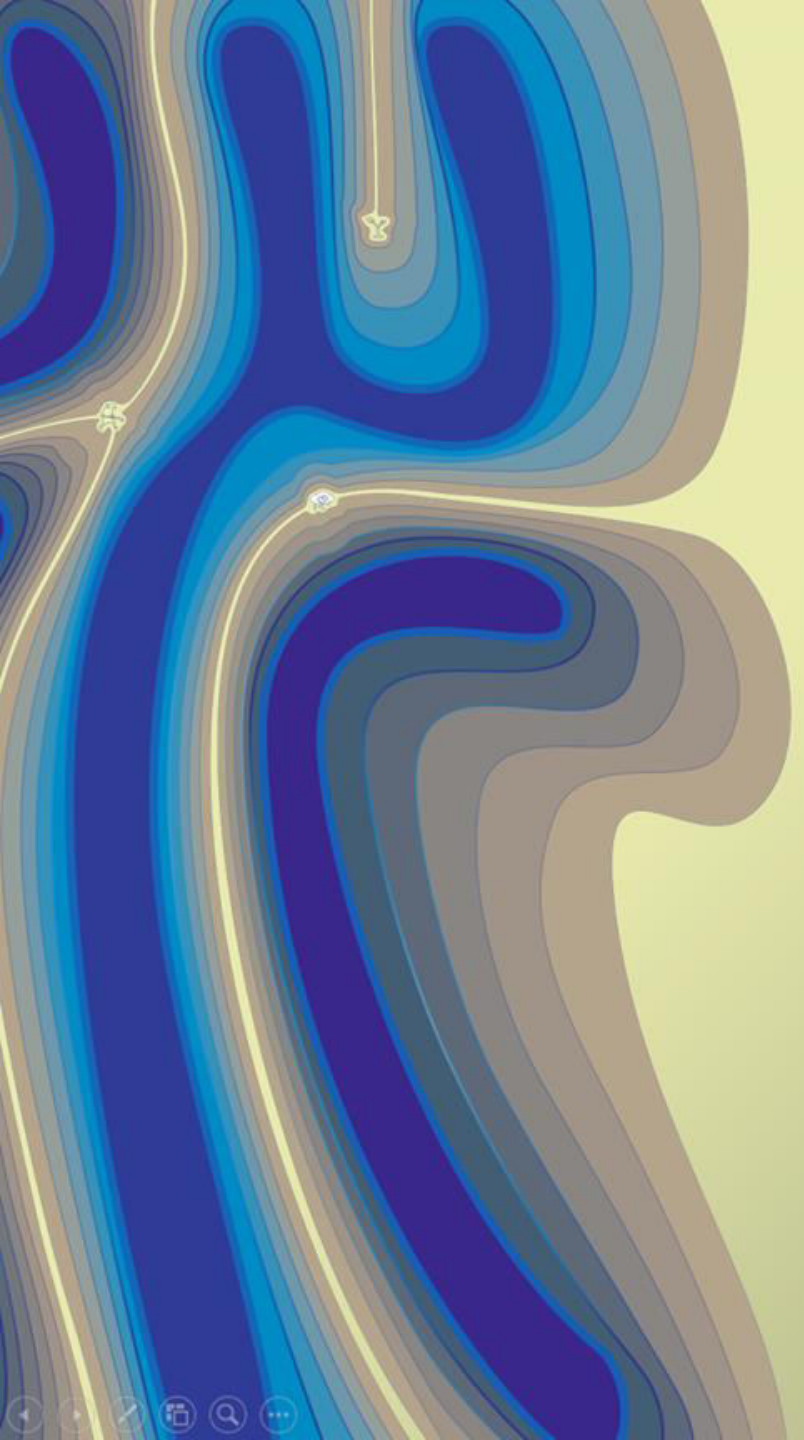

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Groundwater Modeling Of Alluvial Aquifers at Wadi Bani Kharus Catchment in Oman

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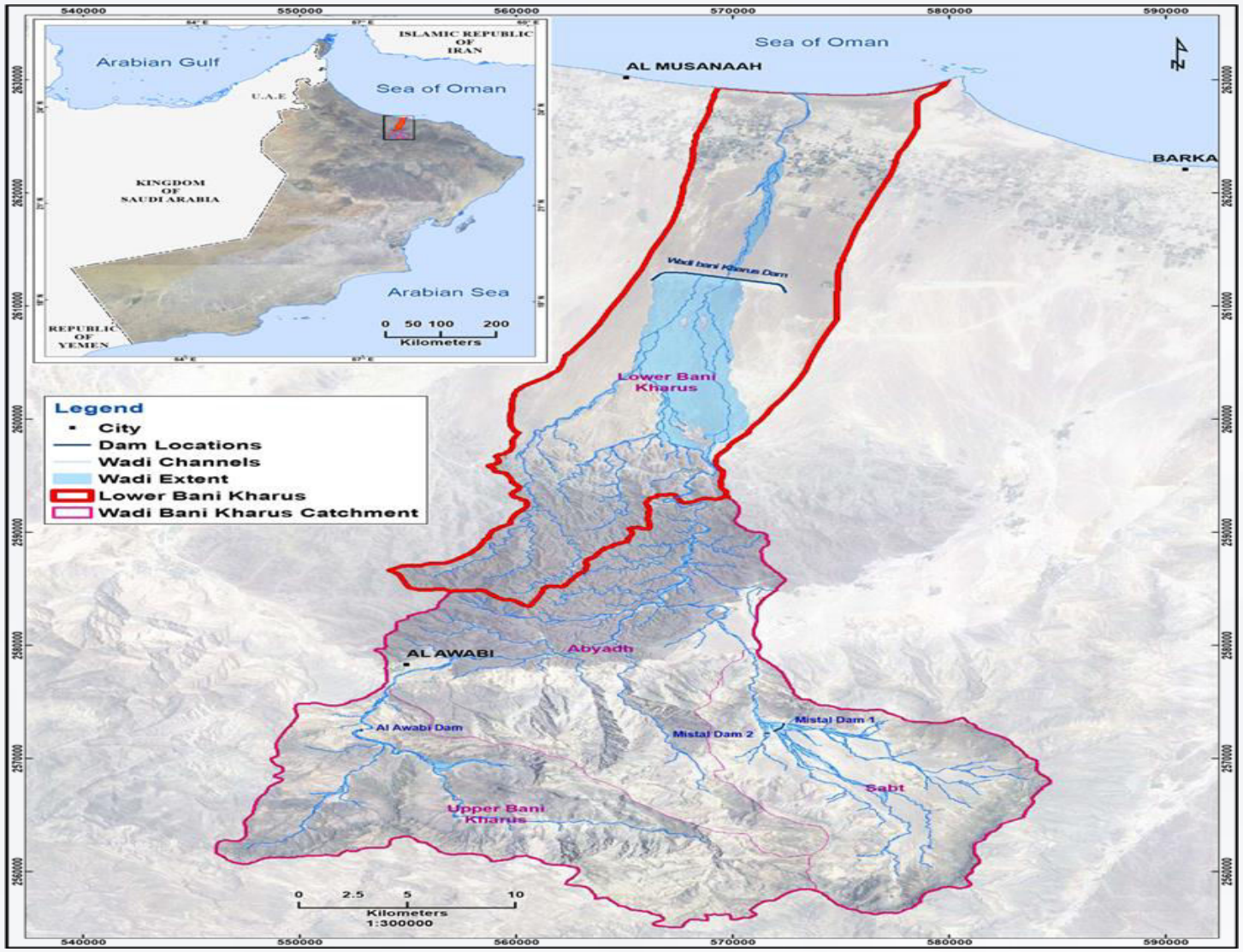
Introduction and background

- Oman is located northeast of the Arabian Banasura Within a semi-arid climatic range and high humidity and population is about four million.
- Oman suffers from a shortage of groundwater with an average annual deficiency of 365 million m3 per year.
- The study area is located at south Batinah coastal plain northern part of the Sultanate of Oman at lower Wadi Bani kharus catchment.
- Agriculture sector has the lion share on water abstraction, constitutes 84% of the total water use.
- Apply groundwater flow water balance modeling (GMS) for alluvial Aquifers of Wadi Bani Kharus Catchment.

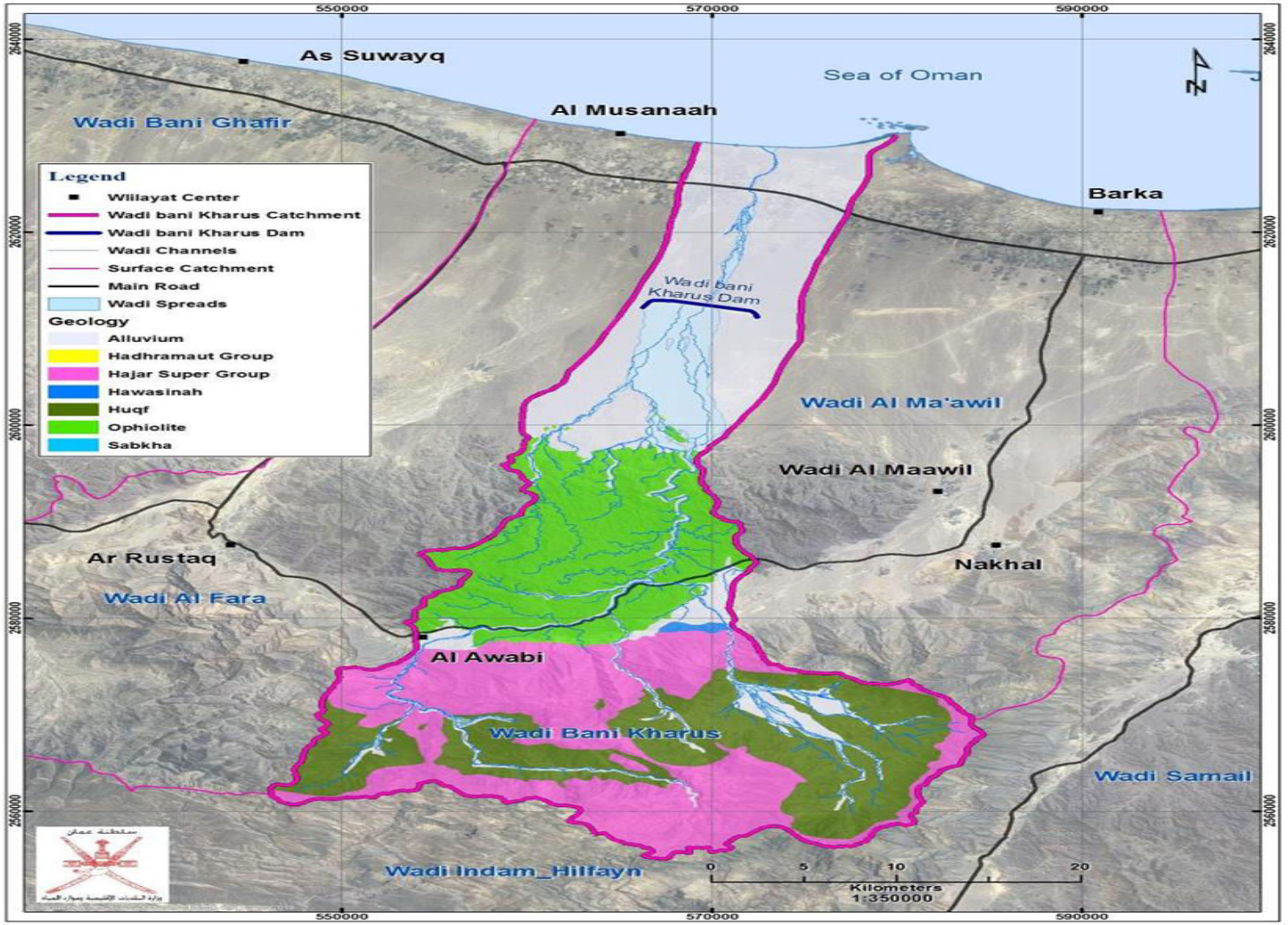
Study area

- The area is a flat land connected to the sea and bordered on the north by the mountains towering (upper).
- The groundwater within the Wadi Bani Kharus catchment faced drought which has been reflected in the groundwater levels in the area.
- An extensive use of groundwater and expansion of agriculture at the study area.



Geology of Area

- Geology of the study area mainly consists of Tertiary to Quaternary alluvial deposits.
- Groundwater aquifers at the study area are divided into two main Layer:
- layer-1: quaternary recent alluvium of clean sand and gravel cemented in places.
- Layer-2: ancient alluvium; a conglomerate with sandy and clayey matrix -Miocene to Pliocene age.



Conceptual model

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Model Chart

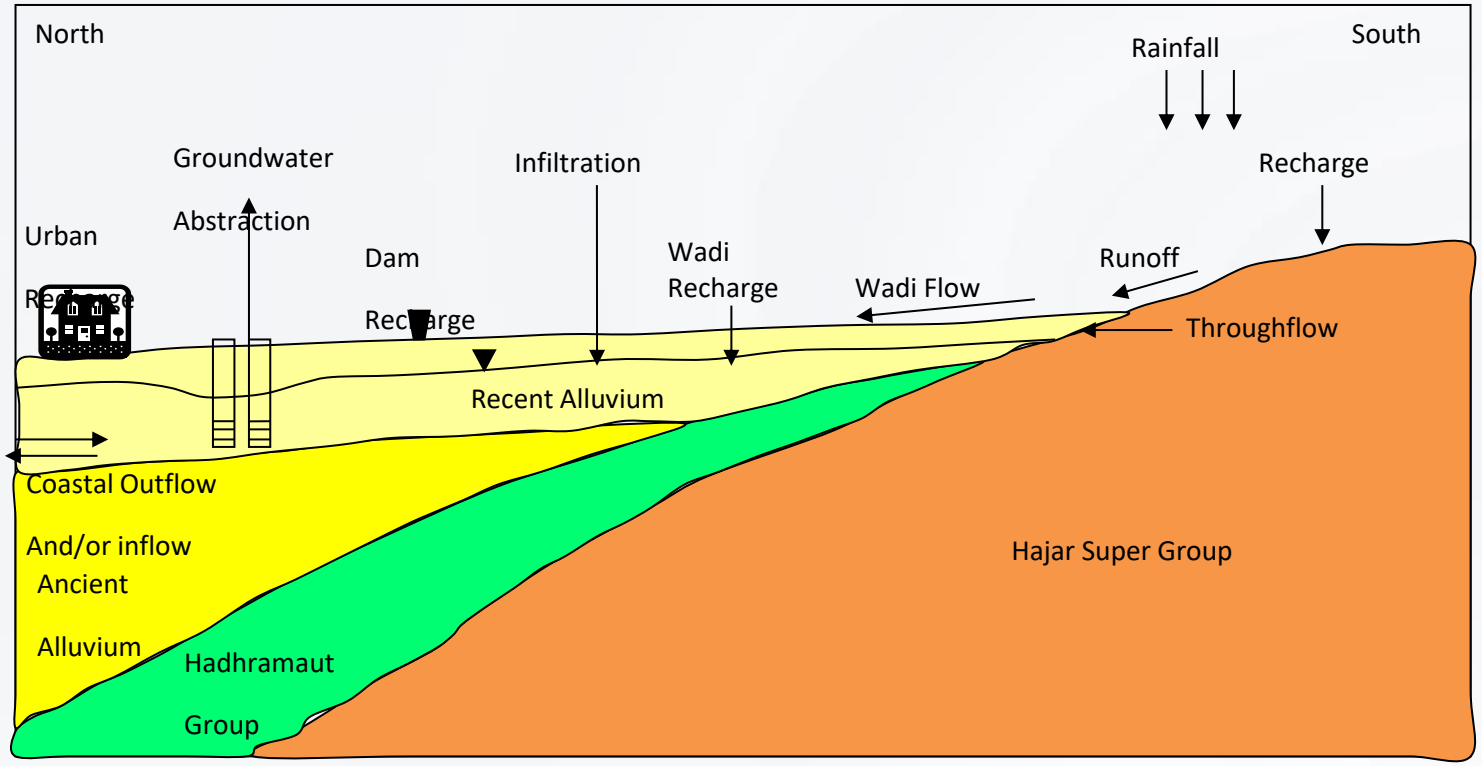
Literature Review & groundwater sampling Data

Input files:
-Boundary conditions
-Recharge
-DEM
-Boreholes cross-section logs from (12) wells.
-Discharge rate from (100) wells.
-Water levels from (15) wells.
-Hydraulic conductivity, Specific storage.
-Specific Yield
- porosity

GMS- MOD FLOW Model
(flow equation based on water balance)

Calibration

-Groundwater flow balance (Inflow + outflow)
-Groundwater flow directions



Hydraulic parameters

Hydrogeologists define the parameters of groundwater aquifer as follows:

- Hydraulic conductivity (K) m/s: physical parameter reflects the relative ease of liquid flow through porous media of the aquifer.
- Specific yield: Ratio of the volume of water that drains from a saturated aquifer to the total volume of the aquifer.
- Specific storage: volume of water that a unit volume of aquifer releases from storage under a unit decline in the head.

Aquifer parameters

Aquifer	Hydraulic conductivity (m/day)	Specific storage	Specific yield
Upper alluvium	5 - 30	0.01	0.01-0.2
Lower alluvium	0.5 - 5	0.001	0.08

Model Build & Equation

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Model Build

- In this study a **pre-and post-processor (GMS)** is used to interface with **MODFLOW** used to evaluate the recent alluvium and ancient alluvium aquifer system of Lower Wadi Bani Kharus catchment.
- The model has been constructed with a rectangular grid system (UTM WGS 1984, zone 40N) and it covers an area of 647 km^2
- Groundwater flow models were developed based on Darcey' s low and low mass conversation.

Model Equation

- The equation of three-dimensional flow of groundwater at porous media has been formulated as follows:
- $\frac{\partial}{\partial x}\left[Kxx\,\frac{\partial h}{\partial x}\right]+\frac{\partial}{\partial y}\left[Kyy\,\frac{\partial h}{\partial y}\right]+\frac{\partial}{\partial z}\left[Kzz\,\frac{\partial h}{\partial z}\right]-W=S_S\frac{\partial h}{\partial t}$
- Kxx, ,Kyy and Kzz are the hydraulic conductivity of groundwater at x, y, and z directions.
- Discharge per unit volume (w), S_s is the specific storage, t is time and h is the hydraulic head.

Boundary Conditions

- Boundary conditions represent locations in the model where water flows into or out of the model region due to external hydrology factors.
- Specific or fixed head located along with Oman sea and the value is zero.
- The water flows into the groundwater from a high gradient level at the upper catchment toward the sea.
- Since the area is divided into catchments there are no flow boundaries of water from both sides.
- The model calibration period was from Jan 1994 to December 2008 and the validation was from January 2009 to December 2014.

Model output

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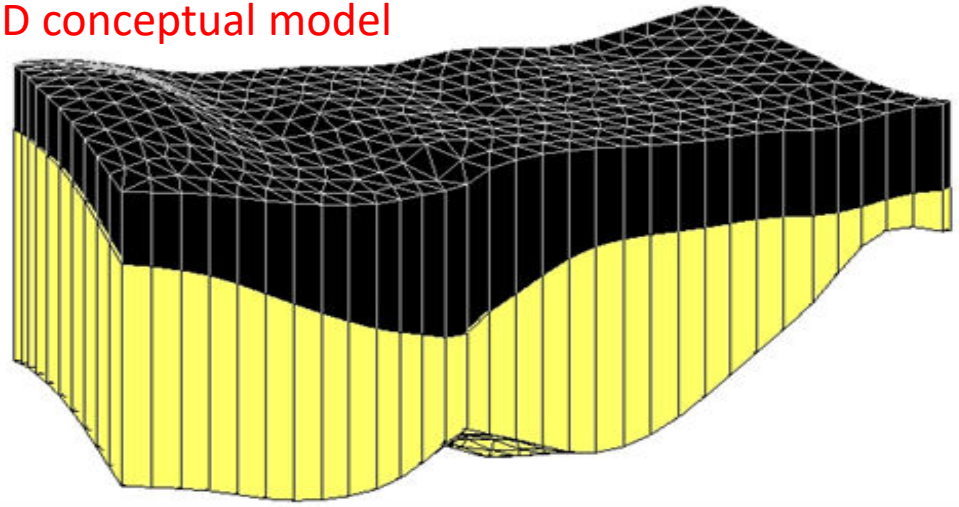
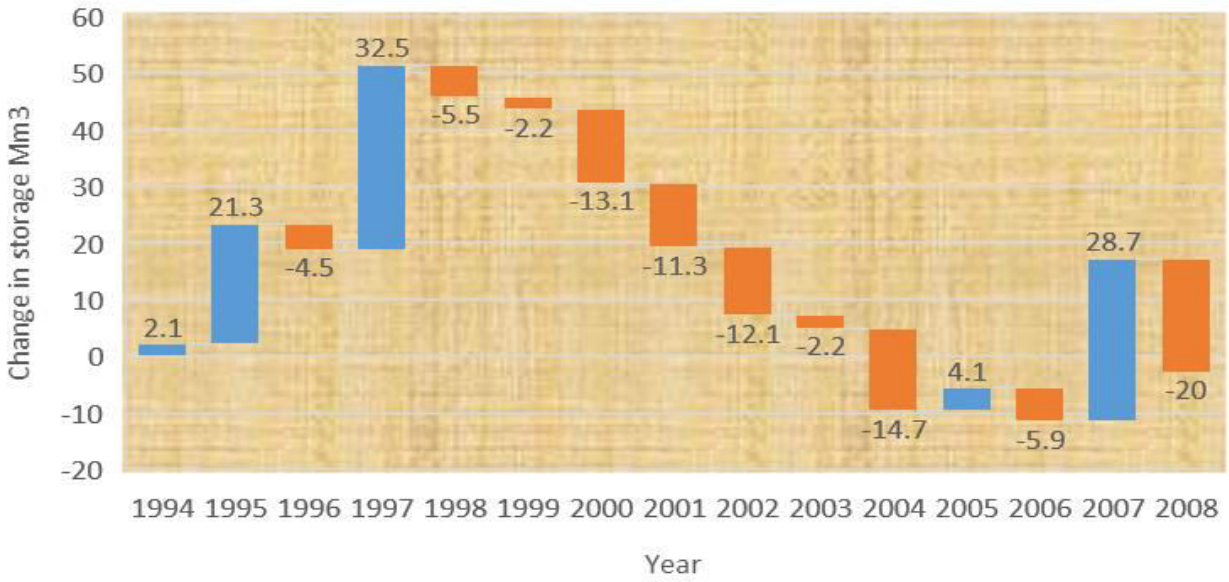
Borehole logs

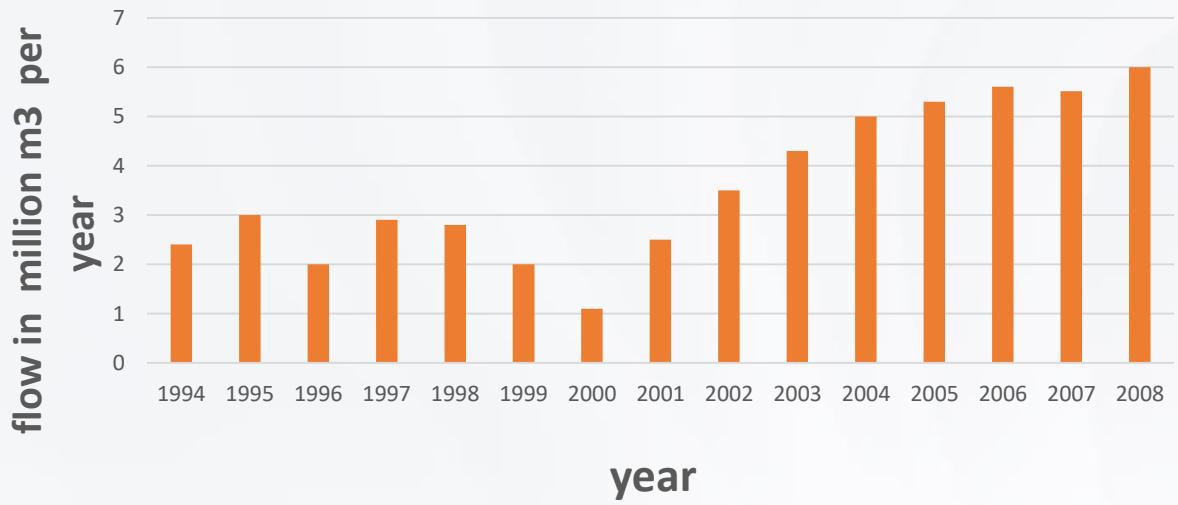
3D conceptual model



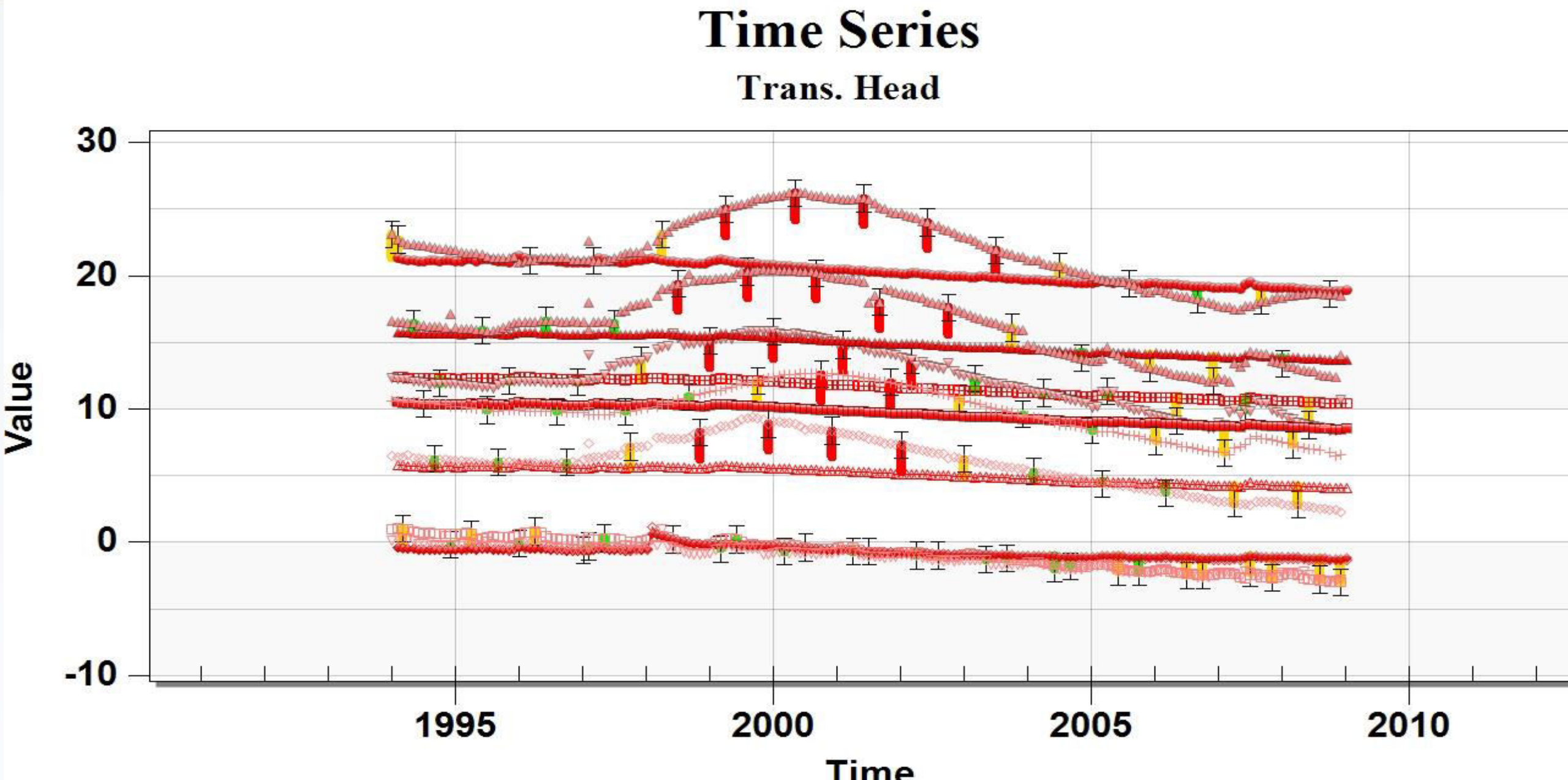
Aquifers change in Storge



Seawater intrusion



Transient Head



Model Auditing & Estimation

- Root mean square error (**RMSE**) and the mean absolute error (**MAE**) were used to evaluate the performance of the model.
- The data (Table -2) indicates a good matching between the measured groundwater level and the water level calculated by modeling and the error was low.
- These data also prove the adequacy of the parameters used in the calibration which are: hydraulic conductivity, specific yield, and recharge.

properties	values
Mean Residual (Head)	0.59
Root Mean square Residual (Head)	1.83
Mean Absolute Residual (head)	1.31

Summary and Conclusion

- Water level dropped 2m below sea level at the area near the coast during the period from 1994 to 2008.
- Water level at the upper part of the catchment dropped 2.5 m above sea level during the period from 1994 to 2008.
- It is expected that the groundwater level will continue to decline during the years from 2009 to 2036 due to the water deficit.
- The groundwater flow model (GMS) will give a predictive scenario for the period between 2009 to 2036 to evaluate the long-term effect on the aquifers without any intervention.
- The use of modern agricultural irrigation systems and the injection of coastal areas with treated water will reduce the interference of seawater inflow to the aquifers.
- We suggest reducing discharge from the aquifer at a rate of 30 percent as a minimum to reduce the groundwater deficit in the alluvial aquifers.
- The second step of the study is to evaluate the salinity intrusion from the sea as well as the nitrate pollution from agriculture activity by linking the current model with the (GMS) solute transport model.

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