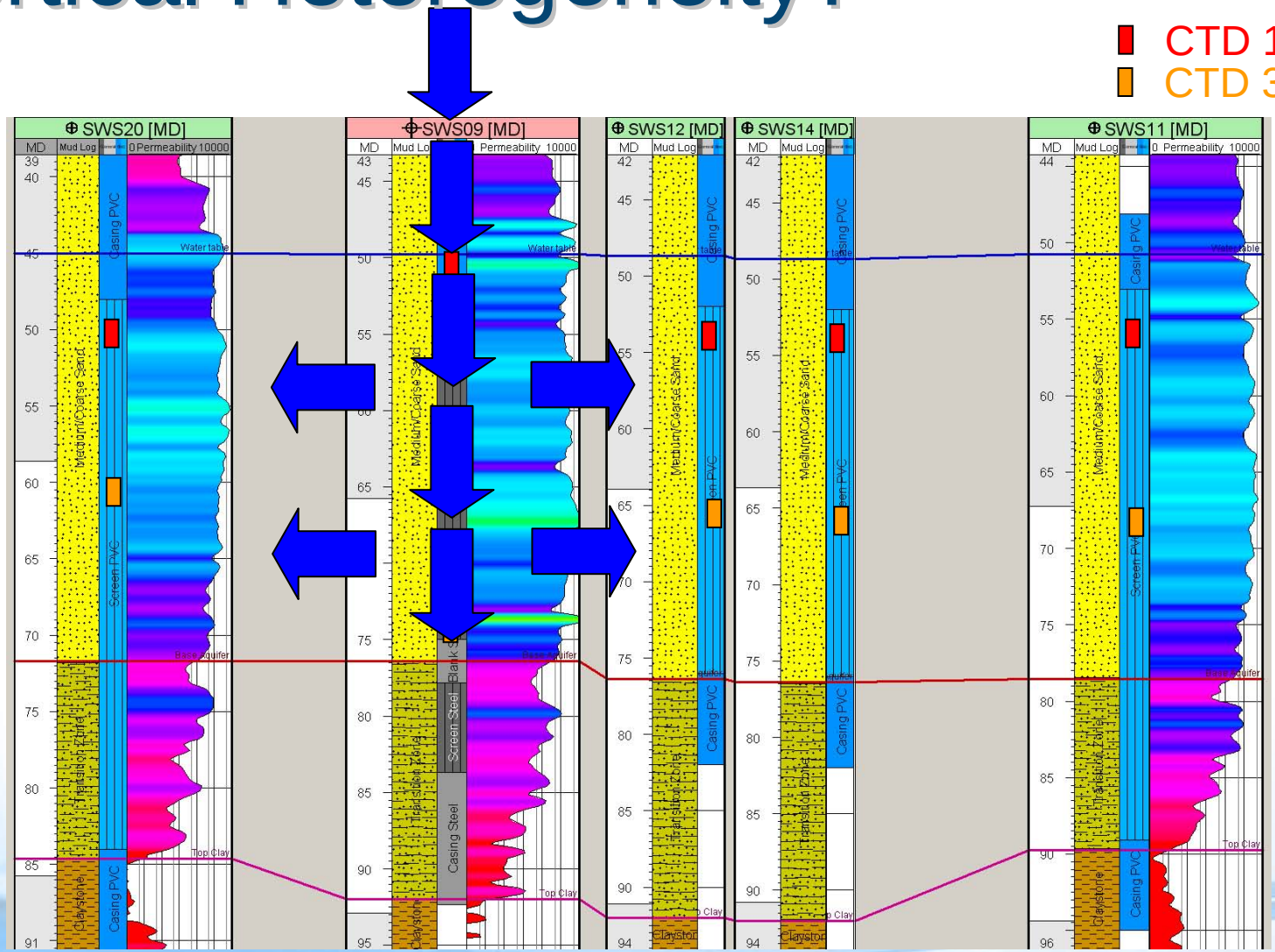
Vertical Heterogeneity?

CTD 10m diver
CTD 30m diver



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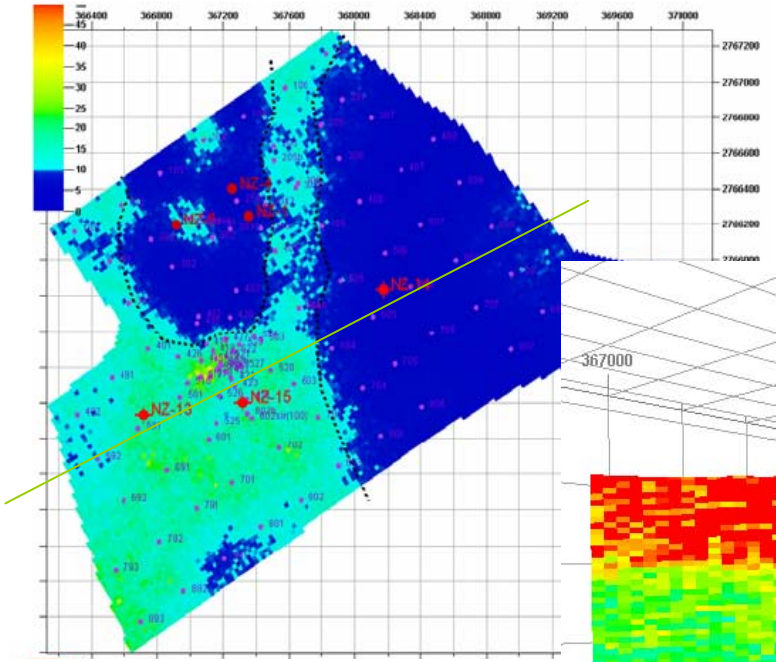
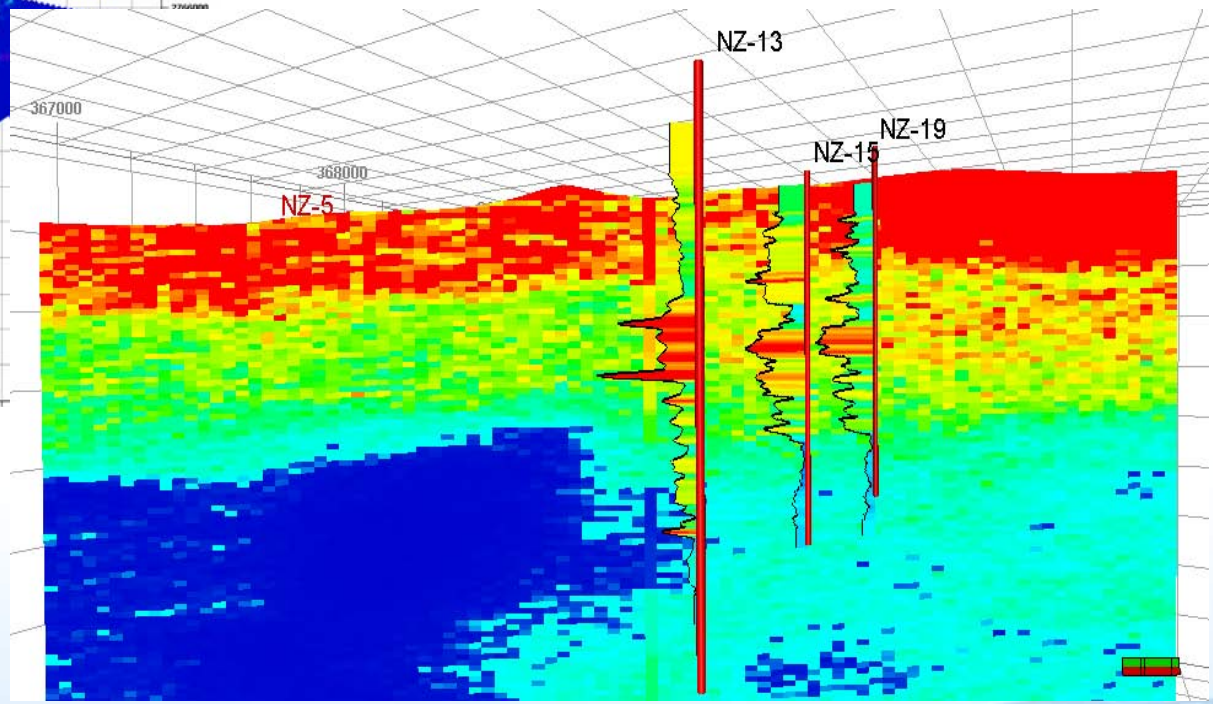
Correlation TDEM and Well Logs





Combination of Methods Leads to Success

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Moving Hydrodynamic Testing Forward

- Traditional:
  - one or two observation wells
  - traditional manual water level measurements
  - step-drawdown test to estimate well losses
  - pump test duration by default max. 24h
- Derivative Well Test Analysis
  - pumping well analysis (no need for observation wells)
  - diver equipment, high resolution at early times
  - flexible duration, a few minutes may be enough
  - real-time quick-look test analysis
  - skin = well efficiency
  - specific yield is known from logs (free water phi)

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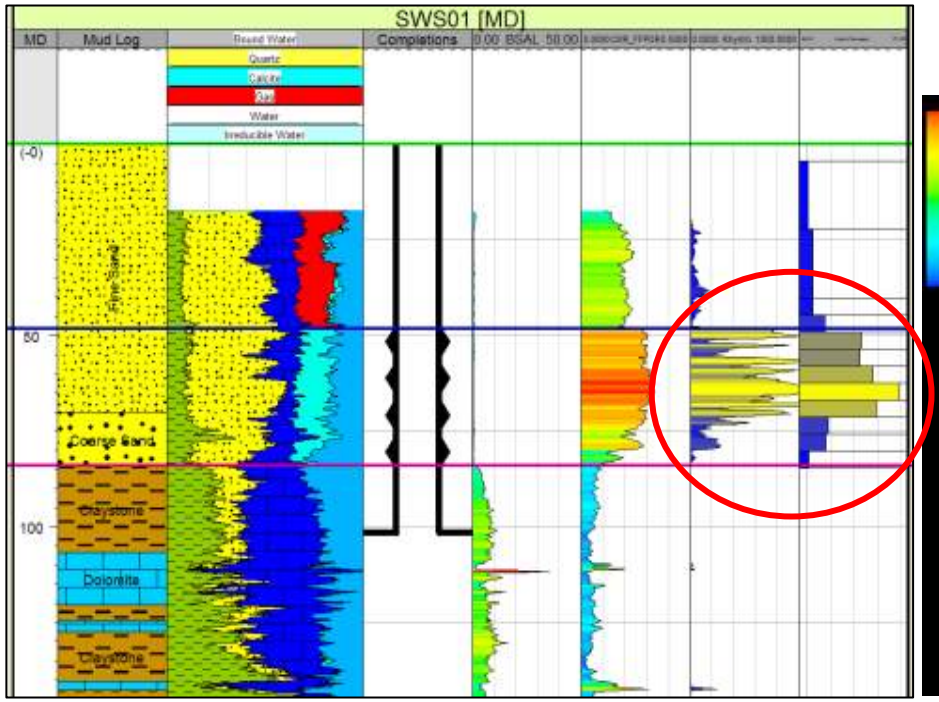
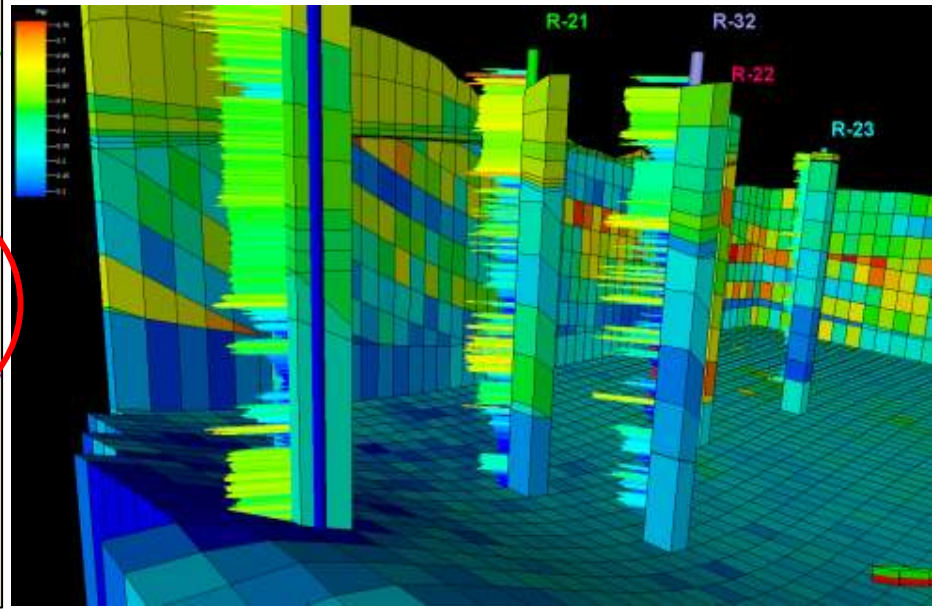
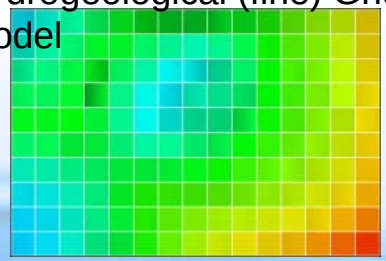
Upscaling and Model Population

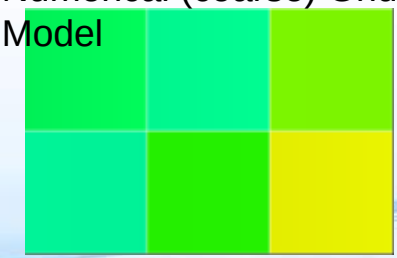




Hydrogeological (fine) Grid Model



Numerical (coarse) Grid Model



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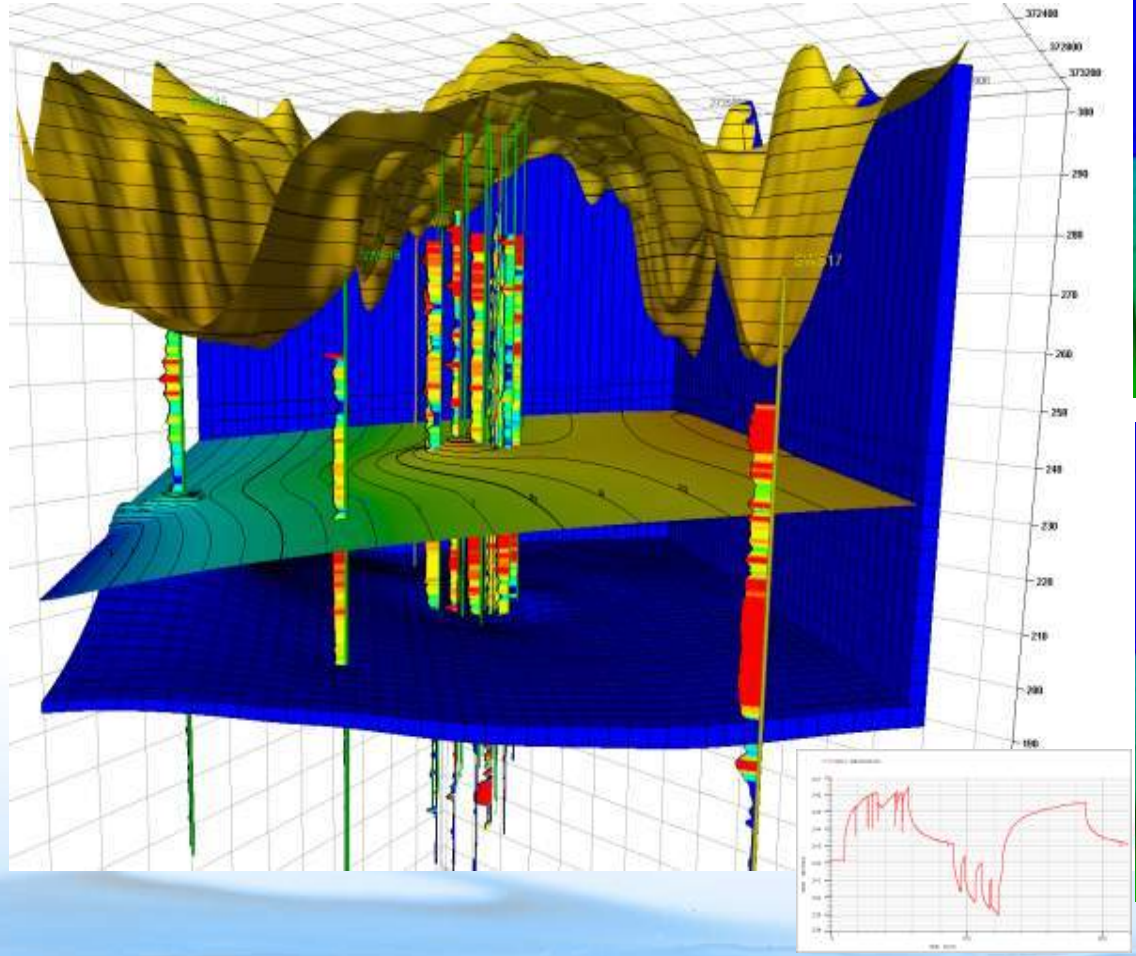
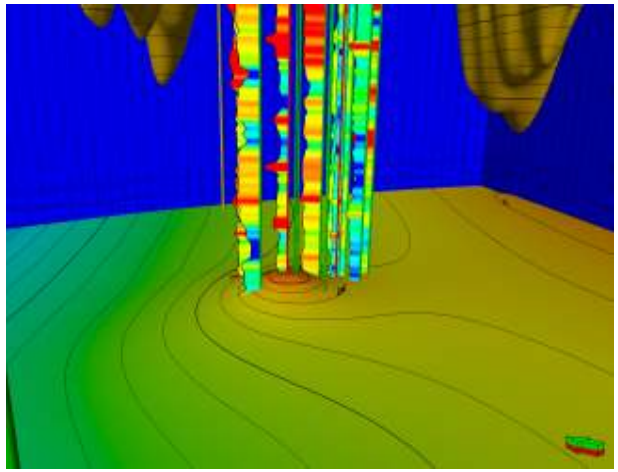
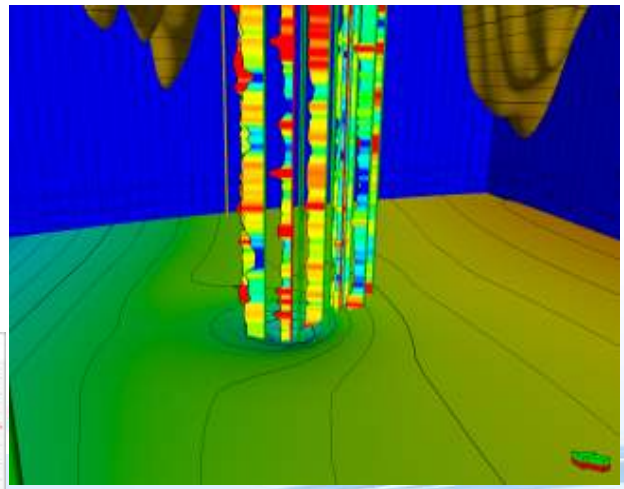
Numerical Simulations







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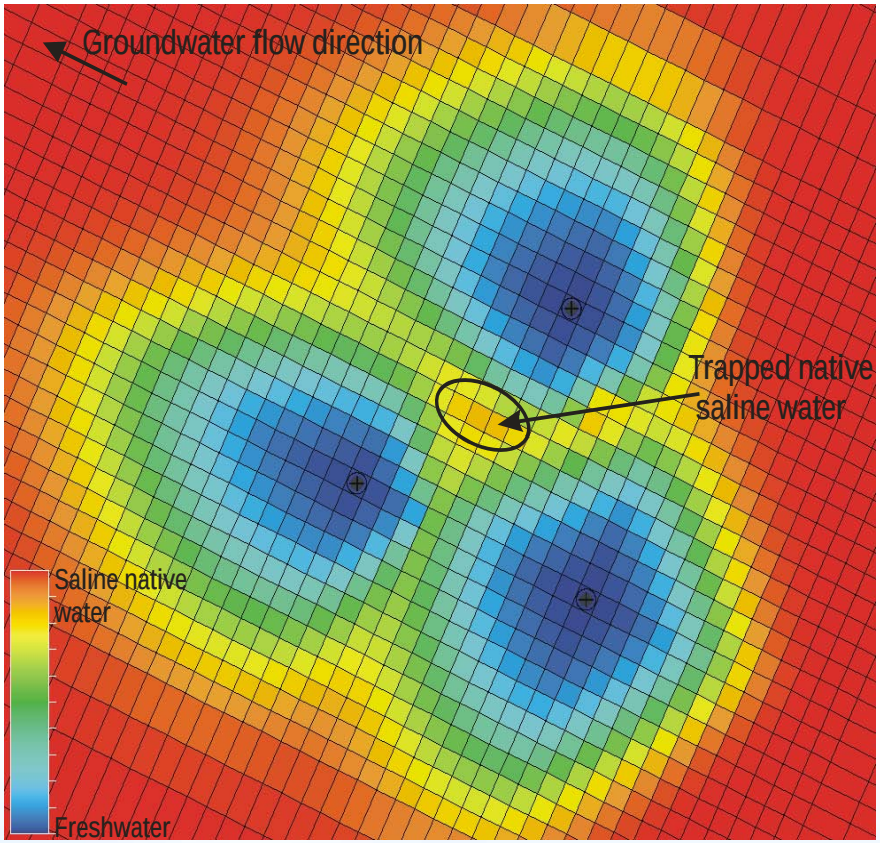
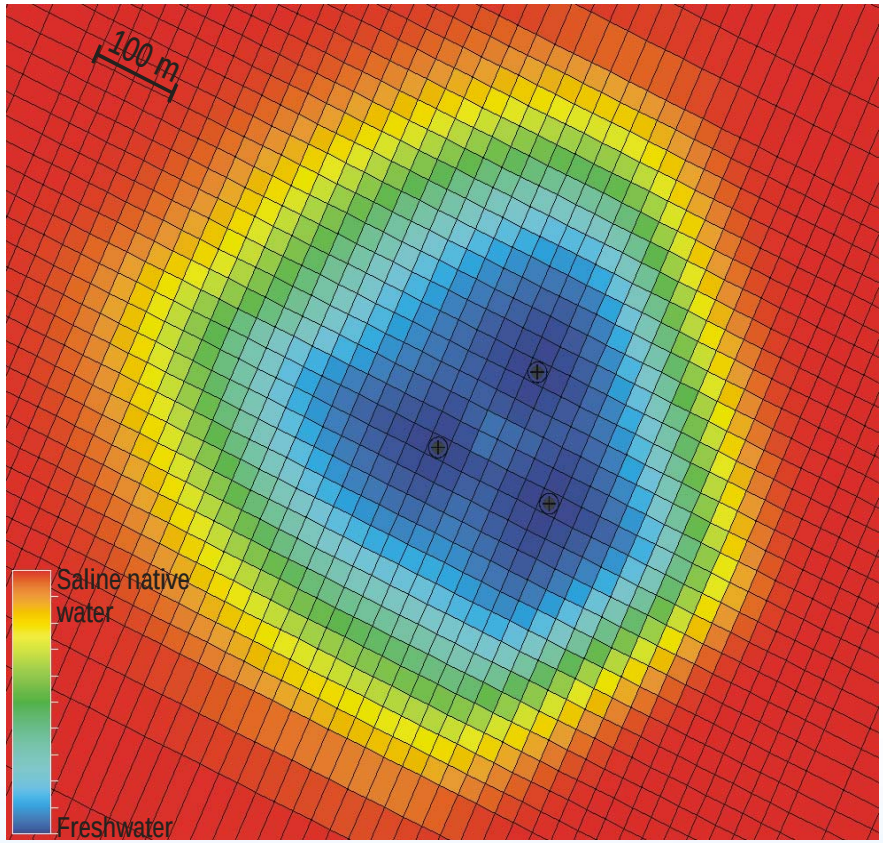
ASR Well Field Optimization





A large well distance will reduce interference effects

A small well distance will ensure efficient connection of the freshwater bubbles

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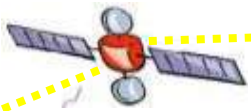
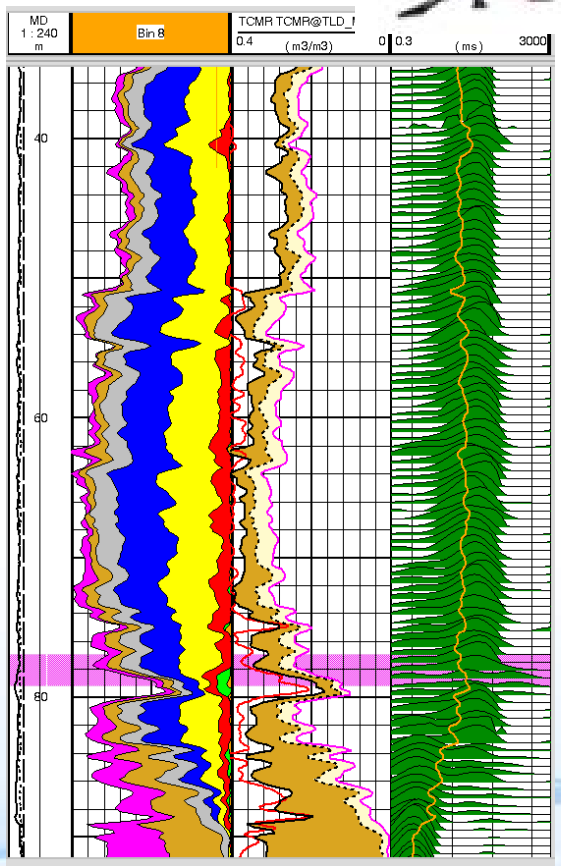
Real Time Solution Applied



Water Services takes full advantage of the real-time solutions provided by InterACT



- Logging CMR/PEX 100 m water wells
- Logging will be supervised real-time through InterACT
- Quick-Look interpretation of CMR log
- Discussion with hydrogeologist to define saturated thickness and casing depths

→ Turn around time quick-look: 6 hours

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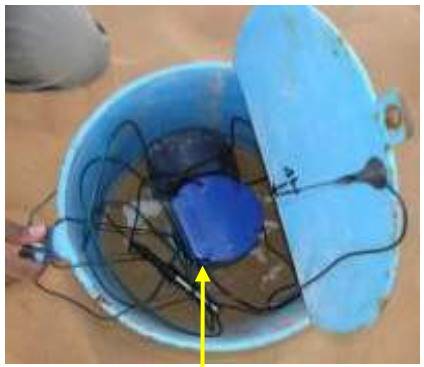
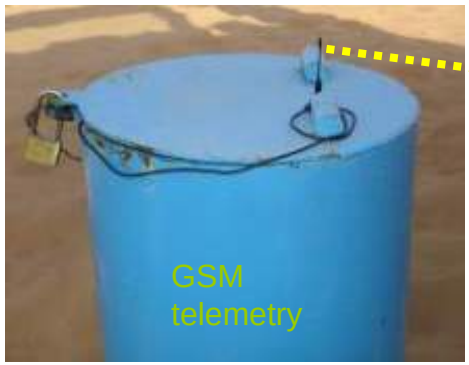
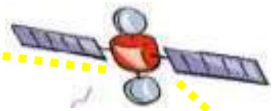
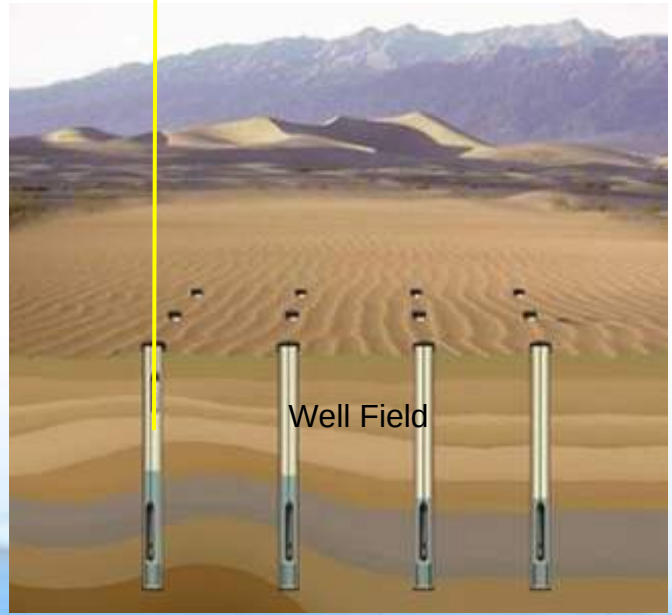
From the Field to the Office







Real-time well field monitoring with telemetry.



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Conclusions:

- New hydrogeological investigation techniques and analysis methods can improve considerably the reliability of the 3D hydrogeological high resolution models.
- Advanced tools such as Geophysics, Petrel and ECLIPSE previously used in the oil industry can increase the capability to delineate a groundwater site with increasing levels of detail.
- This leads to an improved success rate for identifying suitable ASR locations and their implementation.
- Large scale projects will generate volumes of data which must be managed appropriately to make the project a success

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