Groundwater Numerical Simulation of Hawasinah Catchment in North Batinah Region, Sultanate of Oman

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Overview

- **Introduction**
- **Objectives**
- **Study area**
- **Geology**
- **Hydrology**
- **Hydrogeology**
- **Methdology**
- **Calibration results**
- **Conclusion and Recommendation**

Introduction

- **(GMS) has been initiated to Study the groundwater flow in Hawasinah catchments located at North Batinah Region.**

- **In order to build the model, geological, hydrological and hydrogeological data were collected and analyzed.**

- **Review previous studies and investigation carried out on the area of the catchment.**

Cont., Introduction

❖**Objective of this study to :**

❖**Present geology and hydrogeology analysis .**

❖**Simulate and develop model using The MODFLOW (GMS) to study groundwater system.**

❖**Description of the model and its calibration.**

❖**Quantification of recharge to the aquifer system all over the study area.**

❖**Description of existing groundwater resources .**

❖ **Calculate heads and water budget.**

Study Area

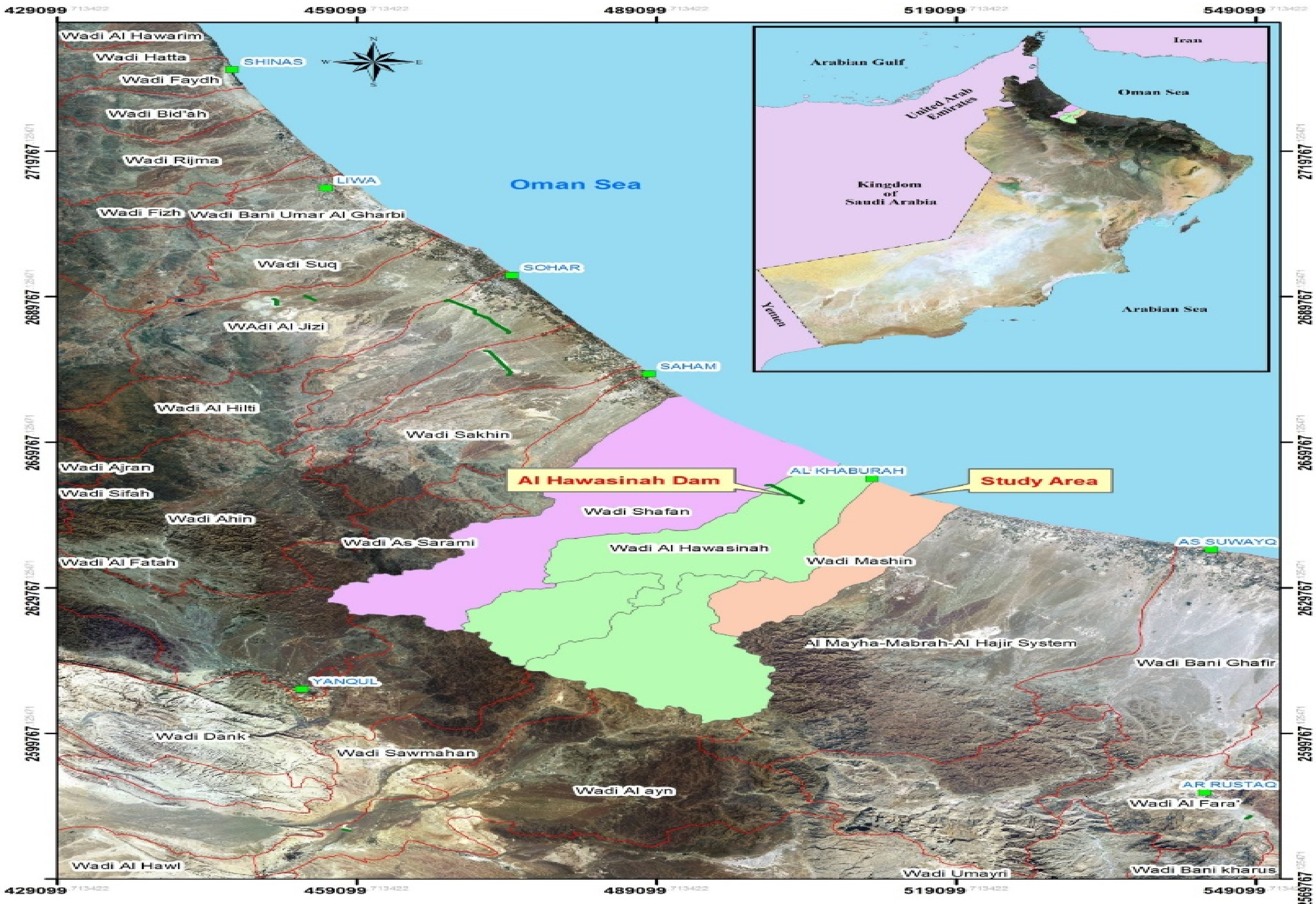
- **Hawasinah catchment area lies in the north-western part of Oman (Fig.1).**

- **Three wadi basins which occupy an area of approximately 2,011 km^2.**

- **The catchments , Wadis Shafan, Hawasinah and Mashin.**

- **The total study area covers approximately 4,483 km^2 .**

STUDY AREA (FIG-1)

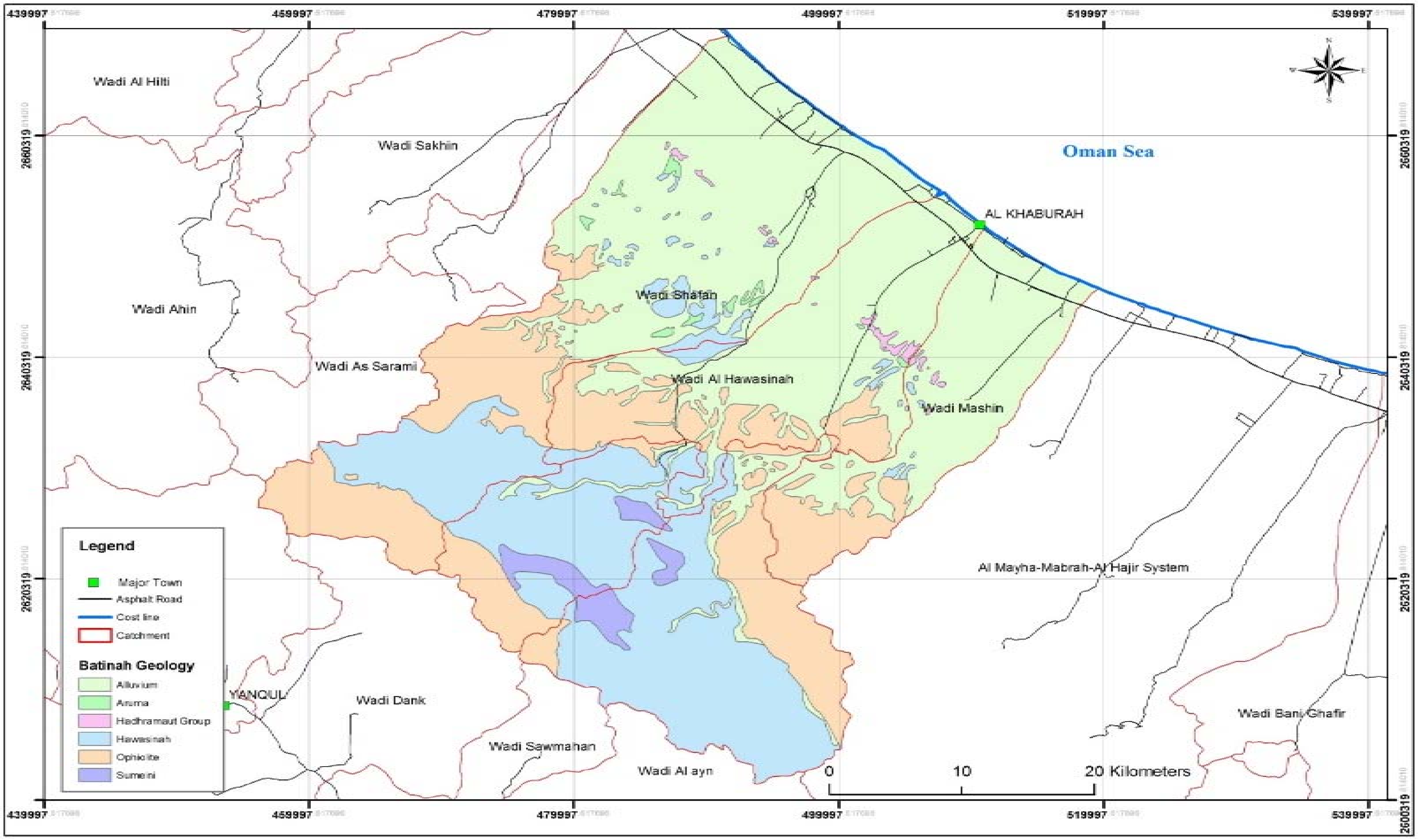


Literature Review

- **Al Khanbashi.S. (2002)** conducted a study to observe the effect of this dam on ground water recharge and quality and the extent of saline water intrusion.

- **Dr.M. El-Bihery, MRMWR(2010)**Carried out a study Integrated Assessment of Groundwater Resources for northern Batinah using (GMS) software .

Geology



Wadi Al Hilti
Wadi Sakhin
Oman Sea
AL KHABURAH
Wadi Ahin
Wadi Shafan
Wadi As Sarami
Wadi Al Hawasinah
Wadi Mashin
Al Mayha-Mabrah-Al Hajir System
Legend
Major Town
Asphalt Road
Cost line
Catchment
Batinah Geology
Alluvium
Aruma
Hadhramaut Group
Hawasinah
Ophiolite
Sumeini
YANQUL
Wadi Dank
Wadi Sawmahan
Wadi Al ayn
Wadi Bani Ghafir
0
10
20 Kilometers
439997
459997
479997
499997
519997
539997
2660319
2640319
2620319
2600319

Hydrology

Total recharge has been estimated by (MacDonald,2010) for all catchments (Table-1)

Catchment	MacDonald(2010)
Shafan East (lower)	4
Hawasinah North(lower)	11.7
Mashin(lower)	4.7

Hydrogeology

- **The study area mainly consists of Tertiary to Quaternary alluvial deposits.**

- **Alluvial deposits form the principal aquifer along the Hawasinah coastal plain .**

- **poorly sorted mixture of gravel, sand, silt and clay to well sorted fine sand silts near the coast**

Table 2 Aquifer thickness (GRC2006)

Name	x	Y	Elevation	bot.alluv bgl	alluv asl	bot.fars bgl	fars asl
NB-11	494936.06	2659497.5	25.	47	-21.9	405	-379.
NB-12	494332.16	2658702.8	31.6	65	-33.4	462	-430
NB-13	492964.51	2657181	46.9	44	2.9	191	-144
NB-14	511781.47	2644554.2	30.8	59	-28.2	533	-502
NB-15	510452.88	2642154.6	53.6	63	-9.3	342	-288
NB-15T	510426	2642165	53.7	61	-7.2		
NB-16	509349.07	2639436.2	78.7	8	70.7		

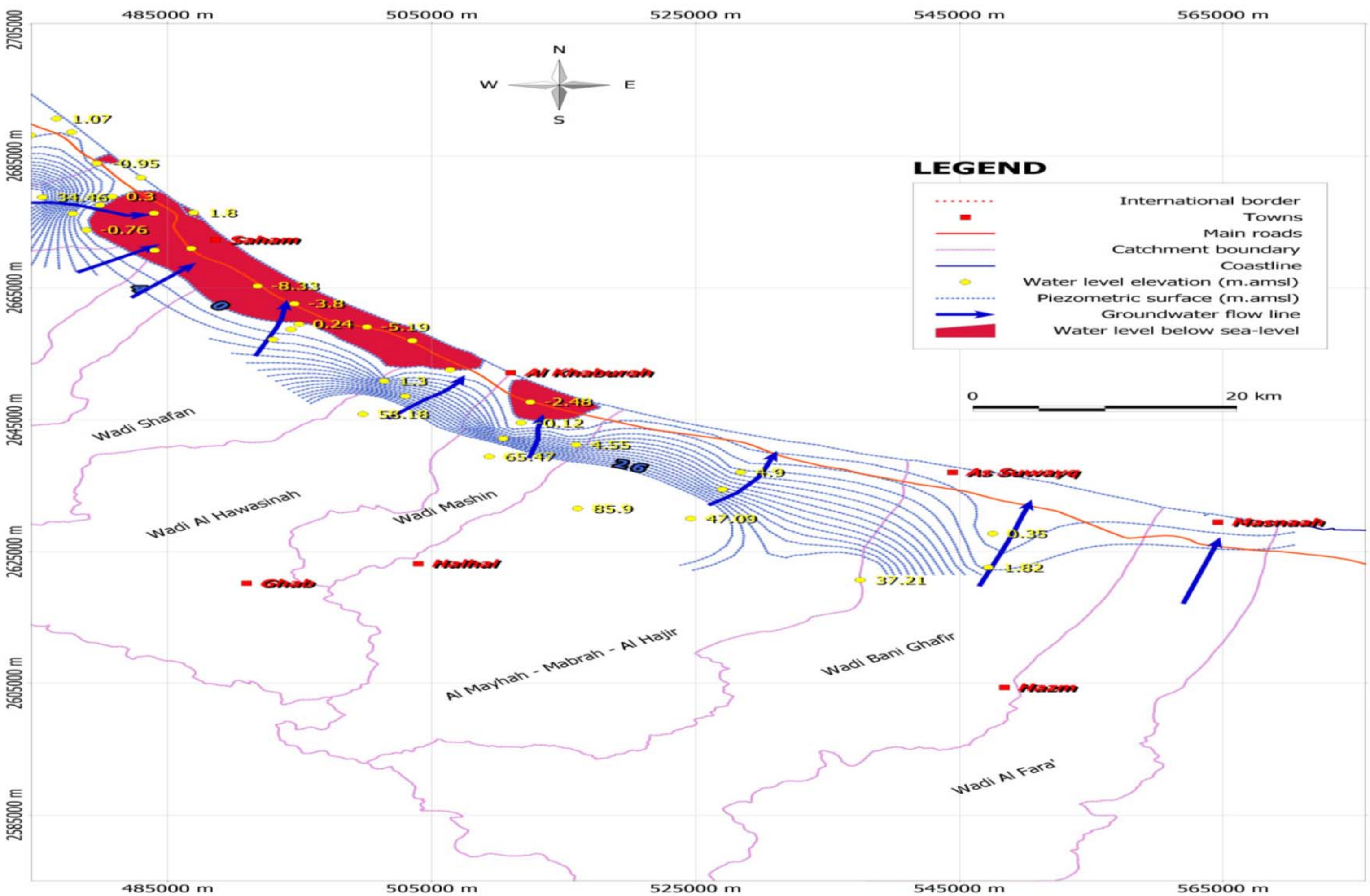
Table.3 Estimated K and S parameters (GRC, 2006)

Local ID	Easting	Northing	T (m^2/day)	K (m/day)	S	Sy
SH-1	491038	2653082	93	2.3	-	-
SH-2	494261	2656288	920	26.4	2.8×10^{-4}	0.017
SH-3	495901	2659009	1,209	22	-	-
SHTW-1	494301	2656162	853	24.5	-	-
NB-15	510453	2642155	81	0.9	2.8×10^{-4}	

Table.4 Aquifer Hydraulic parameters (After MacDonald, 1992)

Borehole	T m^2/day	K m/day	Specific capacity m^2/day	Storage coefficient	Specific yield
WS1-25	1210	100.8	984	-	-
HA-1	5621	243.3	2246	-	-
HA-2	3600	51.4	-	-	-
HA-3	1603	25.6	2160	0.0075	0.015
HATW-1	36	1.3	77.76	-	-

Fig. 3 Composite potentiometric level (October 2005 to June 2006)
(After GRC, 2006)



Note: This map is presented using a Universal Transverse Mercator, WGS 1984, projection.

Cont., **Hydrogeology**

- Major groundwater abstraction was 15.167 Mm^3/year withdrawn from alluvium unit in 1982.
- The total amount of recharge to the aquifer is 20.4 Mm^3/year.
- total present abstraction is 97.28 Mm^3/day.
- which 93.96Mm^3/day used for agriculture and 0.422 M m^3/day for urban uses.

Methodology

- The Hawasinah catchment alluvium and upper Fars form the main aquifer system for conceptual model Fig 4
- The thickness of alluvium generally range from 10 m to 150 m.
- The thickness of upper fars range from 110 m to 580 m respectively.
- In this study a pre- and a post-processor (GMS) is used to interface with MODFLOW.
- The model has been constructed with a rectangular grid system of 725 m ×258 m (UTM WGS 1984, zone 40N) - fig 5

Fig. 4 Conceptual model

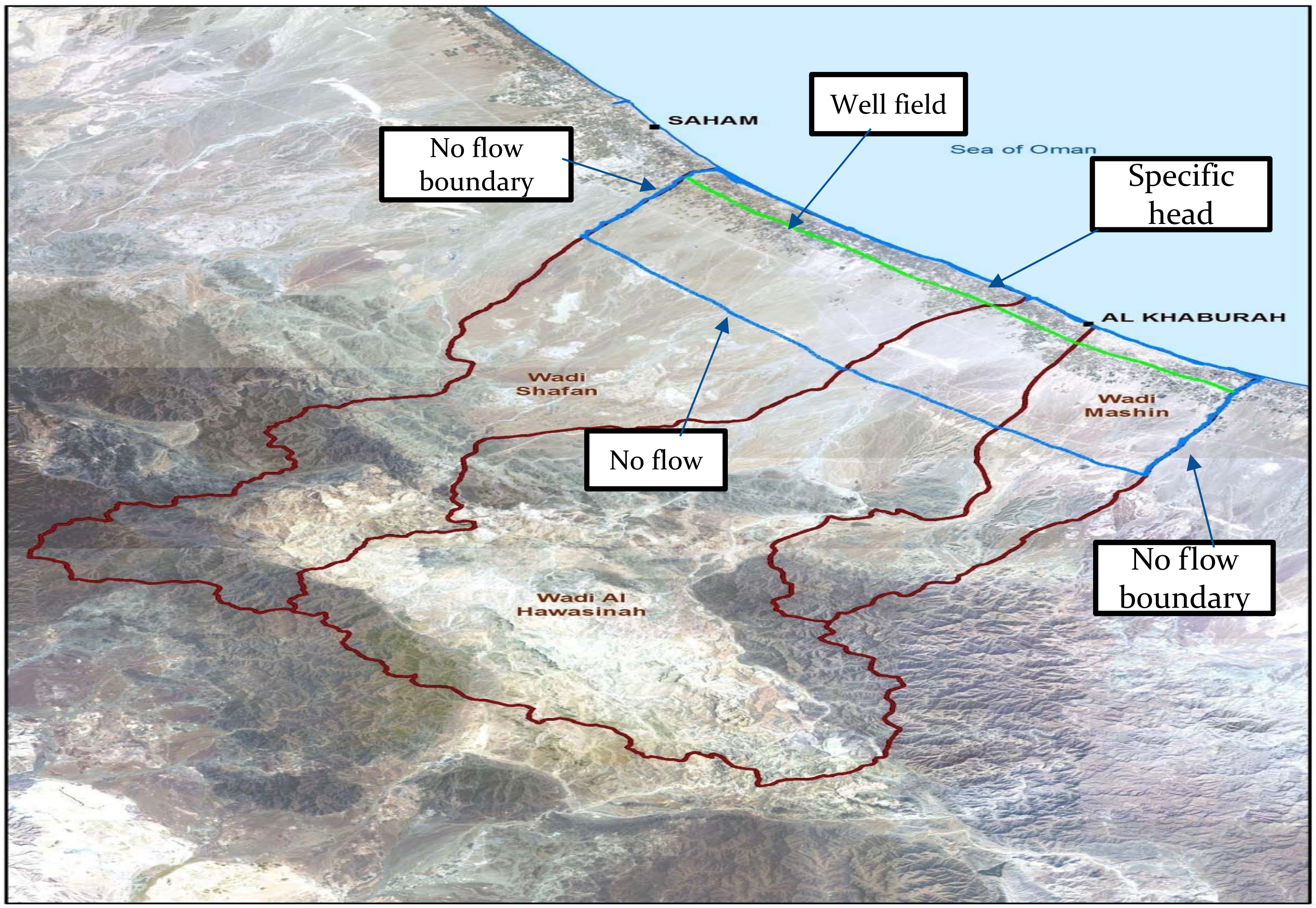


Figure .5 Model Grid

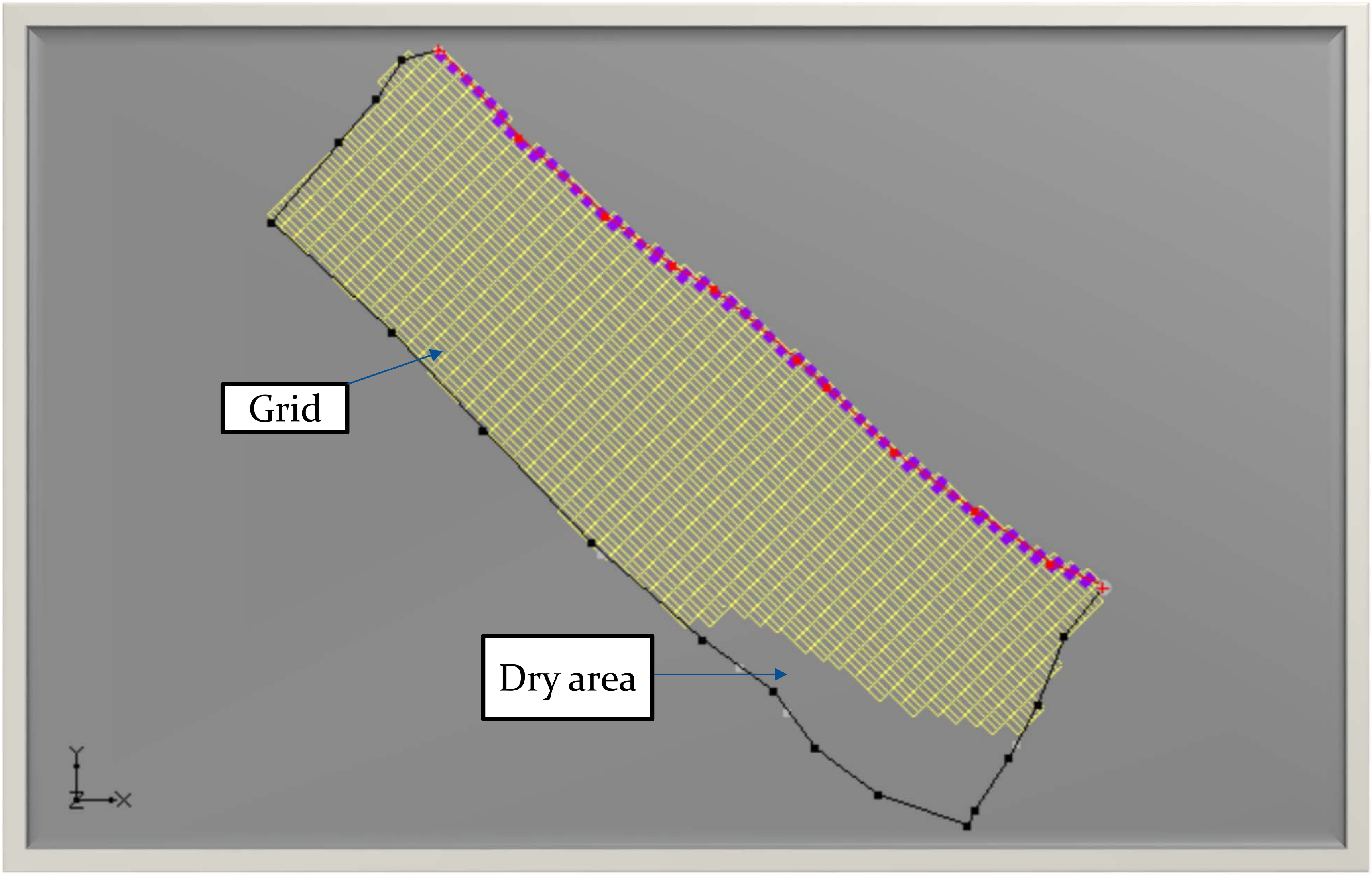


Figure. 6 Cross-sectional area

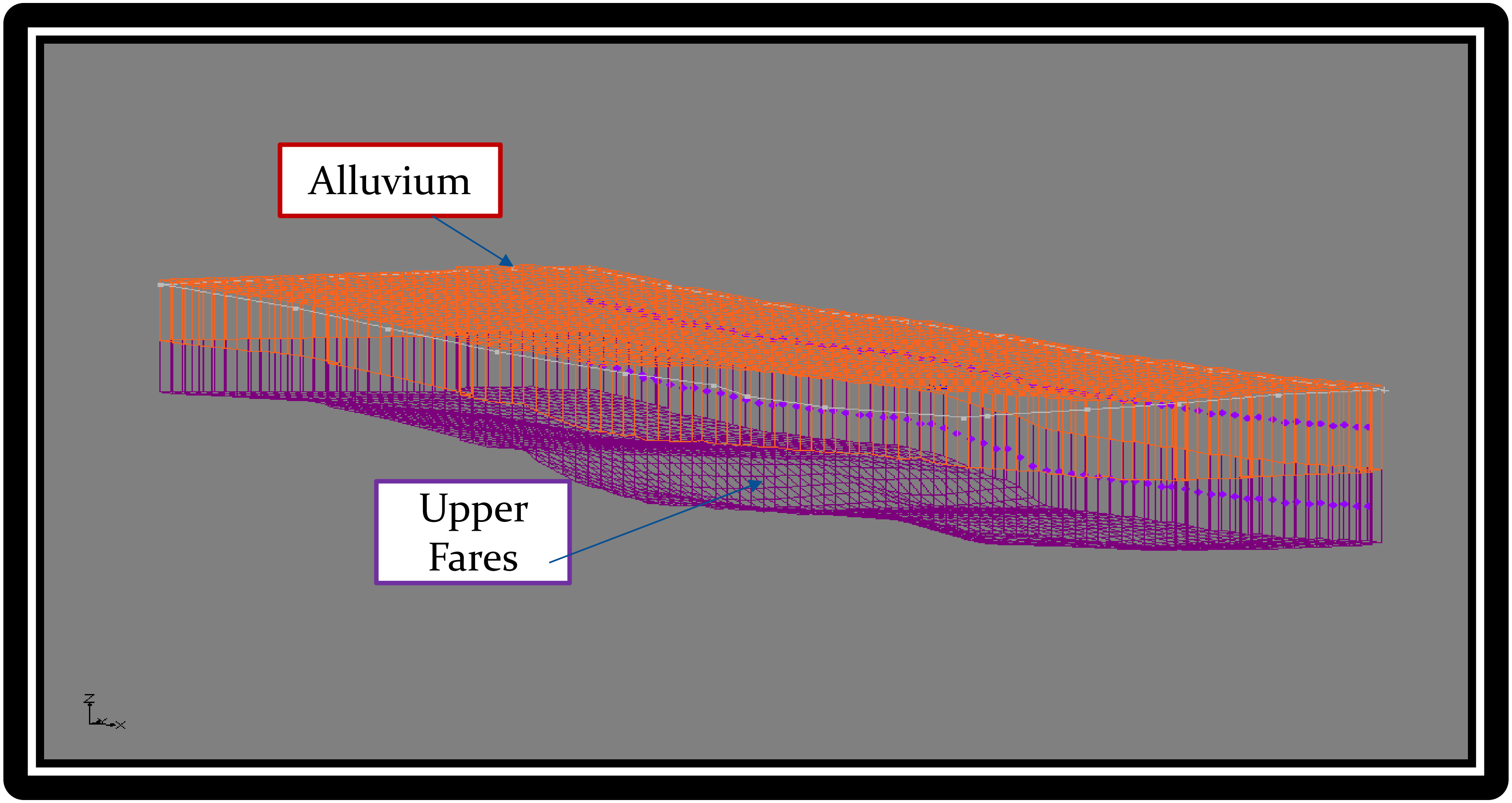


Figure. 7 Top of aquifer system

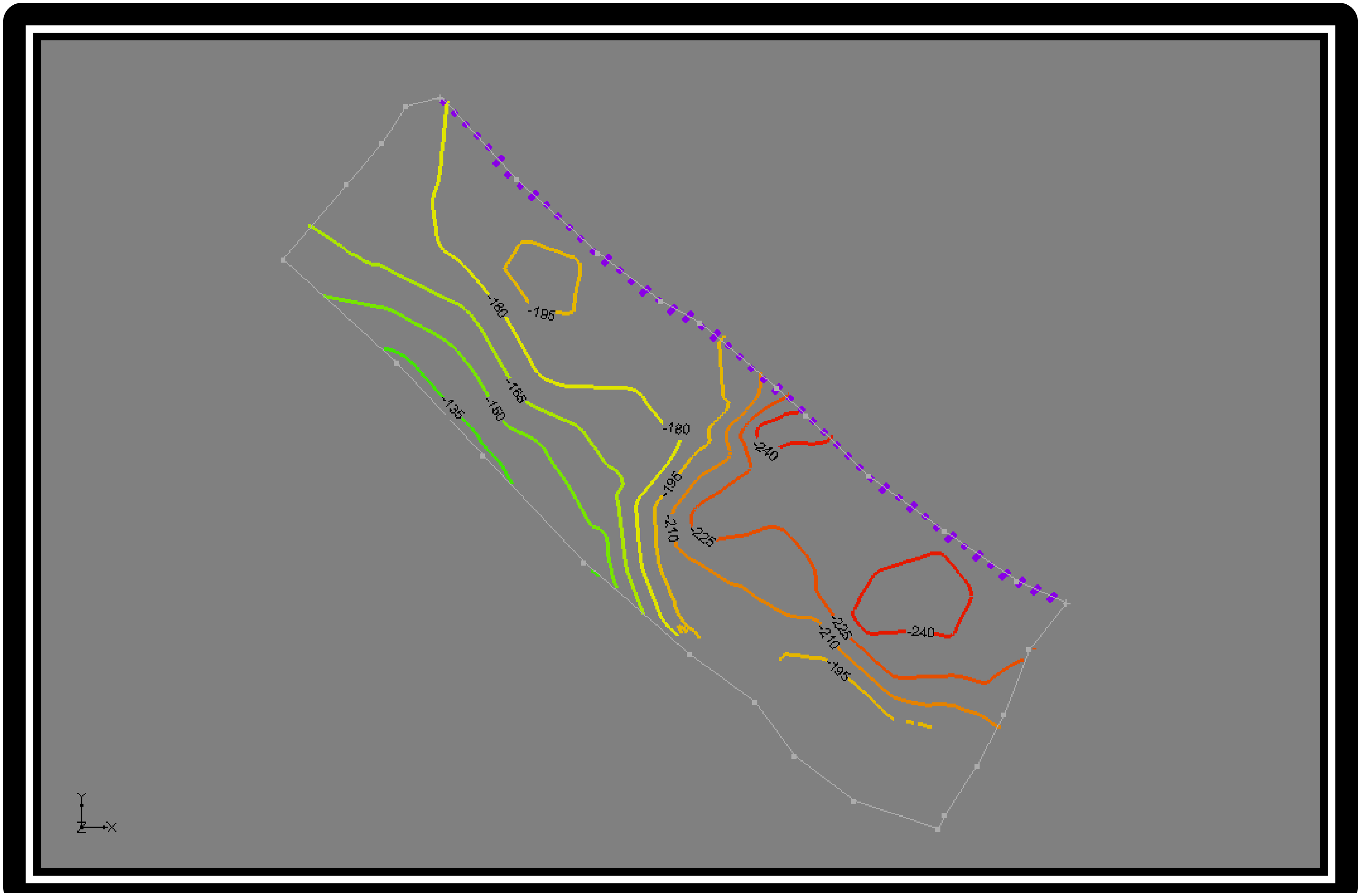


Figure .8 Bottom of aquifer system

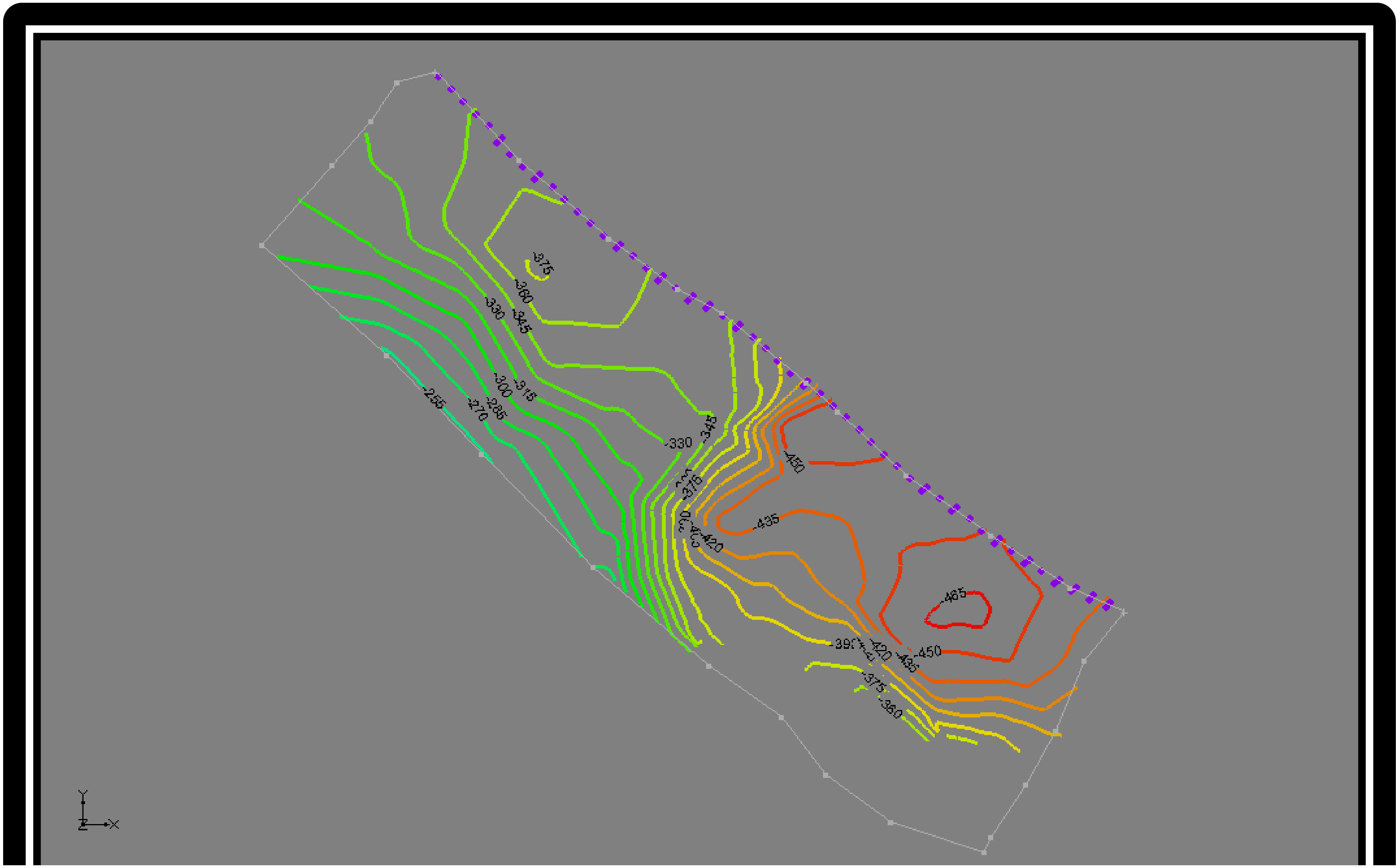
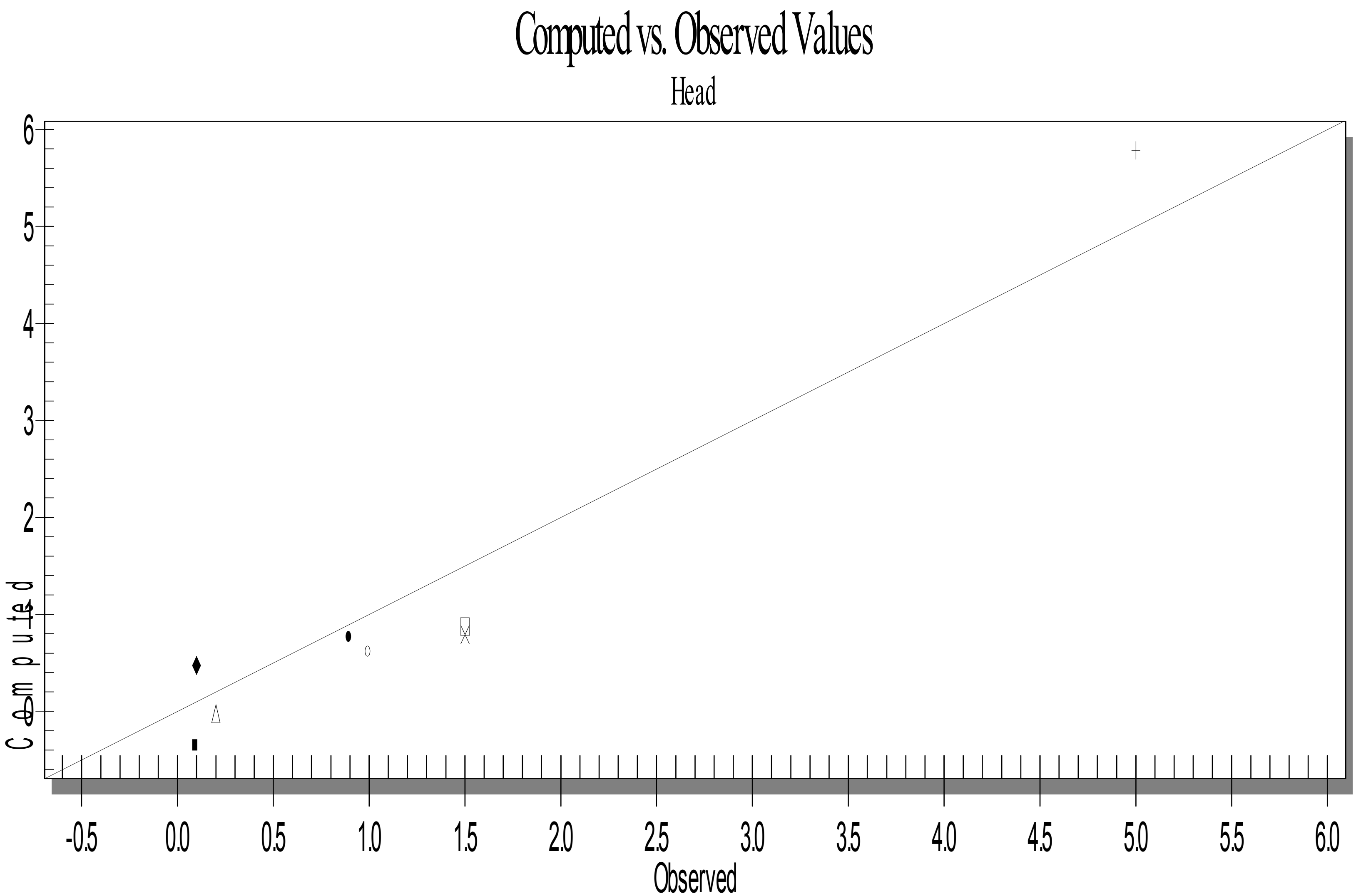


Table. 5 the water level measurements done in 1982

Name	x	y	head(m)
Mohamed Mosallam	494300.00	2662300.00	0.1
AD-35	496900.00	2659600.00	1.5
AS-2	500900.00	2658300.00	0.90
Khawr Al Milh	502100.00	2657900.00	1.00
AlKhaldi garage	502200.00	2657500.00	1.50
WSI-25	506000.00	2649000.00	2.00
JT-34	501950.00	2645048.00	5.80
MOHAMED SHAMIS	491790.00	2665272.00	7.00

Figure.9 Computed Head vs. observed values



Calibration results

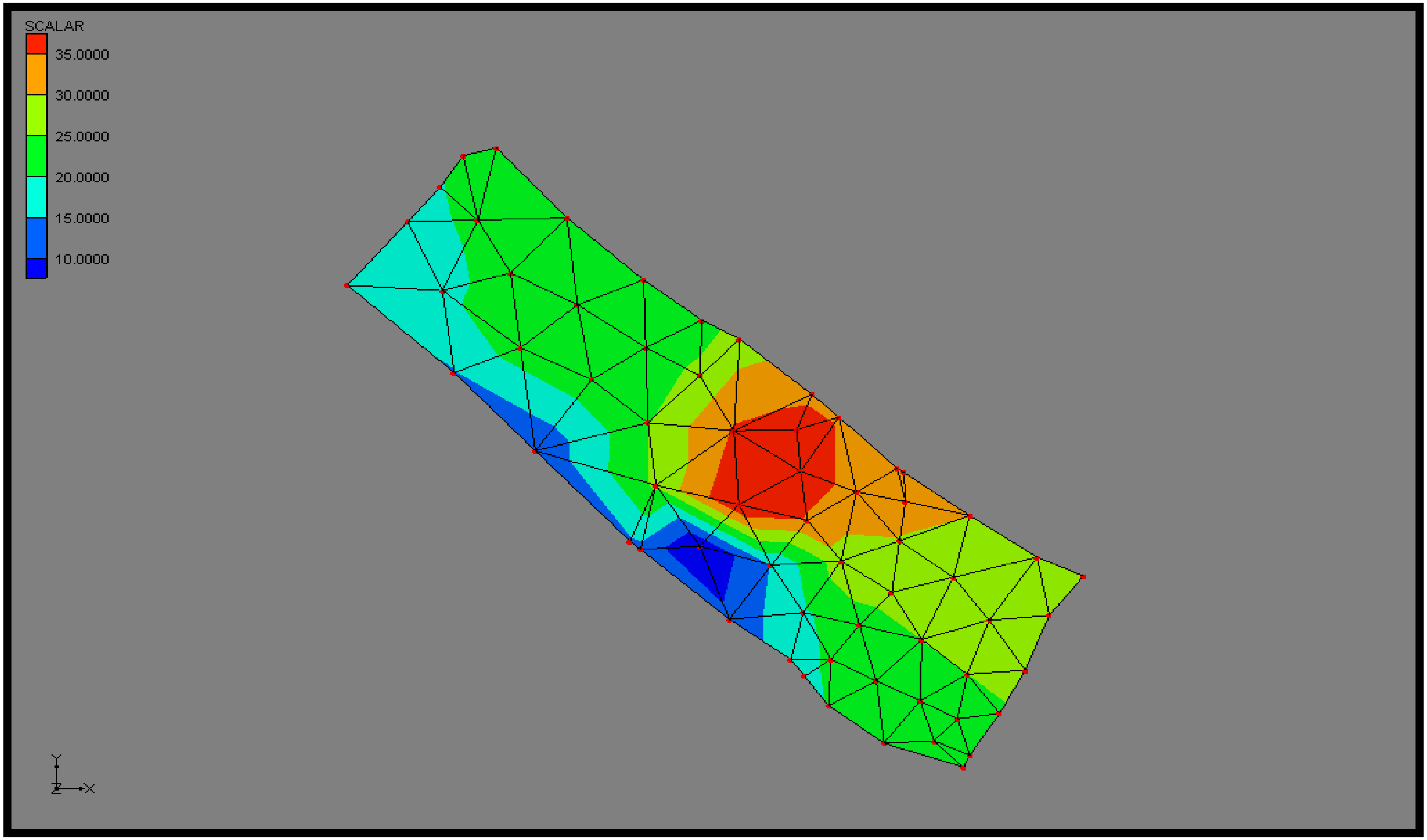
- The value of K has ranged between 10 m\day and 35 m\day for the alluvium .

- upper Fars unit attains a value of K 0.9 m/day.

- Figure. 10 shows that high hydraulic conductivity zones exist in middle area .

- the low conductivity zones exist along the south western area.

Figure.10 Calibrated hydraulic conductivity of alluvium (m/day)



Cont., Calibration results

- **The head of Alluvium ranged from 10 m.asl at the southwest of the study area to zero level along the coast (fig 11).**

- **The head was above sea level (0.1m) at wadi Mashin southeast of the Al Khabourah town near the coast.**

- **calibrated head of upper Fars shows Groundwater flow was thus from southwest to northeast (fig12).**

Cont., **Calibration results**

- **Hydraulic gradient was almost symmetrical all over the study area .**
- **Drying model occurs because of its relatively shallow depth .**
- **Its proximity to the most southwest boundary margins of the model.**

Fig. 11 Calibrated head of alluvium (m)

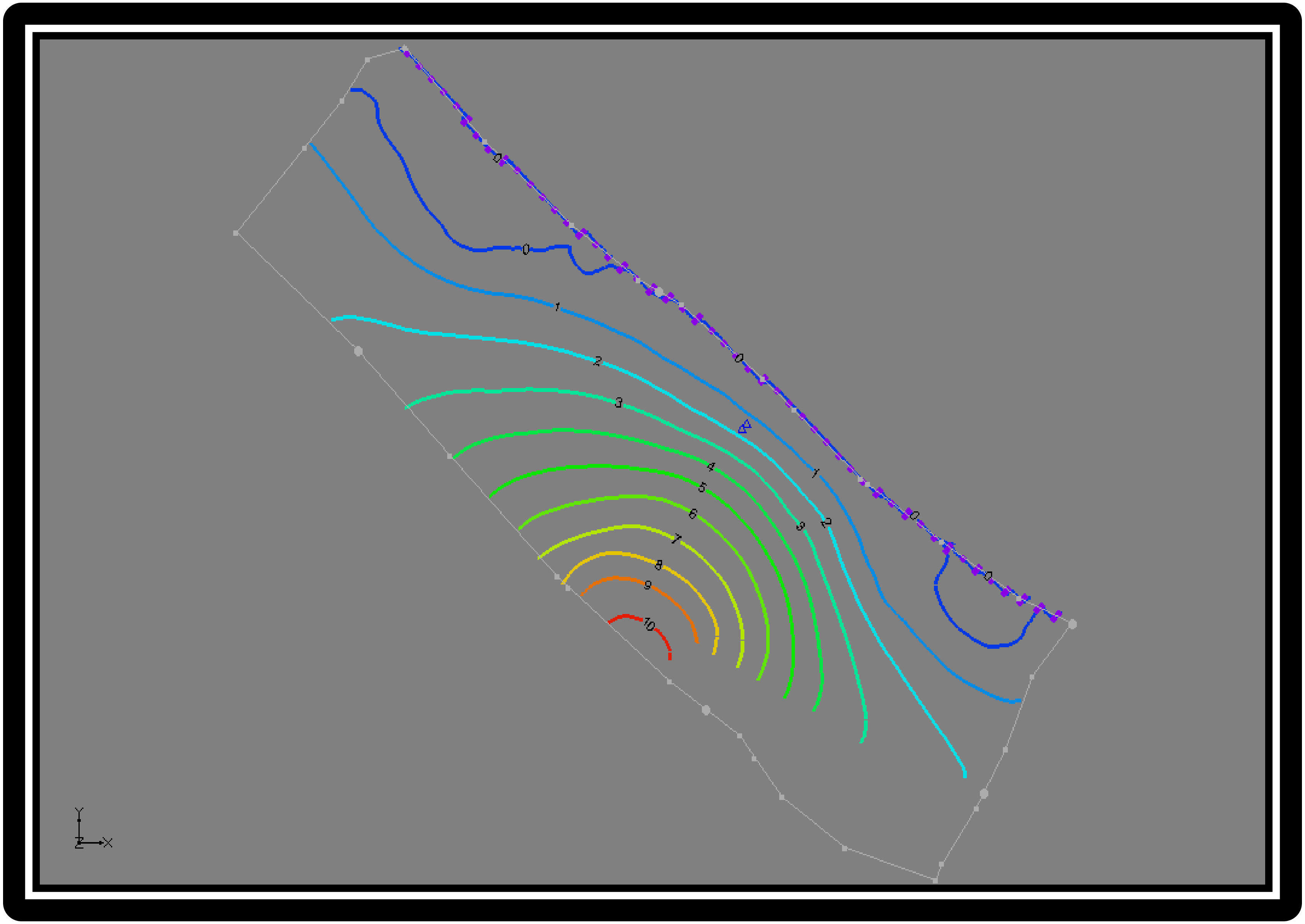
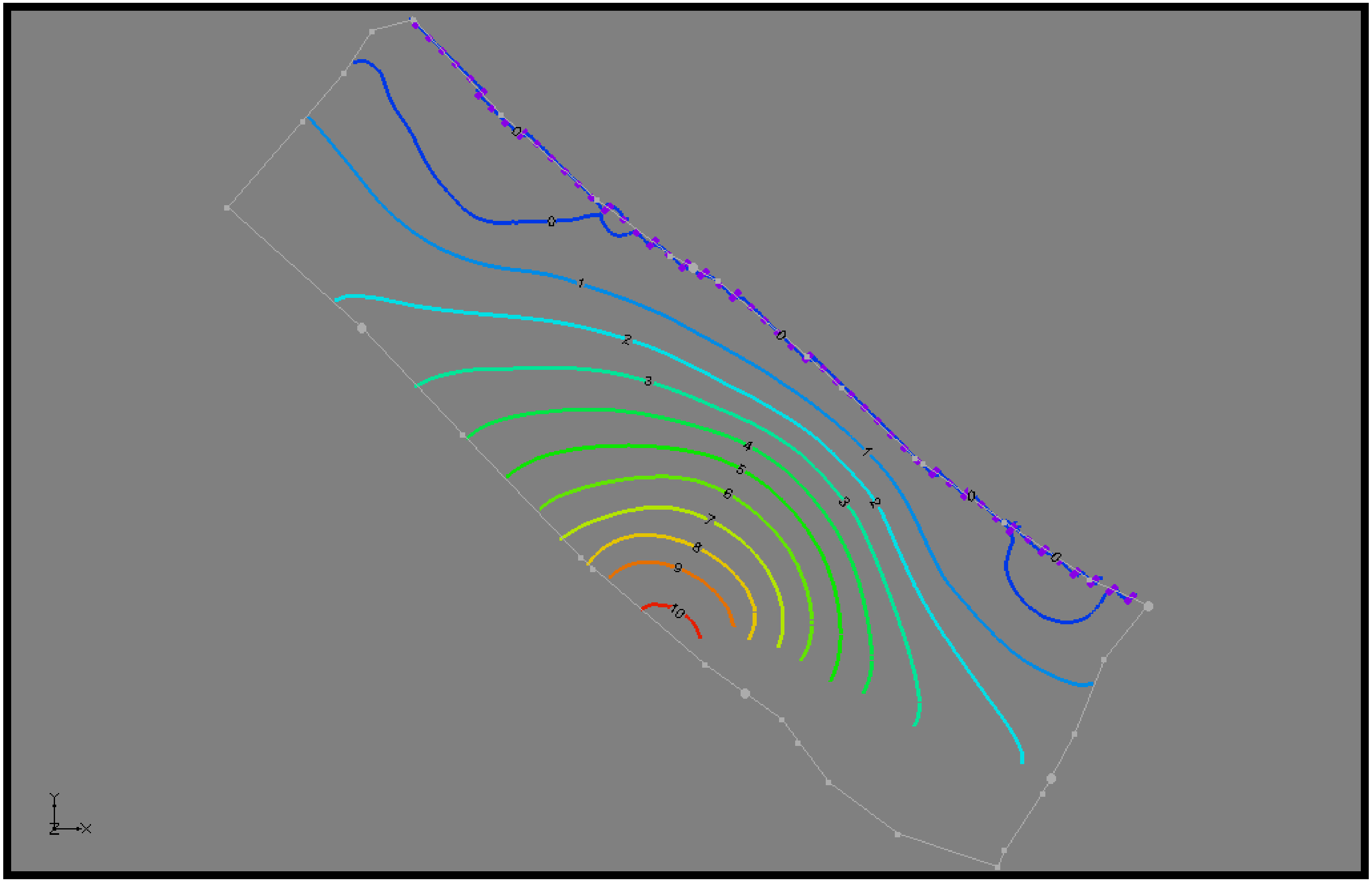


Fig. 12 Calibrated head of upper Fares (m)



Cont., **Calibration results**

- **Inferred flow balance from the steady state model is shown in table6 .**
- **A localized salt water intrusion of $7.6 x 10^5$ and $3.15 x 10^6 m^3/year$ to the alluvium and upper Fars respectively.**
- **Such water intrusion occurs at the two areas listed earlier where groundwater level declined below sea level .**
- **An internal flow from alluvium to upper Fars and vice versa.**
- **The model estimates it as $2.8 x 10^5 m^3/year$ and $3.7 x 10^5 m^3/year$ respectively.**

Table 6 Flow balance for the steady-state model(m3\day)

Component	inflow	internal flow	outflow
inflow from the Gulf (alluvium)	2108		
inflow from the Gulf (u. Fars)	874.87		
recharge (alluvium)			
recharge (u. Fars)			
flow from alluvium to u. Fars		7664.5	
flow from u. Fars to alluvium		10015.5	
abstraction (alluvium)			41128
abstraction (u. Fars)			0.0
outflow to the Gulf (alluvium)			6031.5
outflow to the Gulf (u. Fars)			3225.79

Conclusion & Recommendations

- The main source of recharge to the Hawasinah Catchment area is direct recharge from rainfall as well as wadi flow.
- It is estimated by about 20.4Mm^3/year from both rainfall, wadi flow plus urban flow.
- The total amount of current abstraction is about 97.28Mm^3/year;
- The hydraulic conductivity attains a moderately wide range from 10 to 35m/day for the alluvium.
- Its 0.9 for upper Fars.

Cont., Conclusion & Recommendations

- **high hydraulic conductivity zones decreased by about 5 m/day along the southwestern side.**

- **hydraulic conductivity increased by 5 m/day at the high conductivity zone.**

- **This calibration is rather local because most of the data points exist basically in the central area .**

Cont., Conclusion & Recommendations

- The Head of water range between -0.3 to 6.5 m .
- A localized salt water intrusion of 7.5 and 3 Mm^3/year to the alluvium and upper Fars respectively.
- The abstraction from wells were 15 Mm3/year .

Cont., Conclusion & Recommendations

Recommendations

- **More work required for aquifer geometry.**
- **Additional data of hydraulic parameters are required.**
- **Modeling work needed in the transient state to see the effect of aquifer behavior on the long term .**

Cont., Conclusion & Recommendations

- **Set prediction development scenarios the effect of abstraction on the groundwater level .**

- **Model work on water quality needed to see the effect of development on groundwater quality.**

Acknowledgments

- I would to thank ALLAH who helped me in my life and guided me to the right path. And then my thanks go to thank the Ministry of Regional Municipalities and Water Resources .

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Thank you