Exploration and Hydrogeological Assessment of a Deep Coastal Aquifer System in Tanzania

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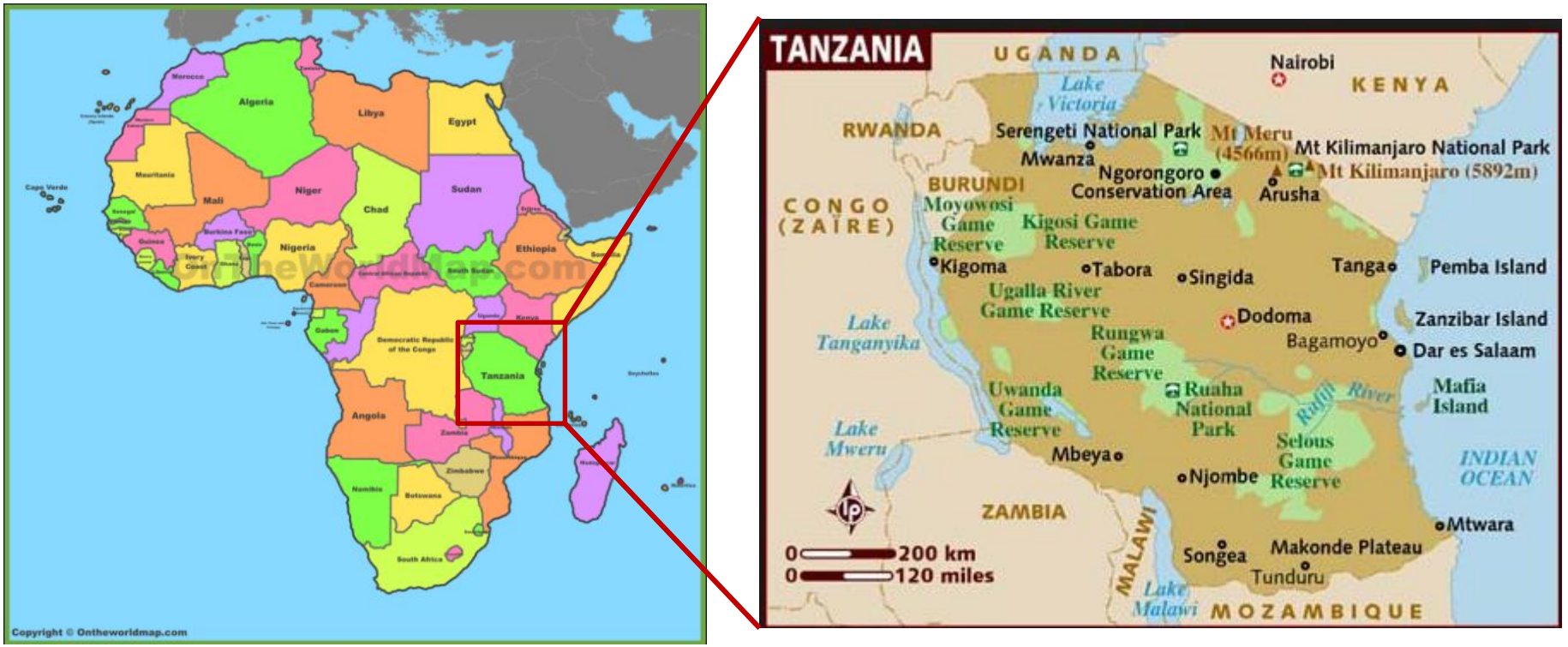
CDM Smith

Overview – Kimbiji Aquifer Assessment Project

- Discovery of a deep coastal aquifer system in Tanzania;
- Use of hydrocarbon exploration data in a groundwater context;
- Verification of aquifer system potential as a new water source for the city of Dar es Salaam;
- Development and application of numerical groundwater flow and transport model (fresh/saline water);
- Conclusions (observations).

Location



Map of Tanzania

- Economic engine of Tanzania
- 2nd largest port in East Africa
- Annual population growth rate ~ 6%
- Projected mega-city status 2030

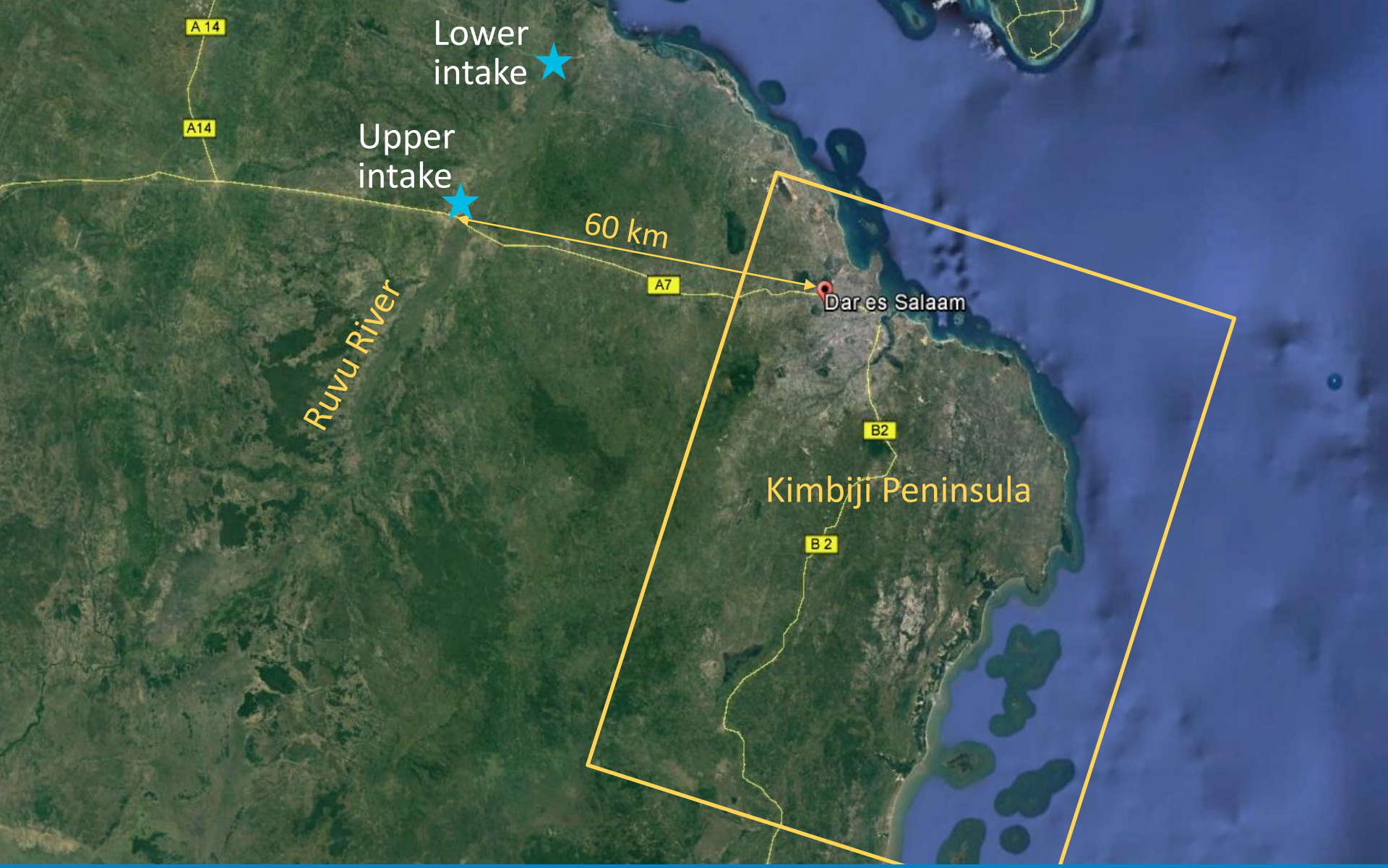
Dar es Salam

River Intake (2)

Regulated sale

Pollution

Unregulated private wells (1,000s)



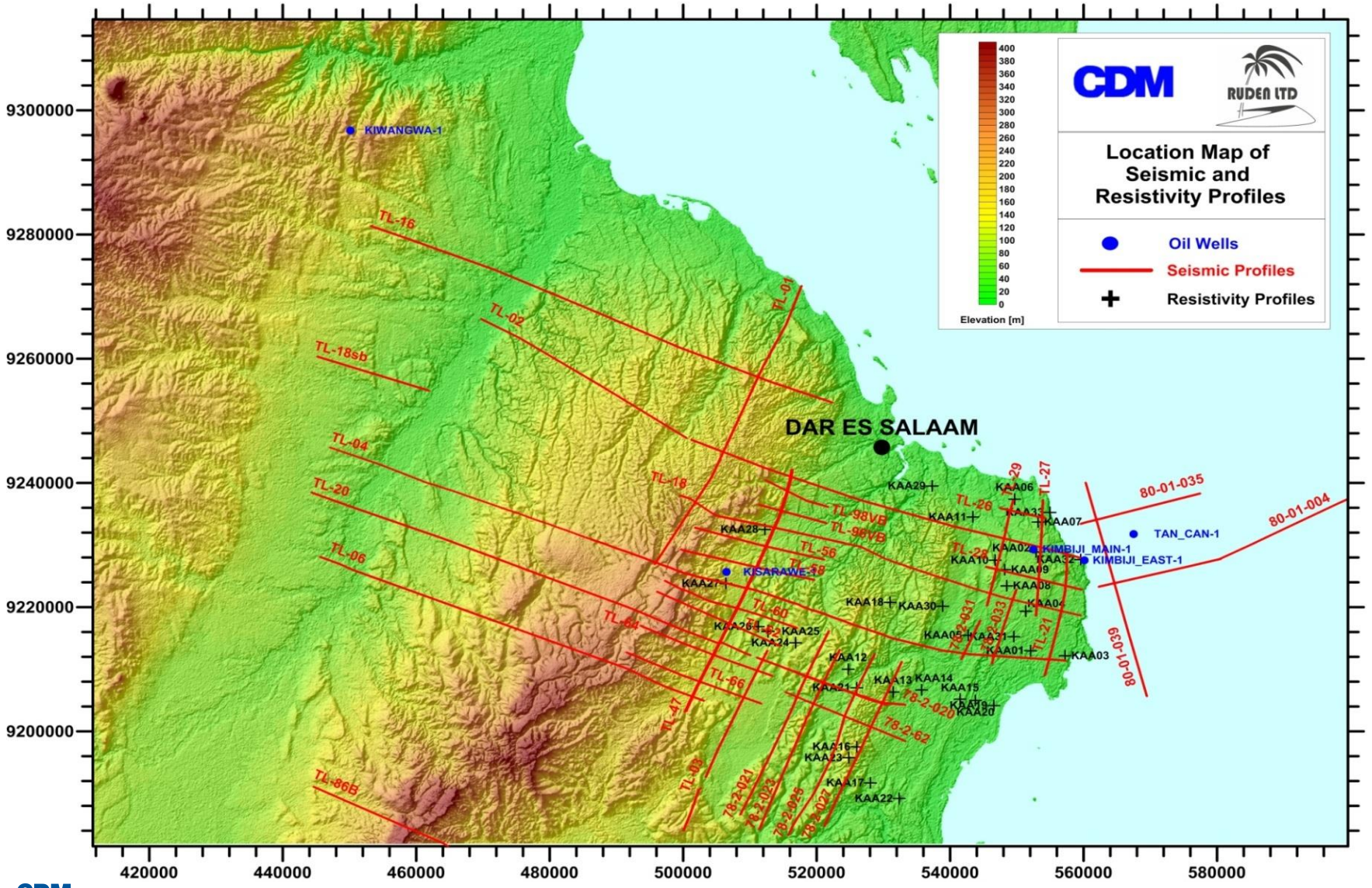
Dar es Salaam: Water Demand >> Water Supply

Kimbiji Test Well 2007

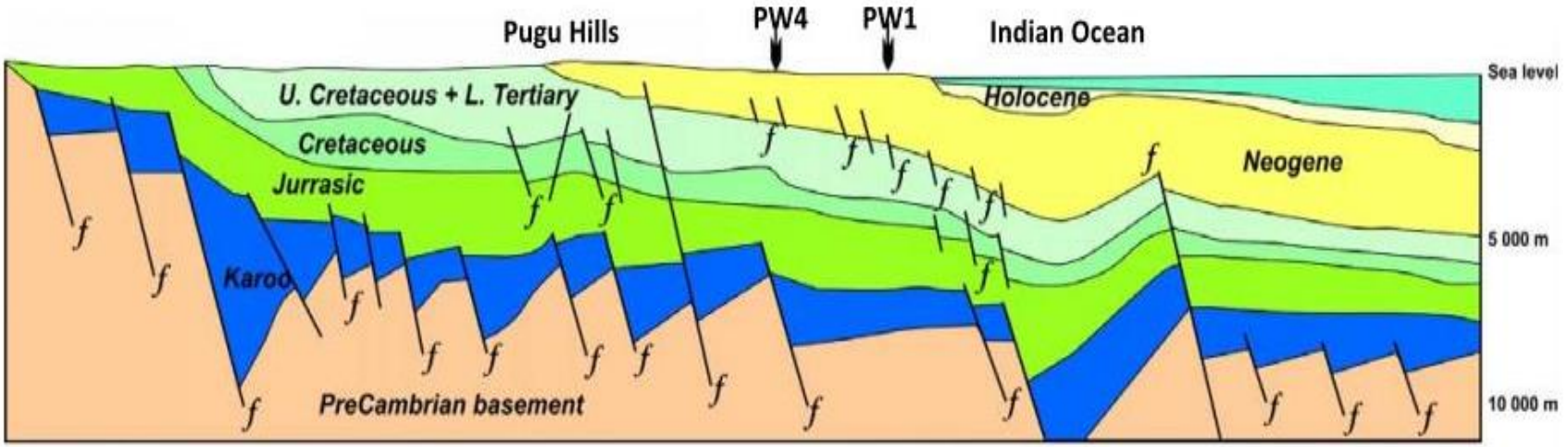
Kimbiji Aquifer Assessment Objective

"to undertake an in-depth integrated qualitative and quantitative analysis of the Kimbiji aquifer for supporting its sustainable development and management".

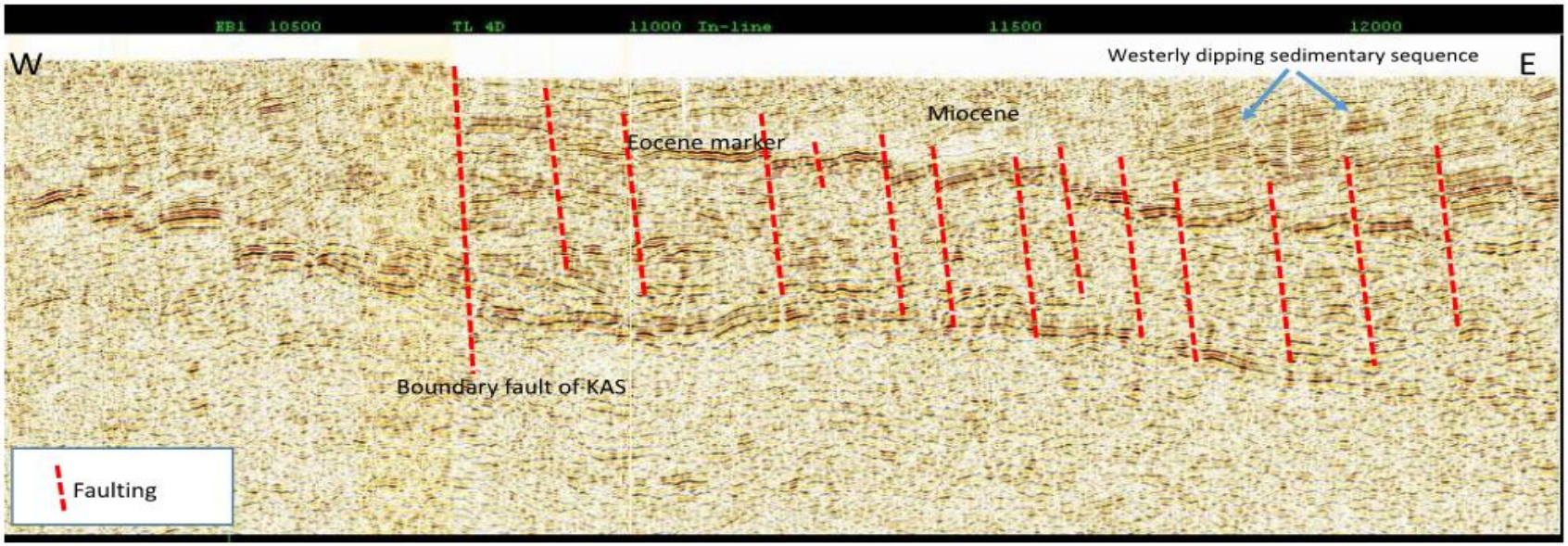
Processed 1,140 km of Seismic Survey Data; Reviewed Borehole Logs and Completion Reports



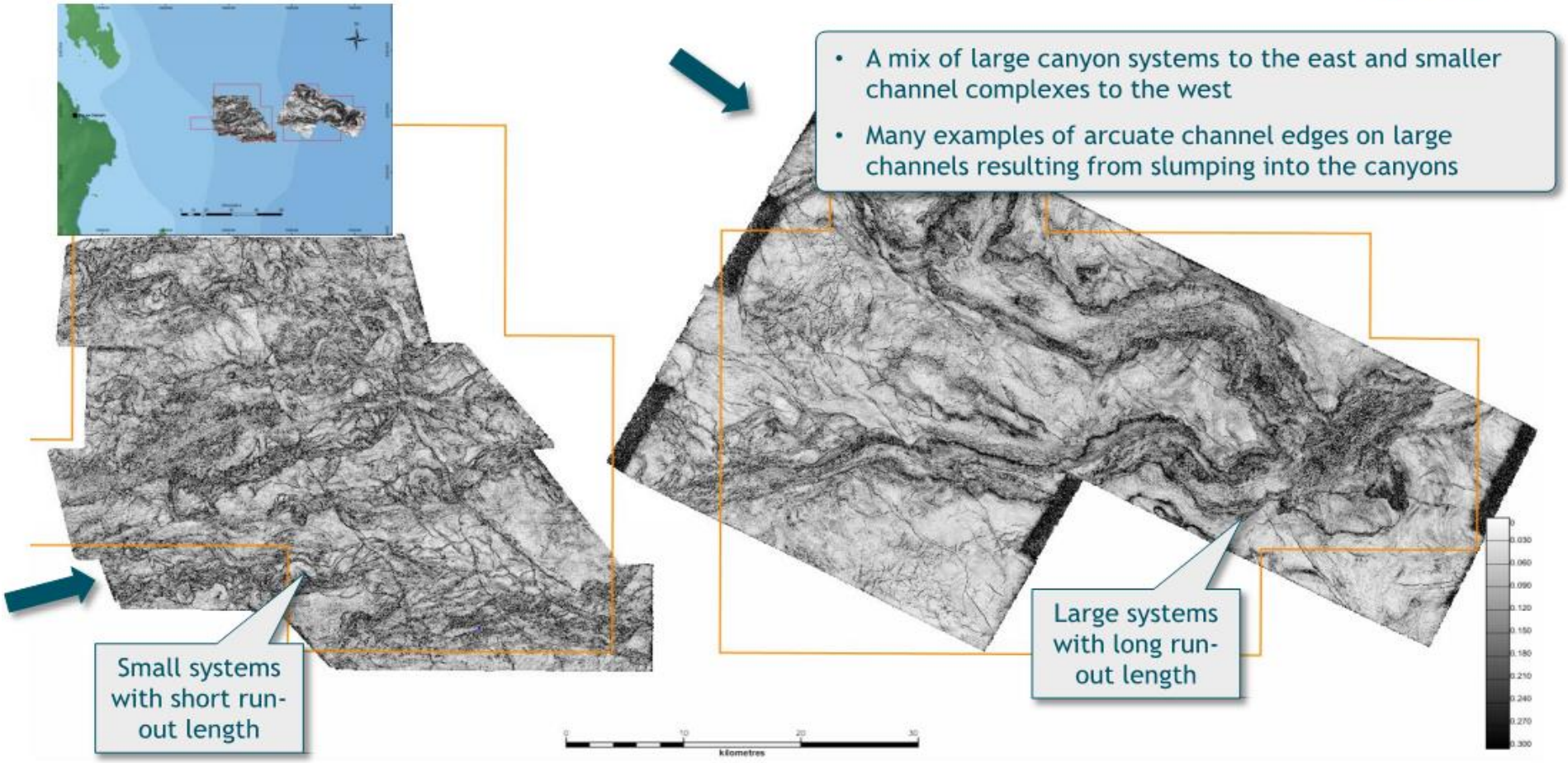
Conceptual Model



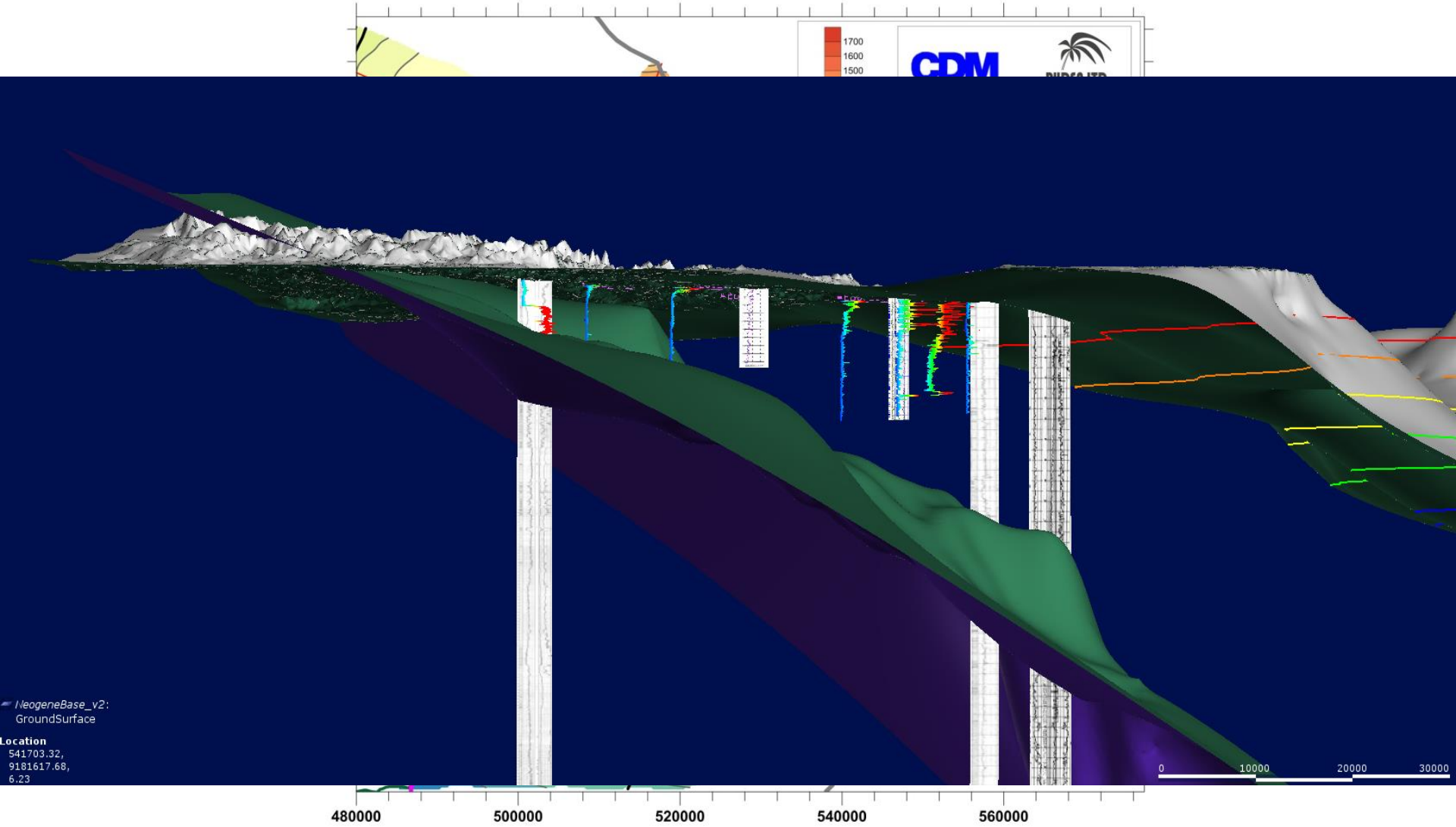
Source: TPDC



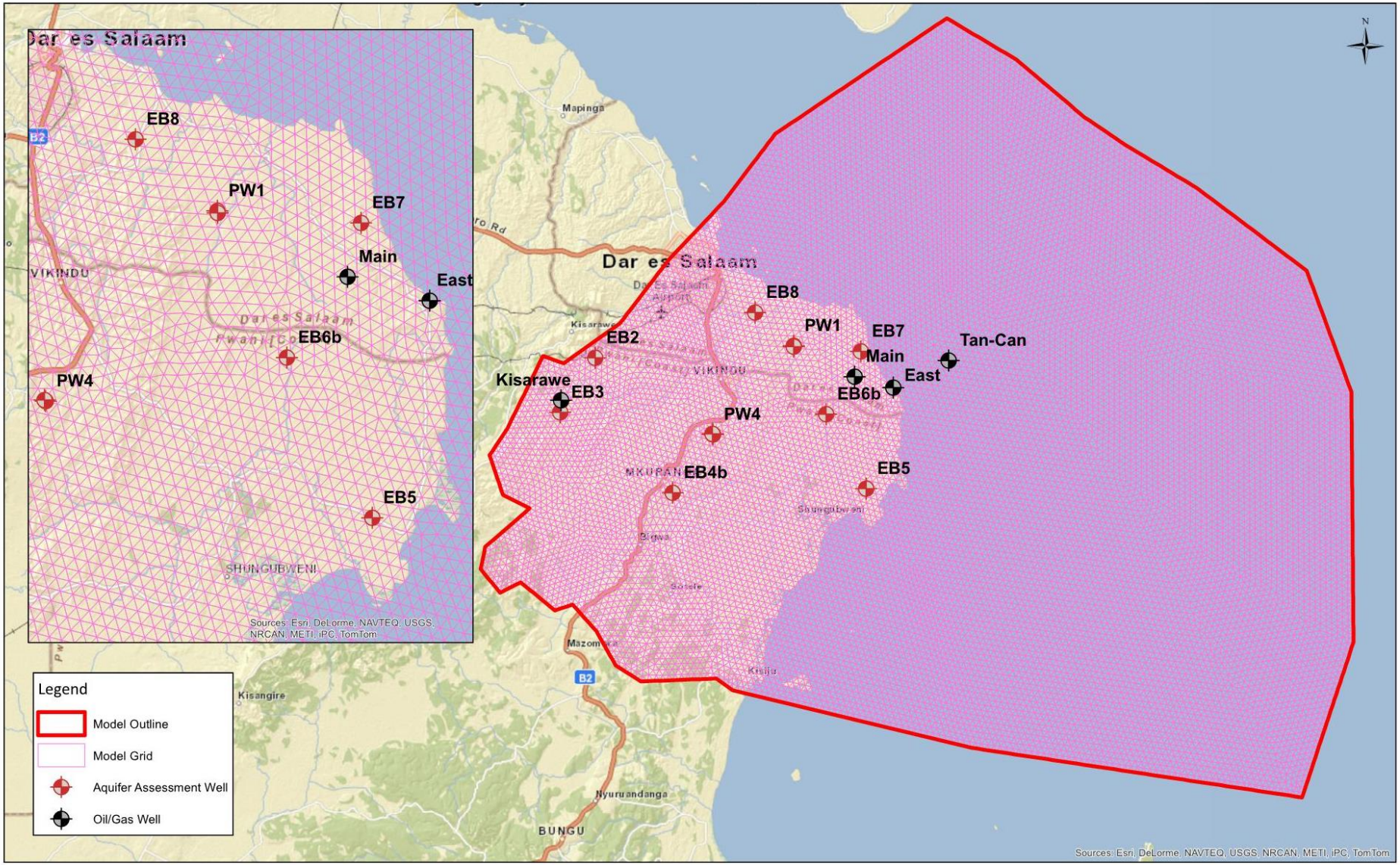
Mid Miocene Incoherence



Source: Davis, K. (2013). Deepwater Depositional Systems of Northern Tanzania



Thickness Miocene



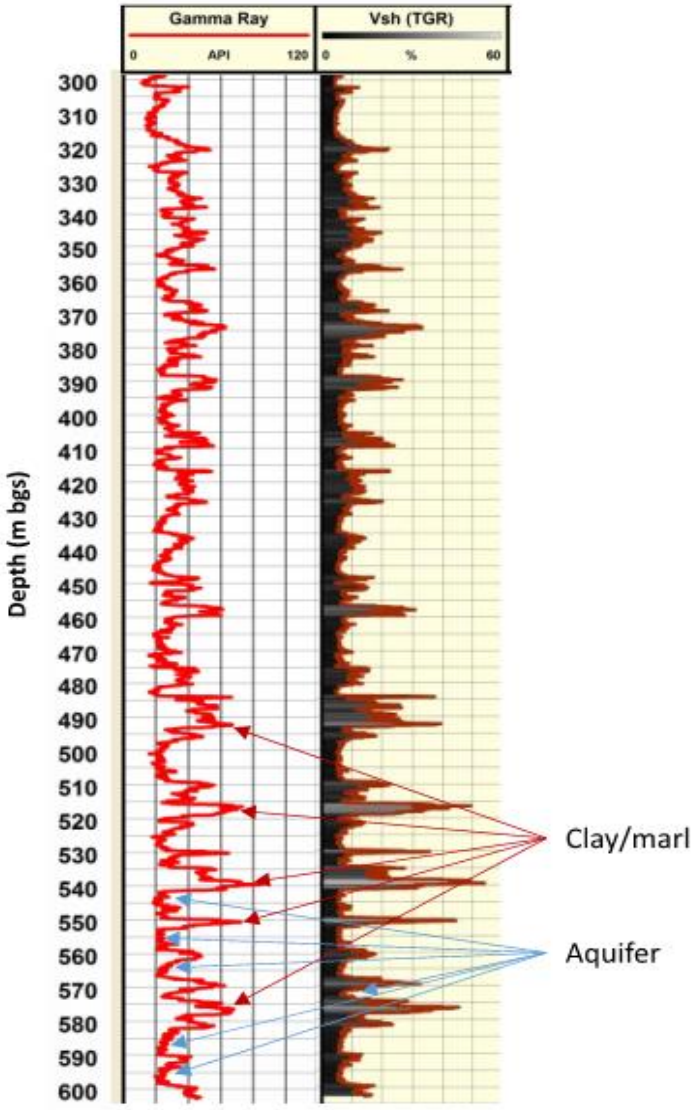
Numerical Model Domain

Reverse Circulation Drilling to 600m in 7 Exploration Boreholes

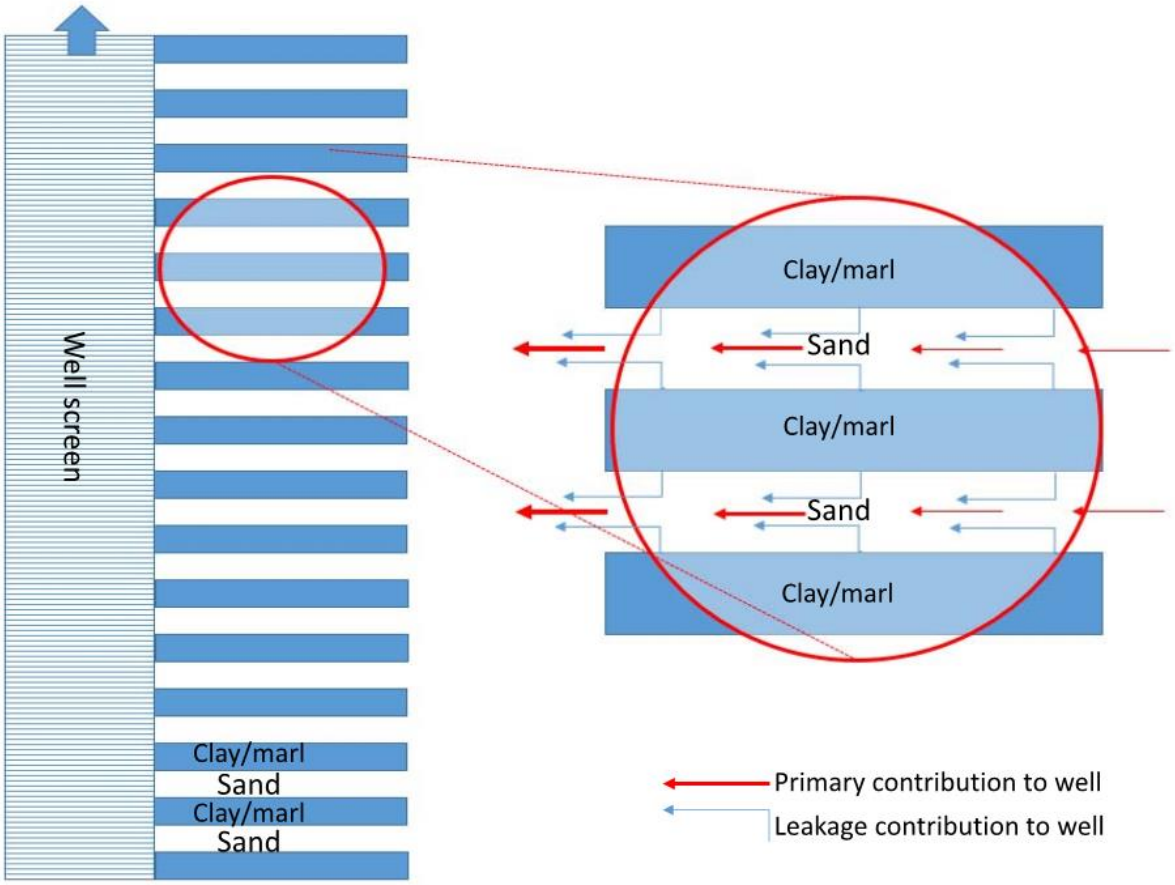
Borehole Geophysical Logging

Aquifer Testing and Sampling

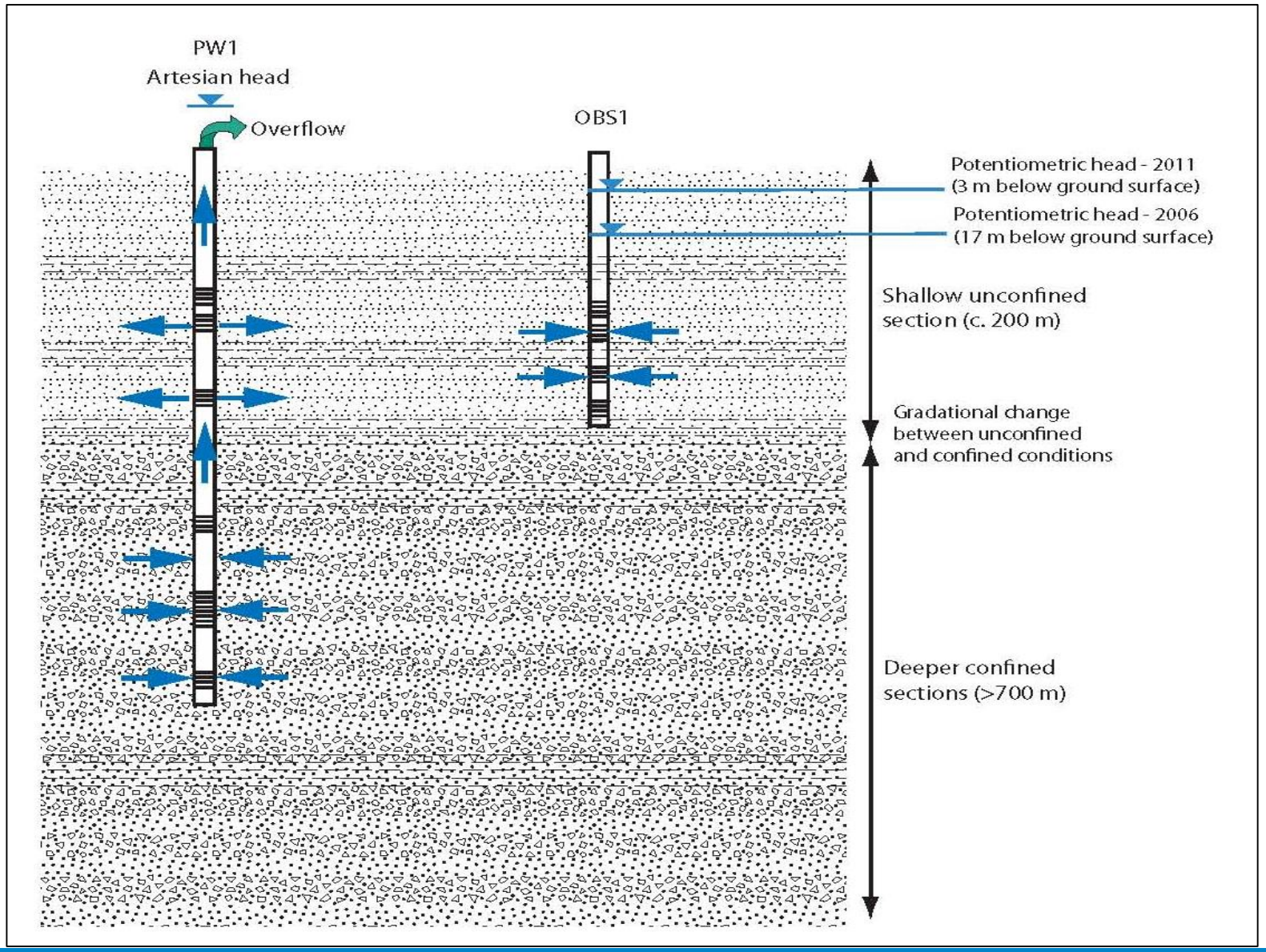
Confined, artesian aquifer system
Potable (and untapped)
Not fossil



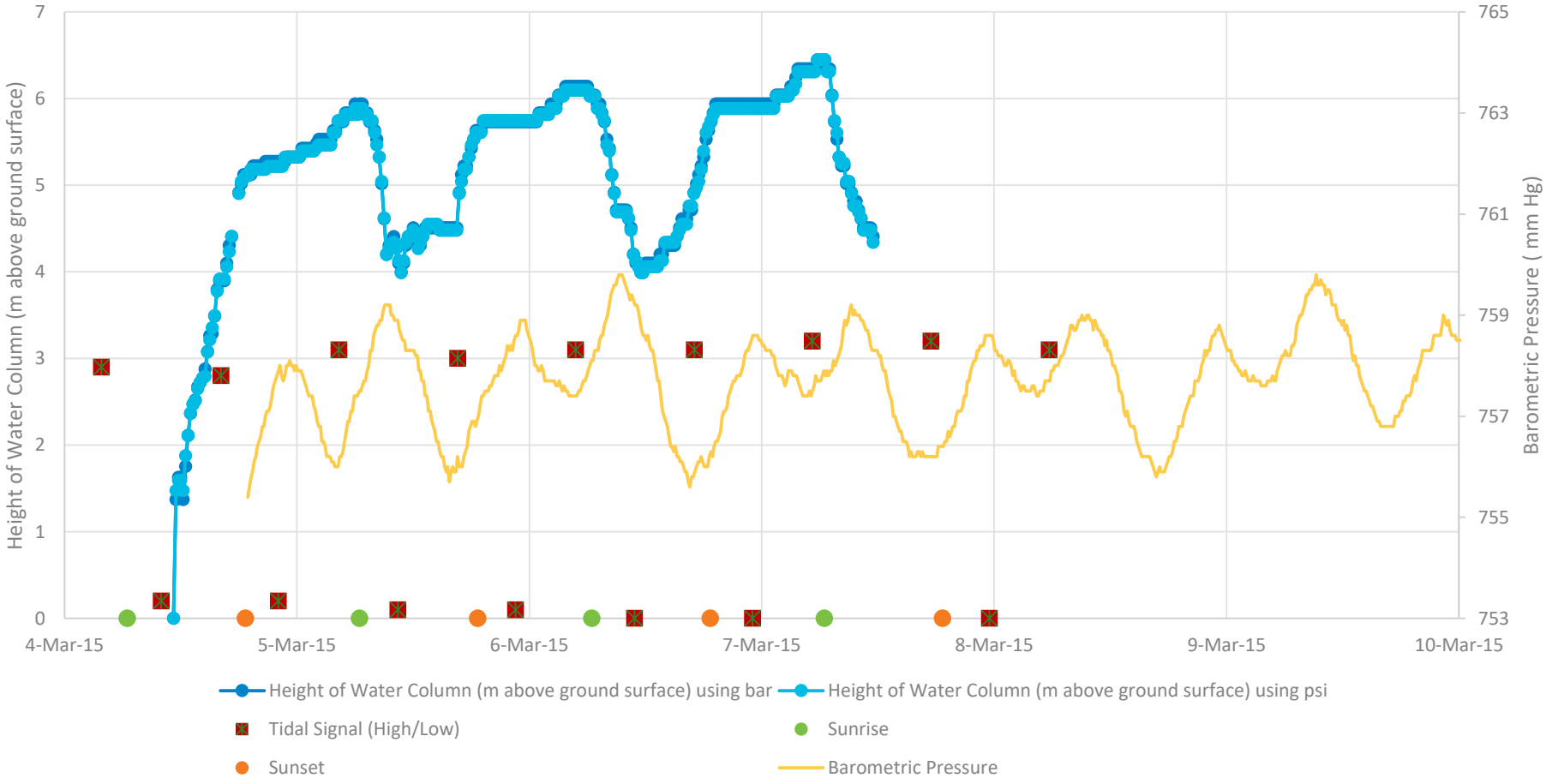
Multiple Subaquifers


Well screen
Clay/marl
Sand
Clay/marl
Sand
Clay/marl
Sand
Clay/marl
Primary contribution to well
Leakage contribution to well

Leakage



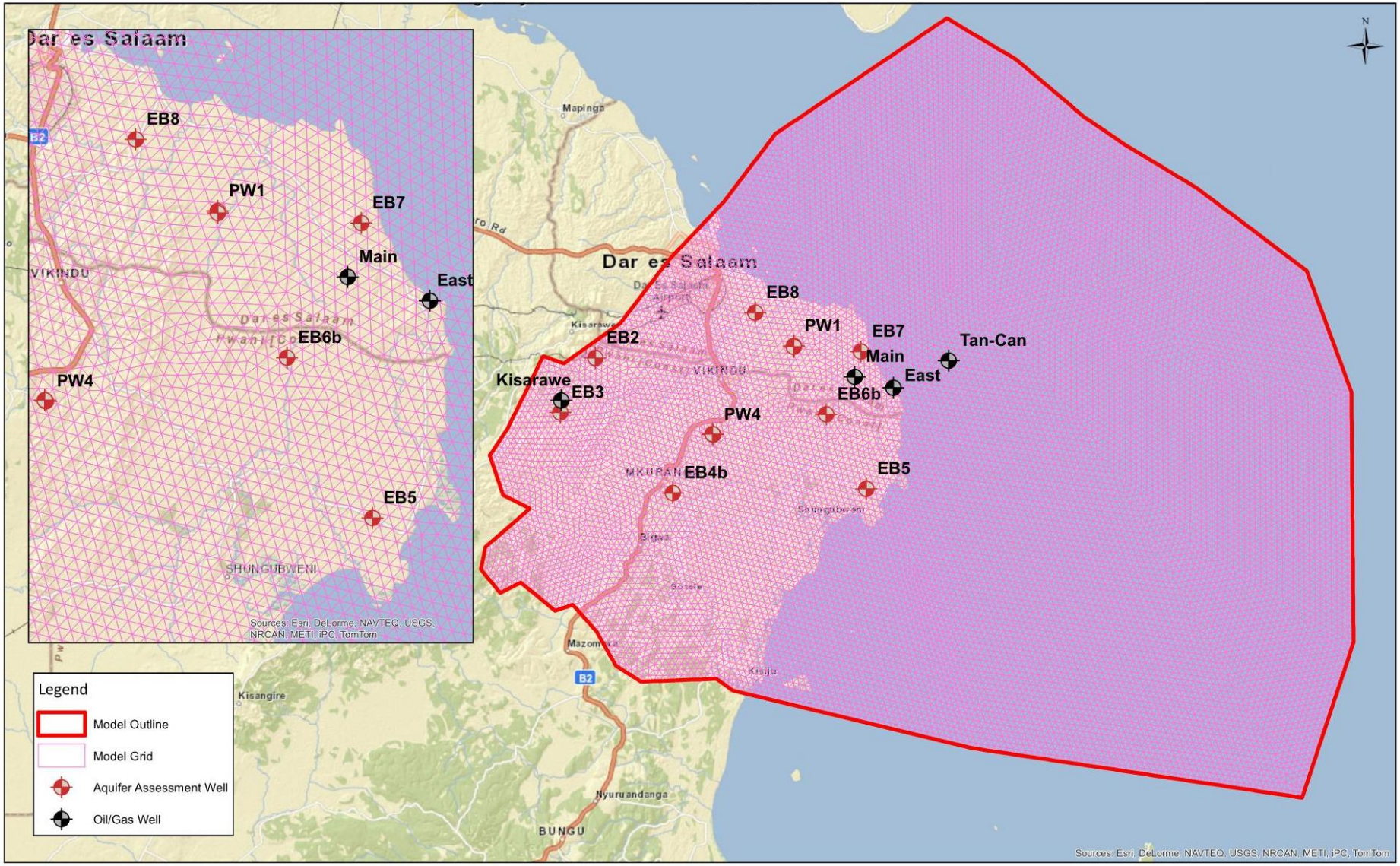
Confinement and Crossflows



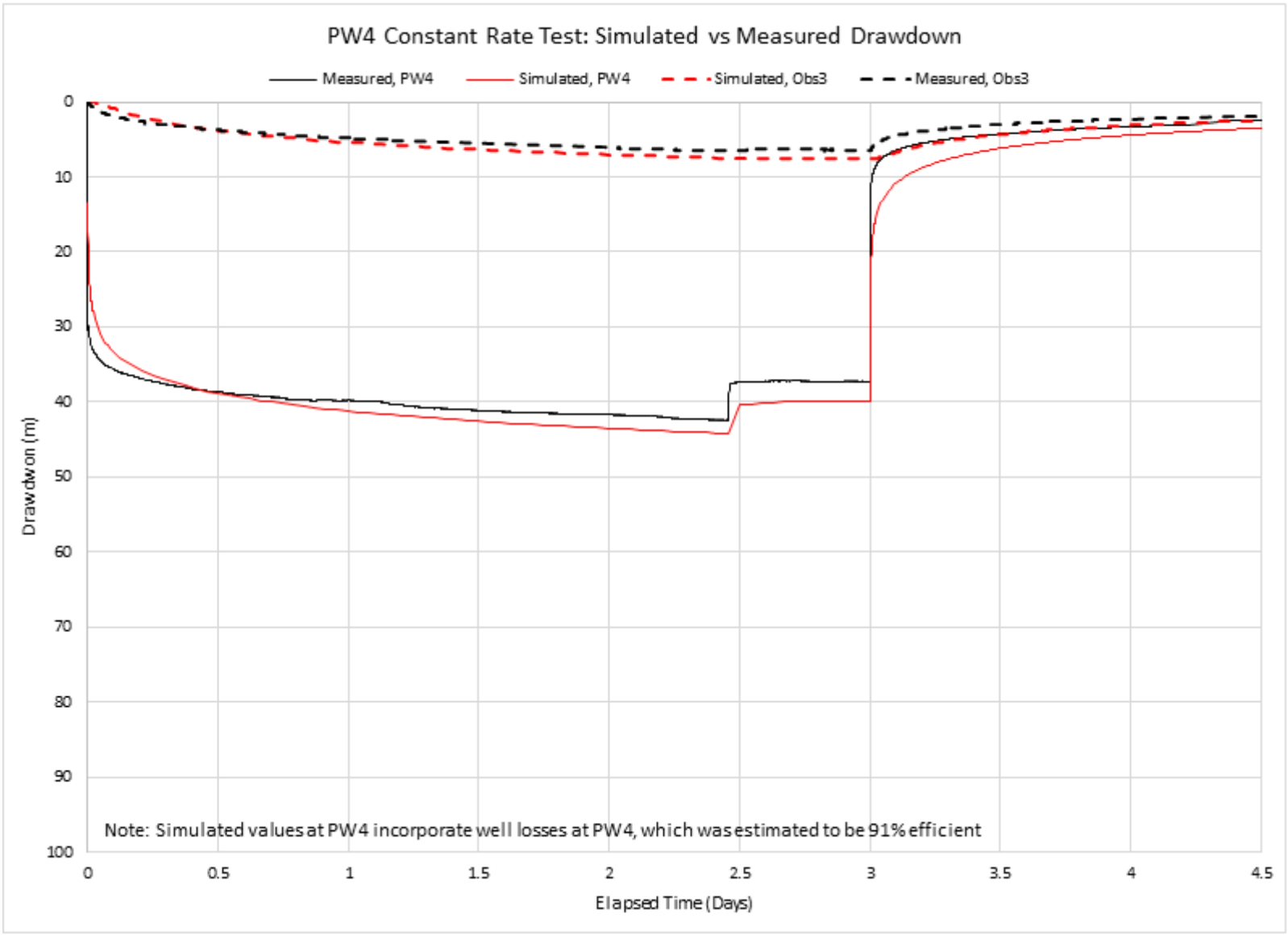
Confined Aquifer Response

Numerical Groundwater Model

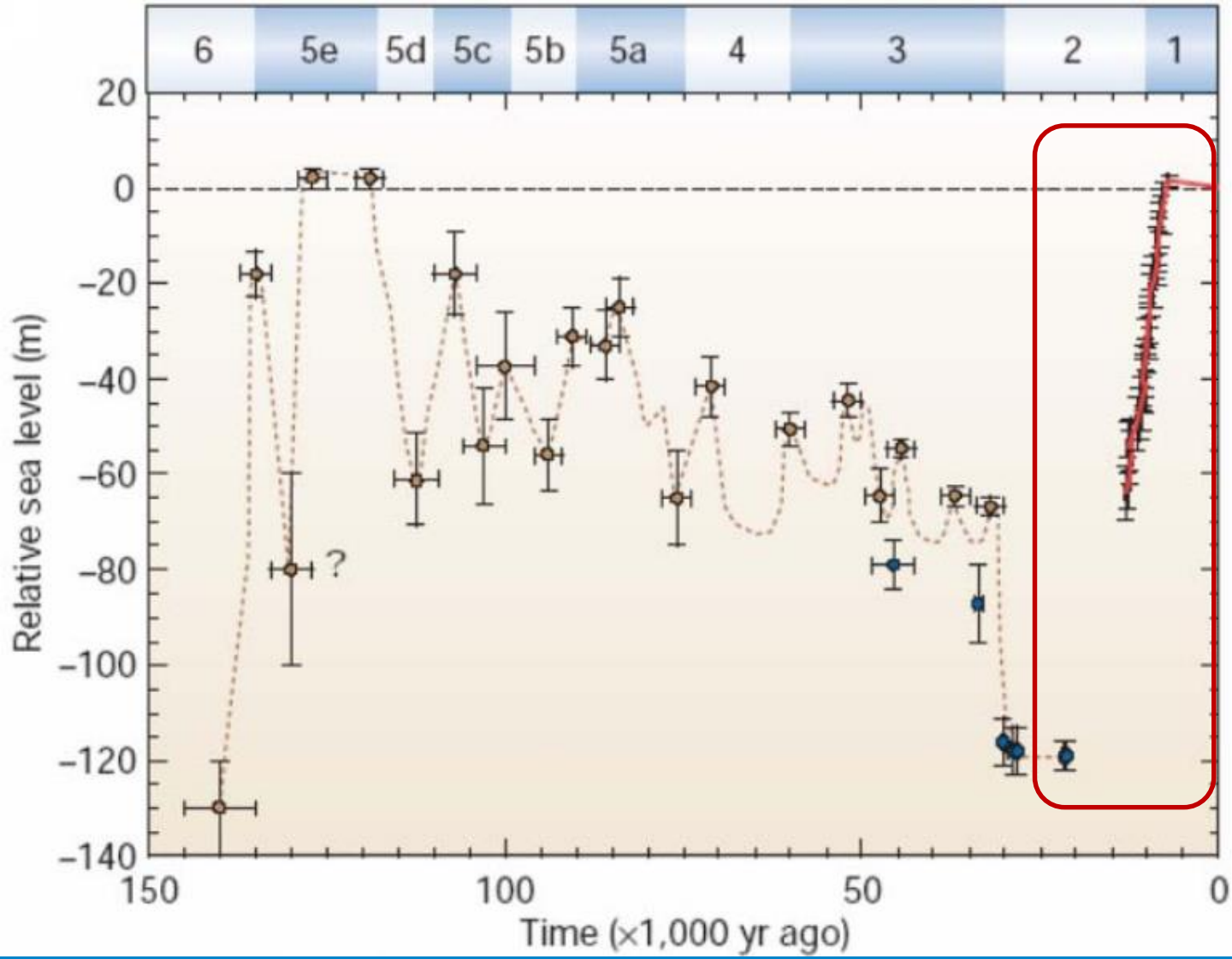
- Fully 3-Dimensional
- Simulates freshwater-saline water interaction
- Extensively documented and independently reviewed
- Calibrated model was applied as an investigation tool to support:
  - Hydrogeological characterization
  - Scientific questioning and guidance
  - Aquifer development planning
  - Strategic environmental assessment



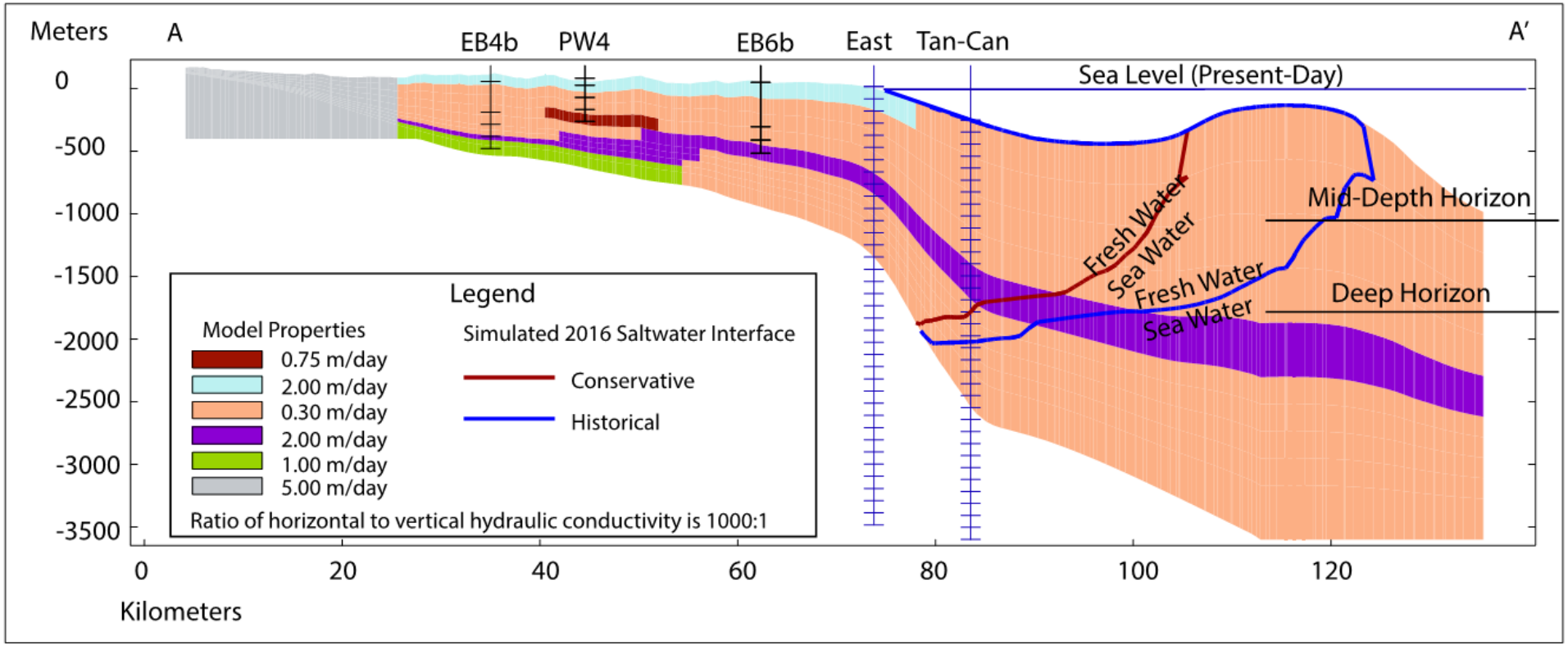
Modeling Code: DYNSYSTEM



Model Calibration - Example

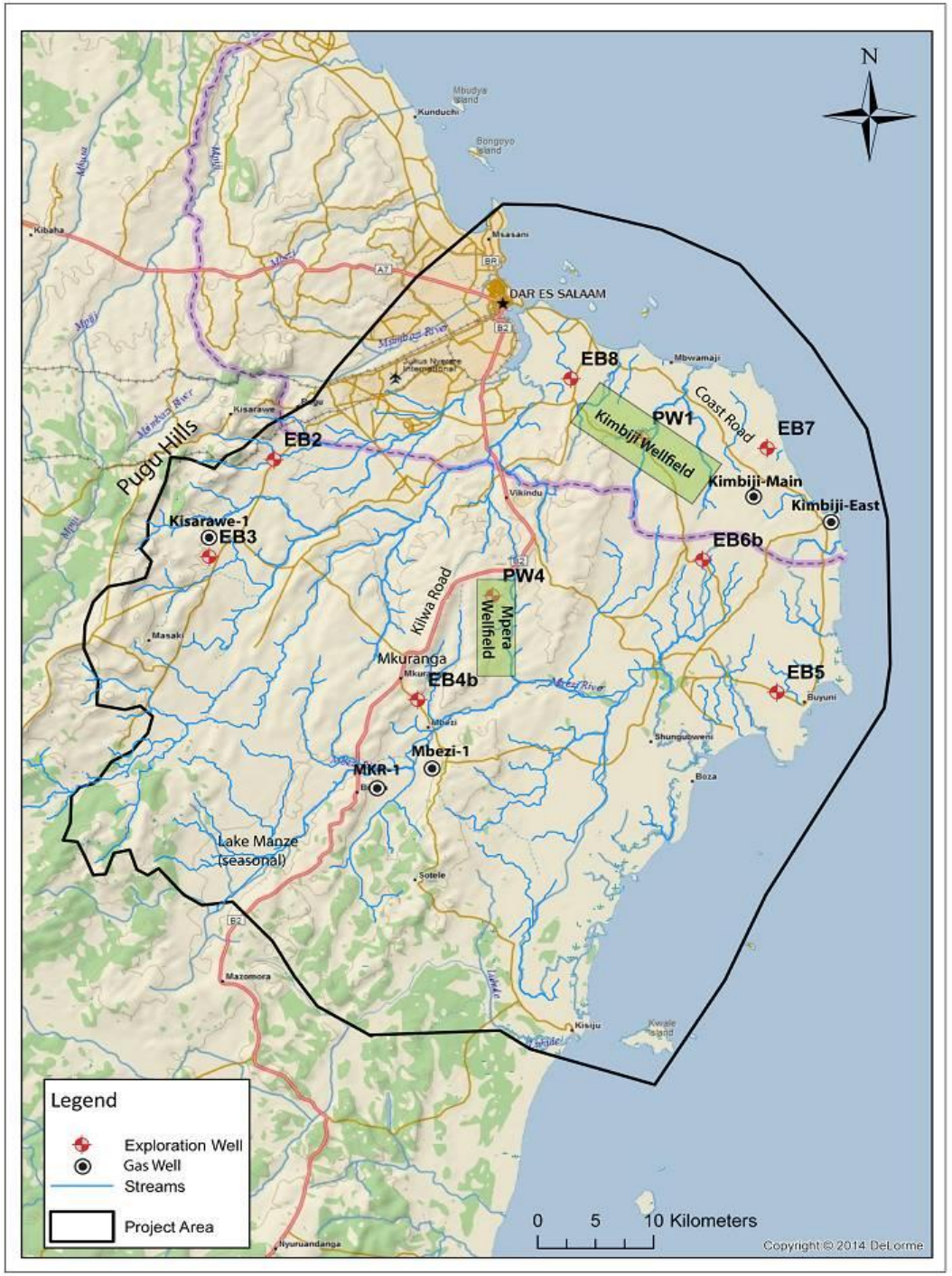


Nicholson, S.E. (1996), A review of climate dynamics and climate variability in eastern Africa, in The Limnology, Climatology and Paleoclimatology of the East African Lakes, edited by T. C. Johnson and E. O.Odada, pp. 25–56, Gordon and Breach, Amsterdam.

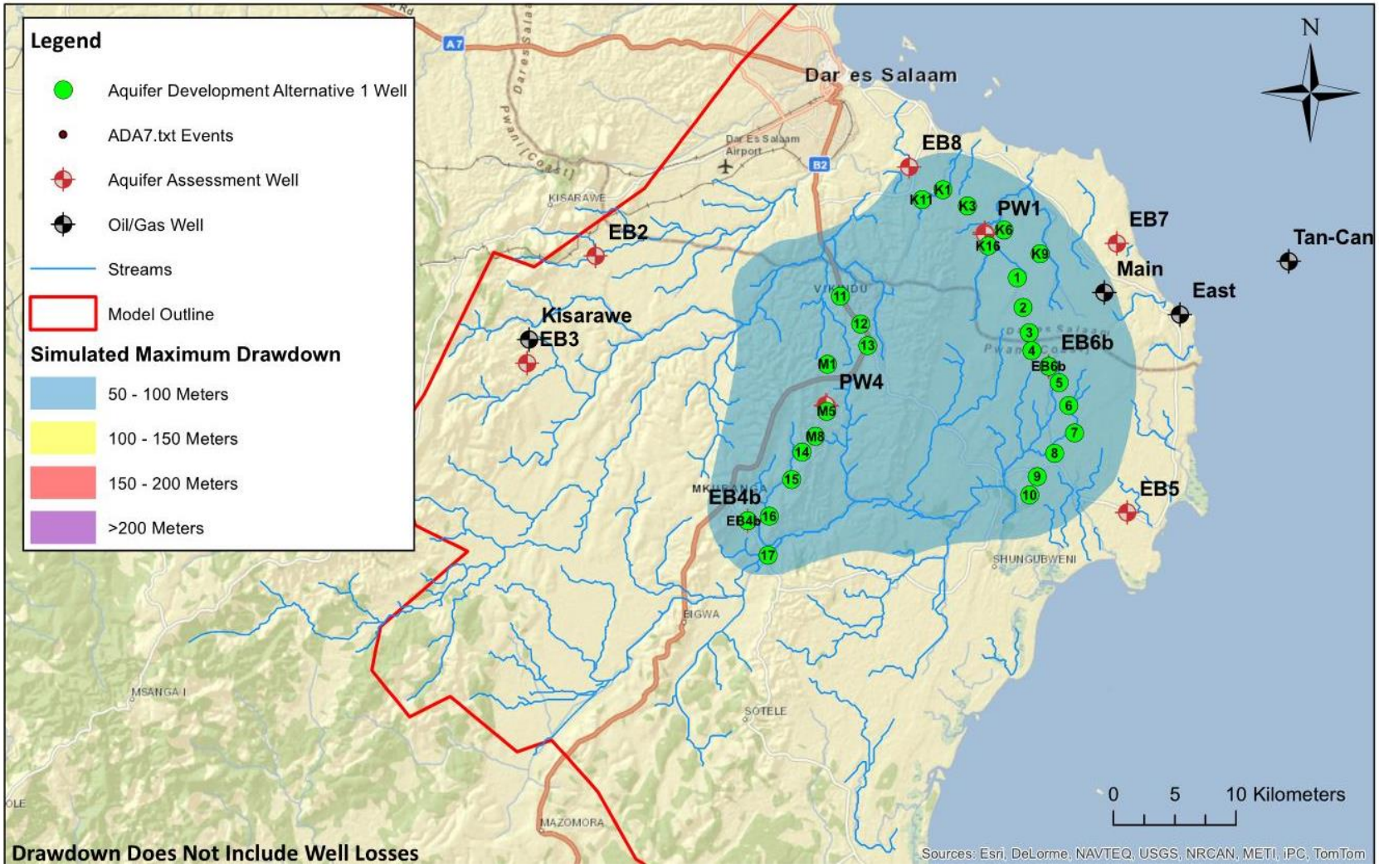


Saline Groundwater Position

Wellfield Development

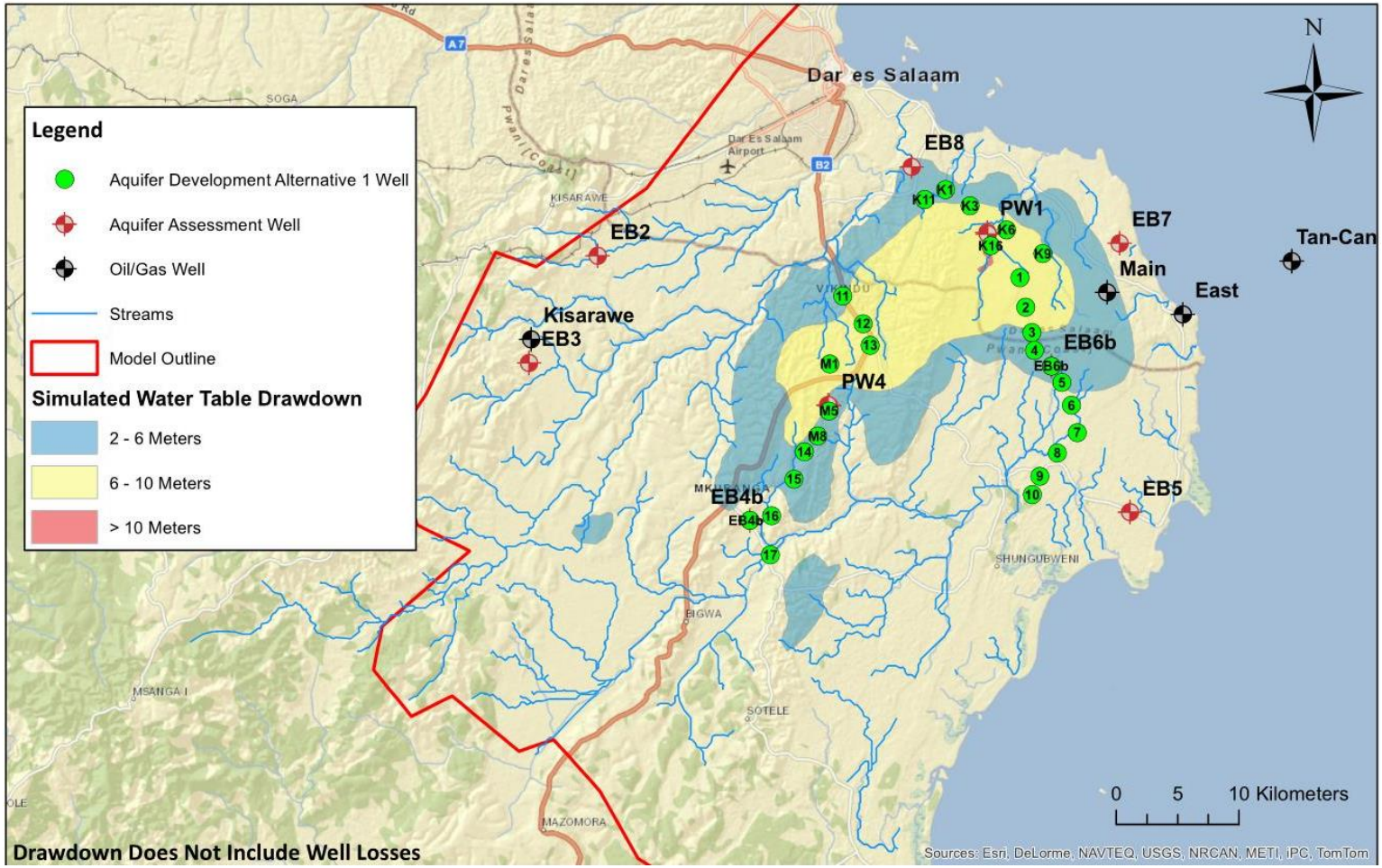


Extended Wellfield – max. drawdown @ 100 years



Simulated Maximum Drawdown, Aquifer Development Alternative 1, 200,000 m³/day

Extended Wellfield – drawdown at water table @ 100 years



Simulated Water Table Drawdown, Aquifer Development Alternative 1, 200,000 m³/day

Conclusions (Observations)

- Benefits and challenges: bridging the oil and water sectors
- Oil/water – “deep/shallow”
- Hydrogeological discoveries are yet to be made
- 3D numerical model was invaluable (at relatively low cost):
  - Framing of questions and focusing recommendations
  - Explaining how the system works to client and funders (also helped explain concepts of wellhead protection)
- Sharp interface modeling is appropriate for regional-scale models

Thank you!

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