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

AfWA 2020
Kampala - Uganda
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
Regulated sale

Pollution

River Intake (2)

Unregulated private wells (1,000s)

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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
Mid Miocene Incoherence

- A mix of large canyon systems to the east and smaller channel complexes to the west
- Many examples of arcuate channel edges on large channels resulting from slumping into the canyons

Source: Davis, K. (2013). Deepwater Depositional Systems of Northern Tanzania
Thick War Miocene
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
Leakage

- Primary contribution to well
- Leakage contribution to well
Confinement and Crossflows
Confined Aquifer Response

Height of Water Column (m above ground surface) using bar
Height of Water Column (m above ground surface) using psi
Tidal Signal (High/Low)
Sunrise
Sunset
Barometric Pressure
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
PW4 Constant Rate Test: Simulated vs Measured Drawdown

Note: Simulated values at PW4 incorporate well losses at PW4, which was estimated to be 91% efficient.
Saline Groundwater Position

Legend

Model Properties
- 0.75 m/day
- 2.00 m/day
- 0.30 m/day
- 2.00 m/day
- 1.00 m/day
- 5.00 m/day

Simulated 2016 Saltwater Interface
- Conservative
- Historical

Ratio of horizontal to vertical hydraulic conductivity is 1000:1
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!