The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD)

ACSAD experience in groundwater management in the Arab region using mathematical modelling

Disruptive Technologies for Improved Groundwater Management in the Mashreq Region

15-17 June 2021

(ESCWA)

About ACSAD

- ACSAD is a regional center for research and studies pertaining to the development of the arid and semi-arid areas of the Arab World. It was established in Damascus (capital of the Syrian Arab Republic) in 1971 within the framework of the League of Arab States. ACSAD is governed by the Council of the Arab Ministers of Agriculture.
- The Arab states' decision to establish ACSAD was based on the importance of the Arab arid and semi-arid lands vis-à-vis the future of the agricultural development and the realization of the objectives of the food security in these lands which cover about 90% of the area of the Arab World.

ACSAD Divisions

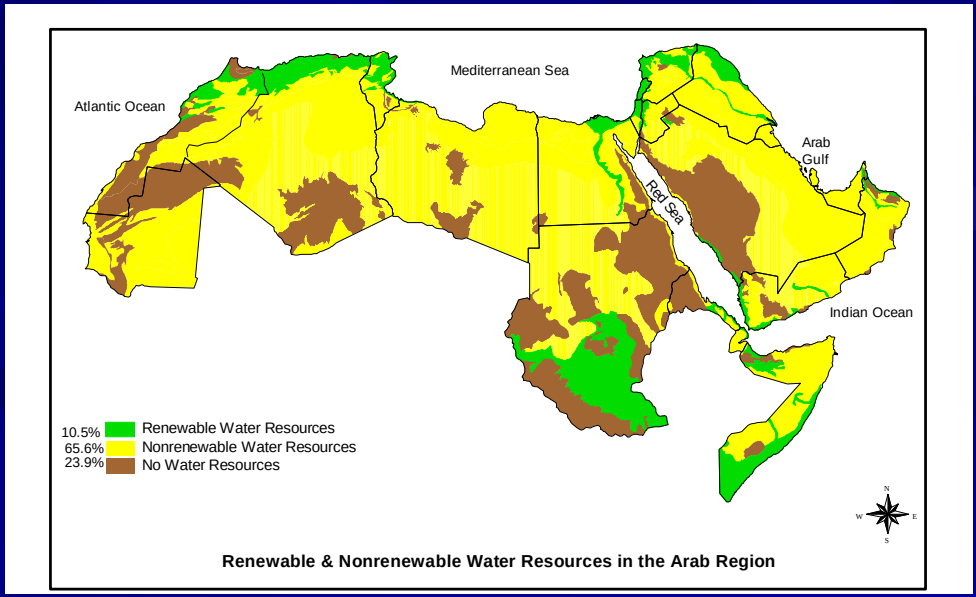
ACSAD has six main divisions :

- Water Resources
- Soil Science
- Plant Wealth Studies
- Animal Wealth Studies
- Planning & Economic
- Financial Administrative

Water Resources Management

- Groundwater

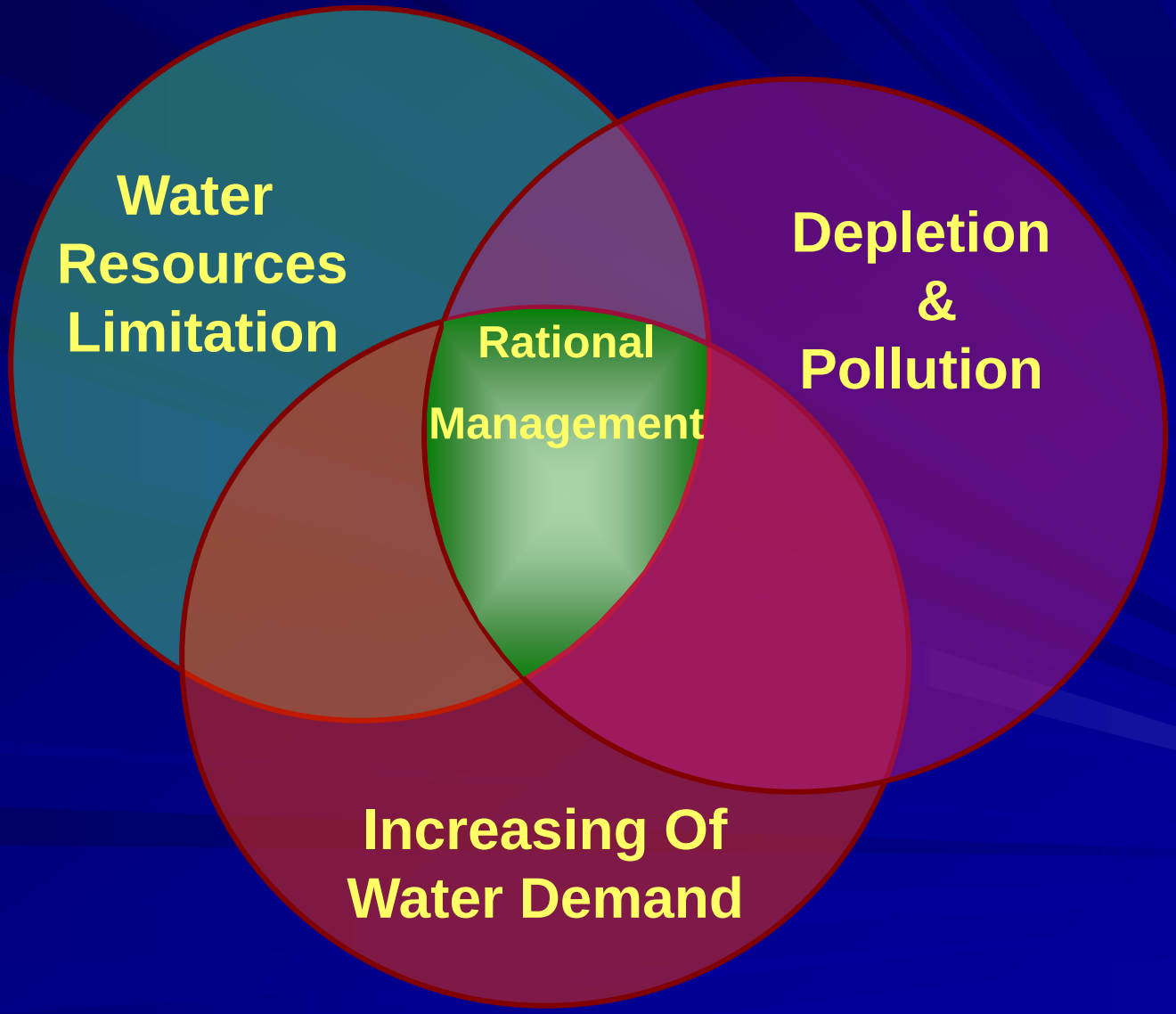
Throughout the Arab world, the majority of countries suffer from imbalance between the constantly increasing demand of water and the natural available water resources.
As the second largest sources of fresh water, groundwater is under high pressure. Many countries are already using more water than their renewable water supply, and are in water deficit situation (ACSAD, 2000; Abu-Zeid & Hamdy,2004).



Renewable & Nonrenewable Water Resources in the Arab Region

Water Resources Status In The Arab World

Importance of Rational Management



Groundwater Modeling is one of the main tools used in the hydrogeological sciences for the assessment of the resource potential and prediction of future impact under different circumstances/stresses.

Its predictive capacity makes it the most useful tool for planning, design, implementation and management of the groundwater resources.

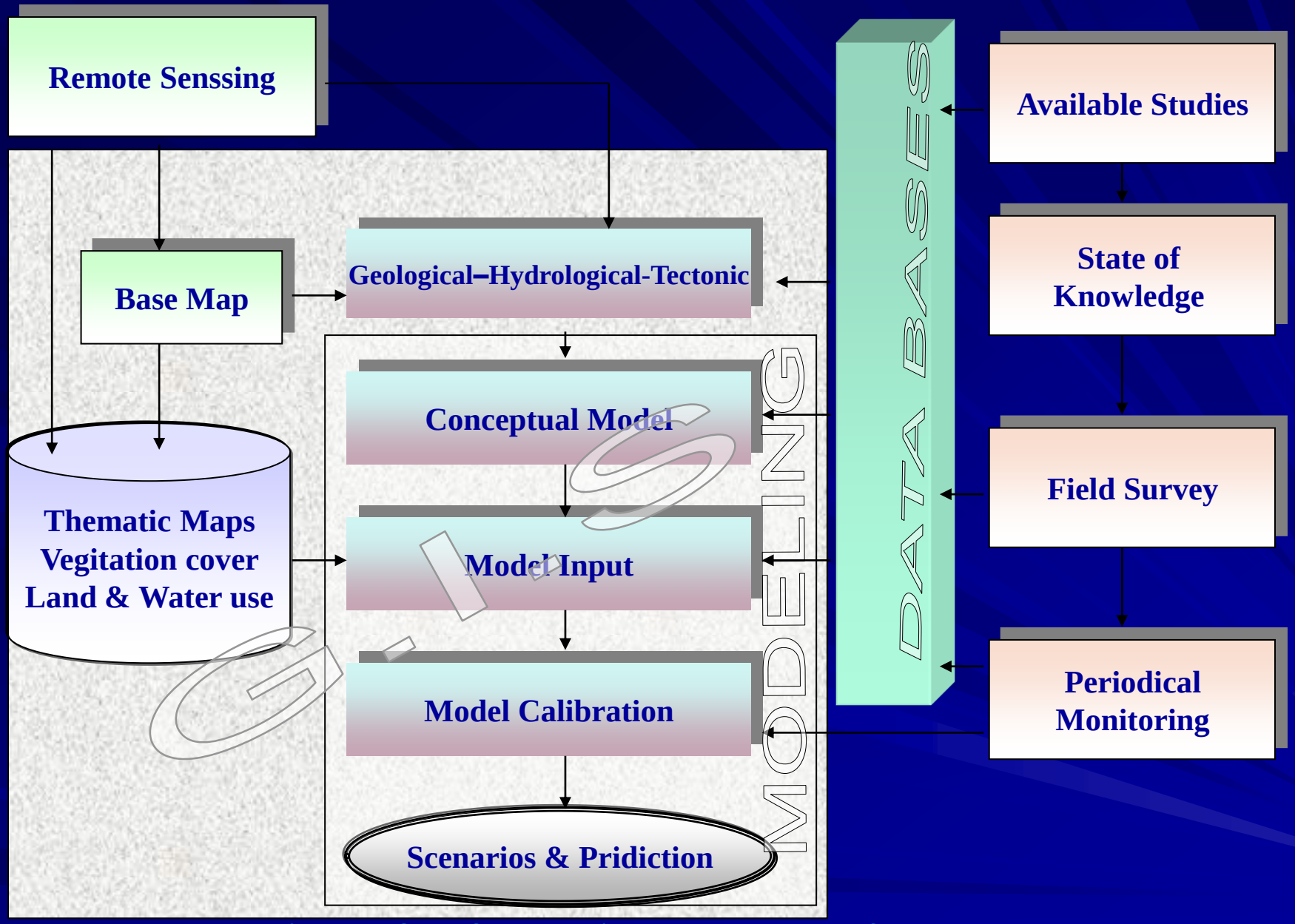
To permit prediction of hydrologic events

Forecasting

Numerical groundwater flow models

Modern tool for development and management of water resources

- Since late seventies ACSAD started to apply computer simulation models for analyzing flow in groundwater systems. Numerical groundwater flow models have been constructed to
  - develop an understanding of the groundwater flowing systems,
  - evaluate the effects of development on groundwater resources and support groundwater management.
  - evaluate the effects of climate change on groundwater resources

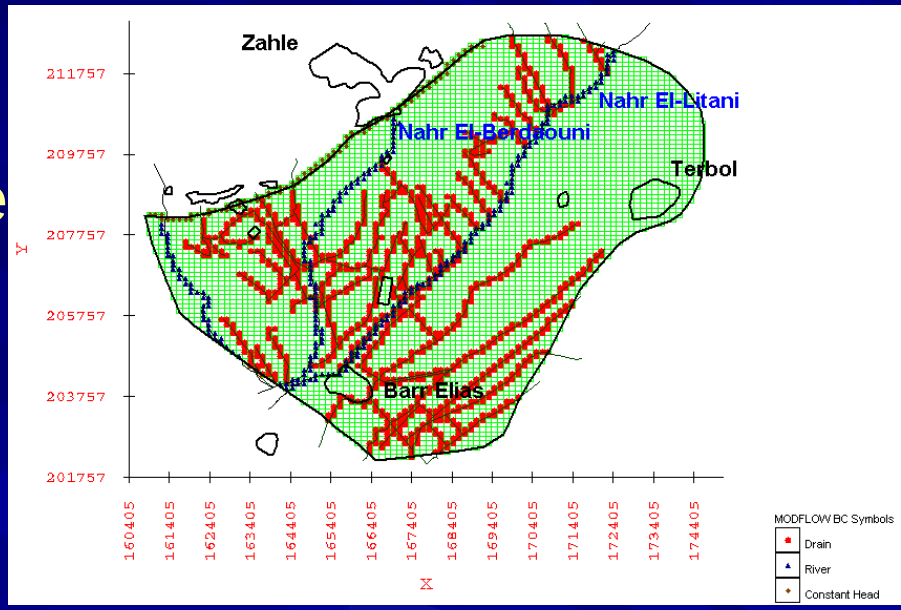


Integration of Information Systems for W.R.M.

Case Studies

Developing a Model for groundwater flow and contaminant transport for Beka’a valley in Lebanon

The Lebanese Beka'a valley is situated at an average elevation of 900 m between the western Lebanon and eastern Anti-Lebanon mountain ranges. It comprises around 170 km in length, with a varying width between 20 km in the central part and 5 km near the southern tip. Due to intense agricultural activities in the valley, the Beka'a is of vital importance to the country's economy and food supply. With an estimated 540 000 inhabitants it is home to about 13.6 percent of the Lebanese population.



Pilot area: Beka'a valley, Lebanon

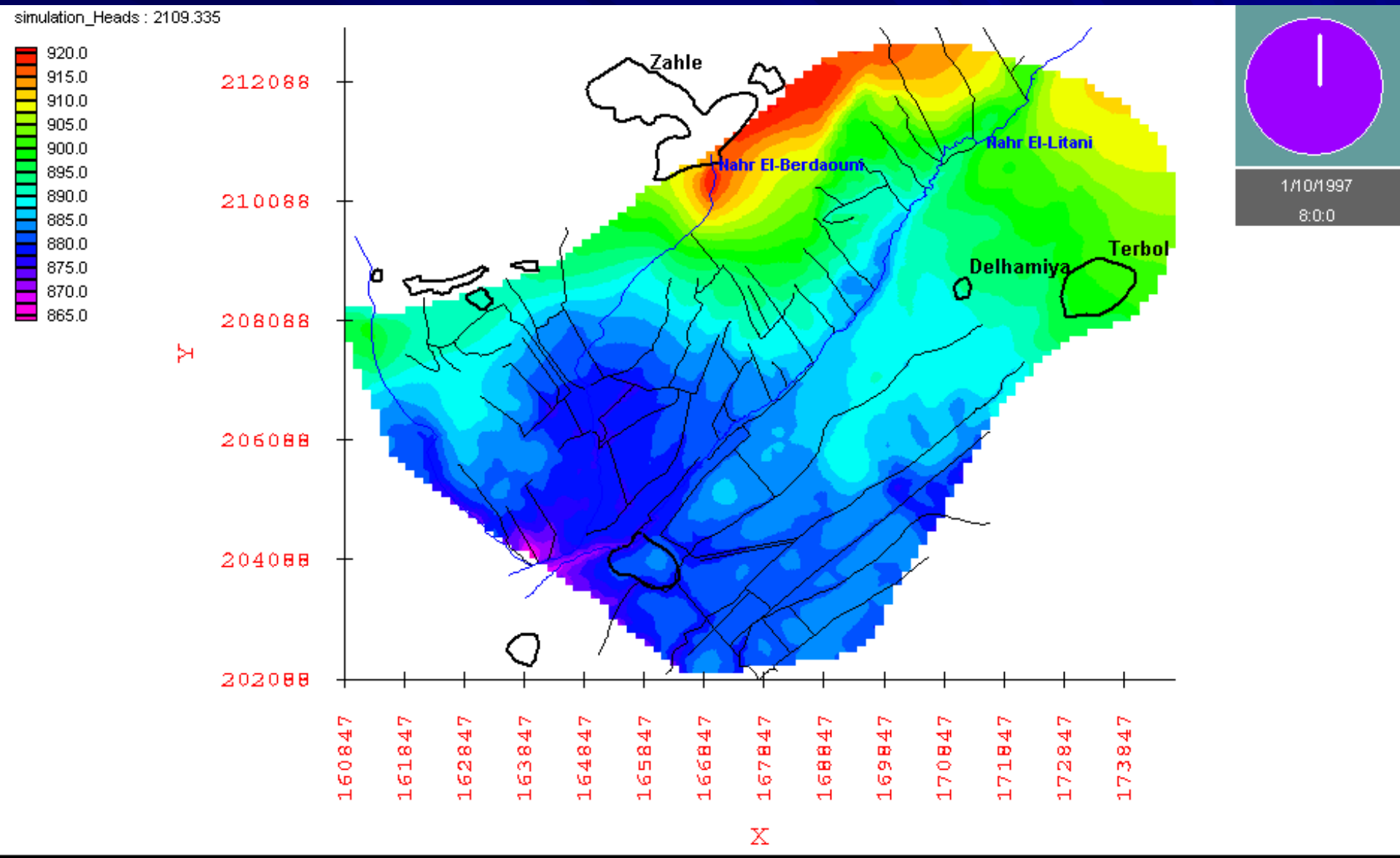
Identified problems:

- Nitrate pollution from agricultural non-point sources
- Possible pollution from existing point sources (waste dumps)

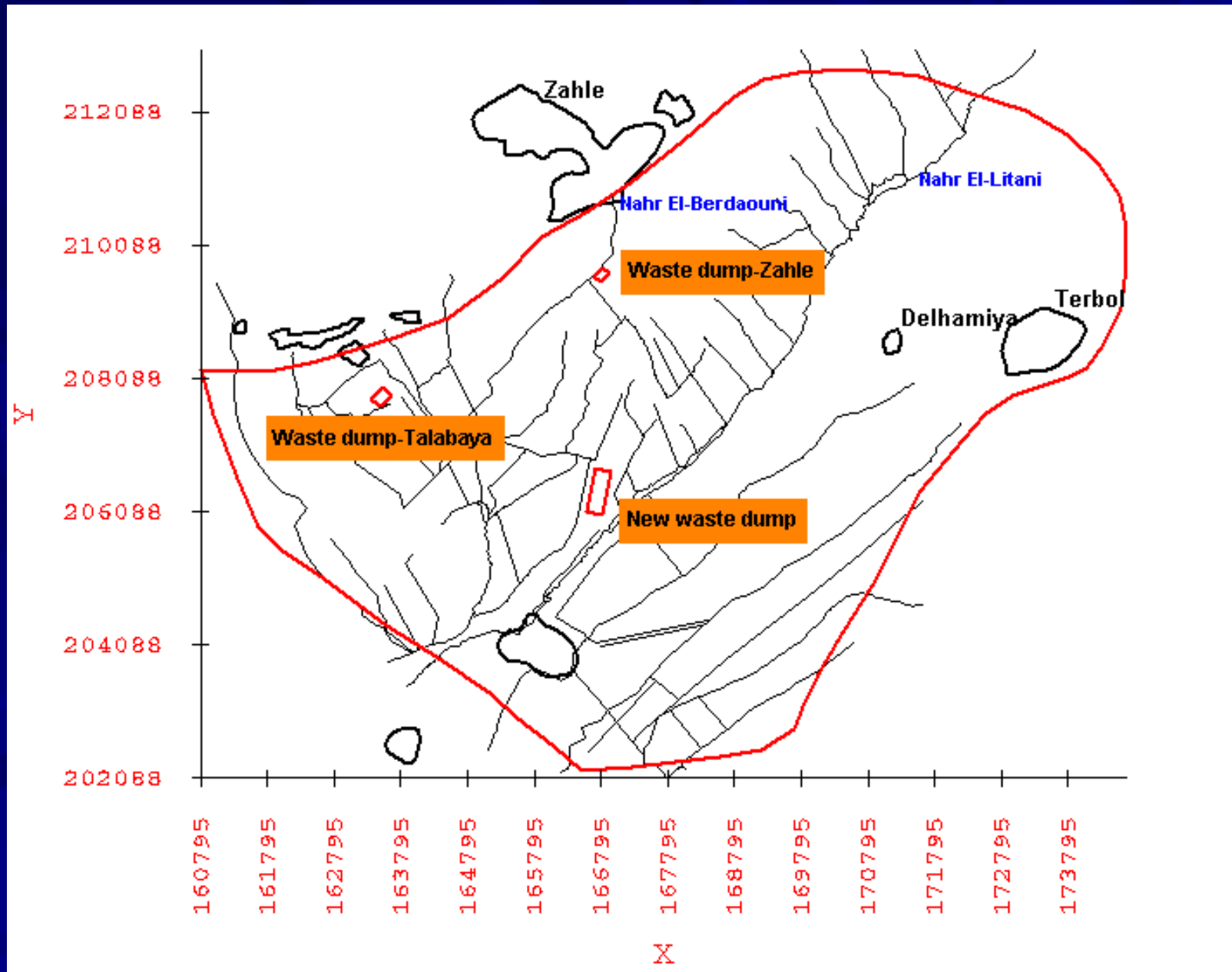
Project Achivements:

- Data enquiry and field work
- Developing and calibrating the groundwater model
- Calculation of transport scenarios

Calculated heads for the upper aquifer 1997-2010

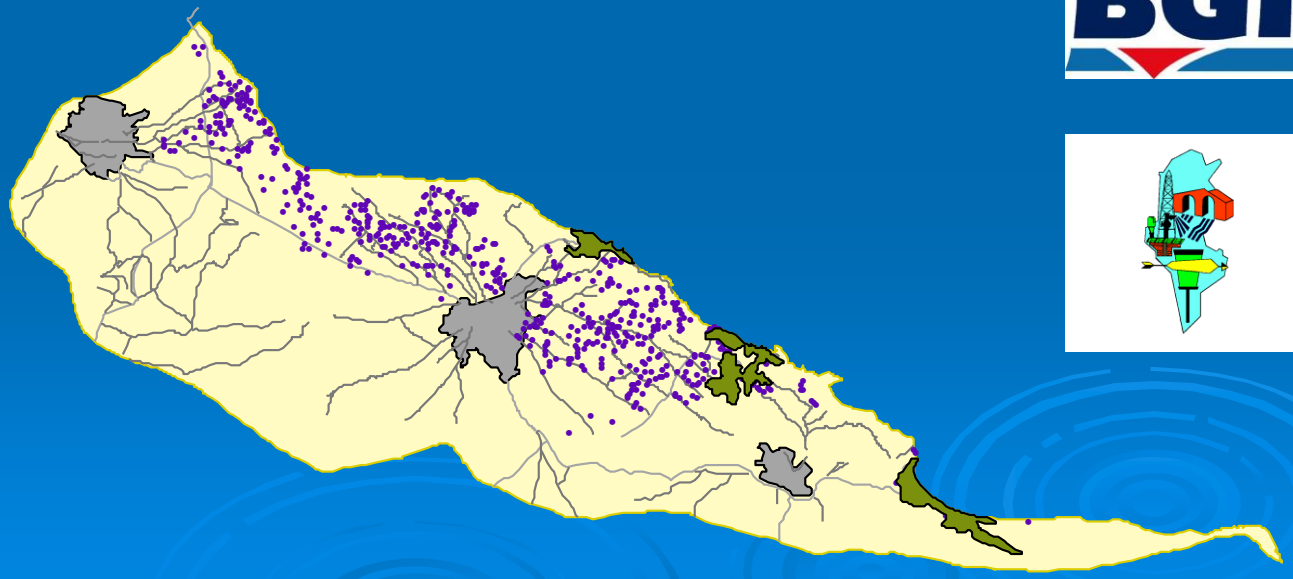


Solute transport scenarios: point source pollution from waste dumps.



Transport scenario 1 (upper aquifer): constant input of a nonsorbing and nondegradable contaminant, 1997-2010.

Development of a Model for the alluvial coastal aquifer of Ras el-Jabal of Tunisia

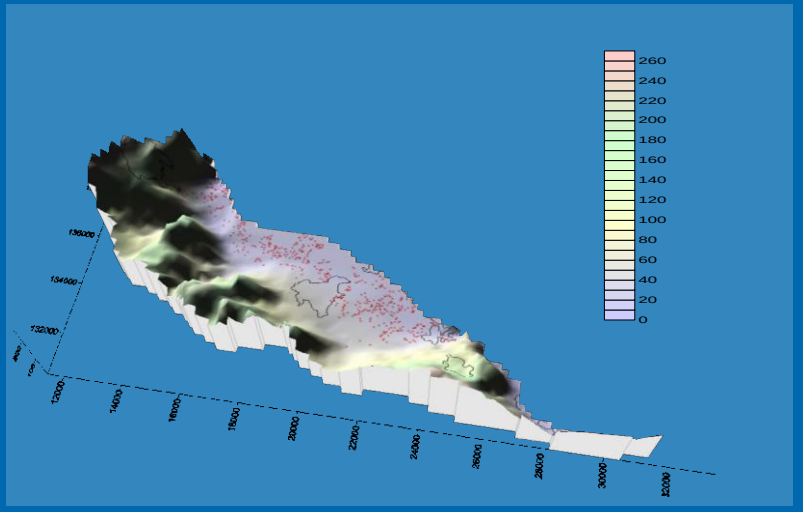


N

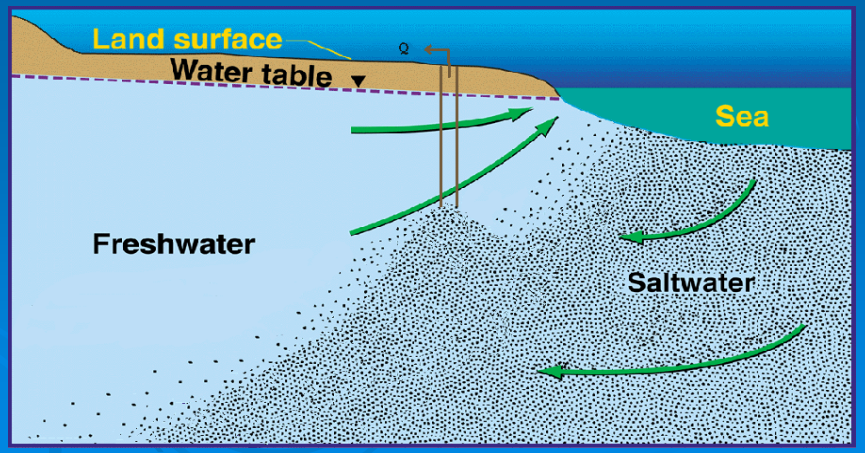
The Basin of Ras El Jebel is situated in the north east of Tunisia and has an area of 73 km². It is bounded in north by Mediterranean sea and surrounded by mountains.

. The plain is a typical example for an intensively cultivated coastal basin in the Arab Region, where the over-utilization of groundwater resources has led to a number of water quality- and quantity-related problems

The alluvial aquifer in the plain covers an area of 35 km2. 1372 wells in the plain exploit the aquifer with extraction rates amounting to 13.5 Mm3/year. The recharge of the aquifer is estimated at 8.5 Mm3/year, which are provided by the infiltration of rainfall and excess irrigation water.



This overexploitation caused a drawdown of groundwater levels ranging from about 3m on the coast to 10m inland.
Consequently the aquifer started to suffer from seawater intrusion and the water quality degraded rapidly. The model will provide an in-depth



Model investigation for analyzing and evaluating a freshwater / saltwater system in a costal area

Possible sources for the salinisation of the groundwater

- Seawater intrusion from the Mediterranean Sea
- Salt water up-coning due to overabstraction
- Salt intrusion by return flow from irrigation and by recharge

Model types

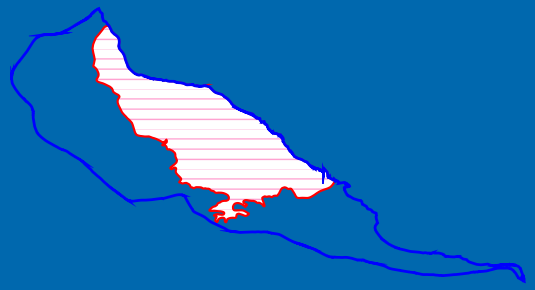
- Simplified 3D freshwater model (GMS/Modflow)
- 2D saltwater/freshwater model for one cross section (SUTRA)

Other problems in the area, possibly caused by agriculture:

- High nitrate contents and pesticides in the groundwater

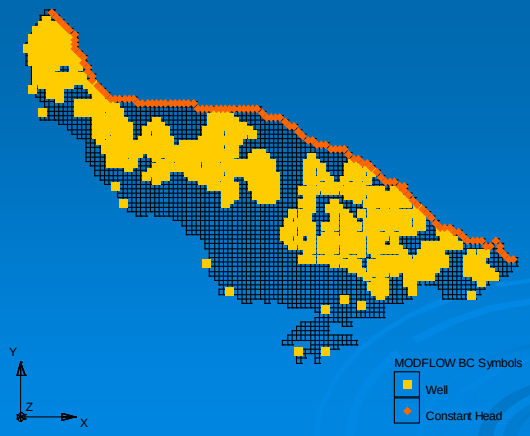
3D Modeling

Model Area



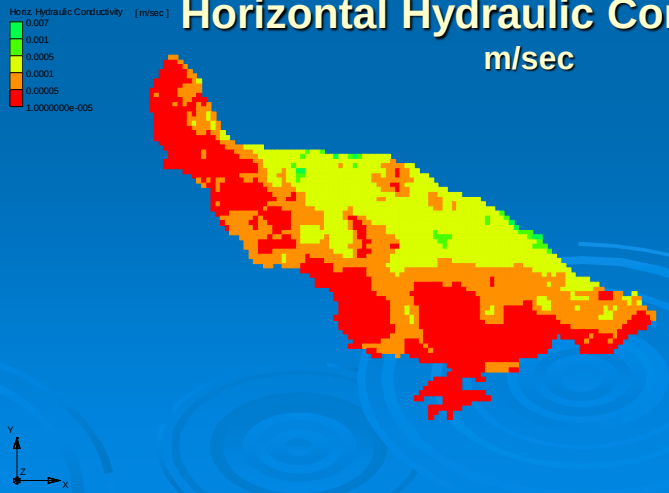
Model Grid

Conceptual Model



Horizontal Hydraulic Conductivity

m/sec



DSS - Project?

to develop and apply a :

user-friendly

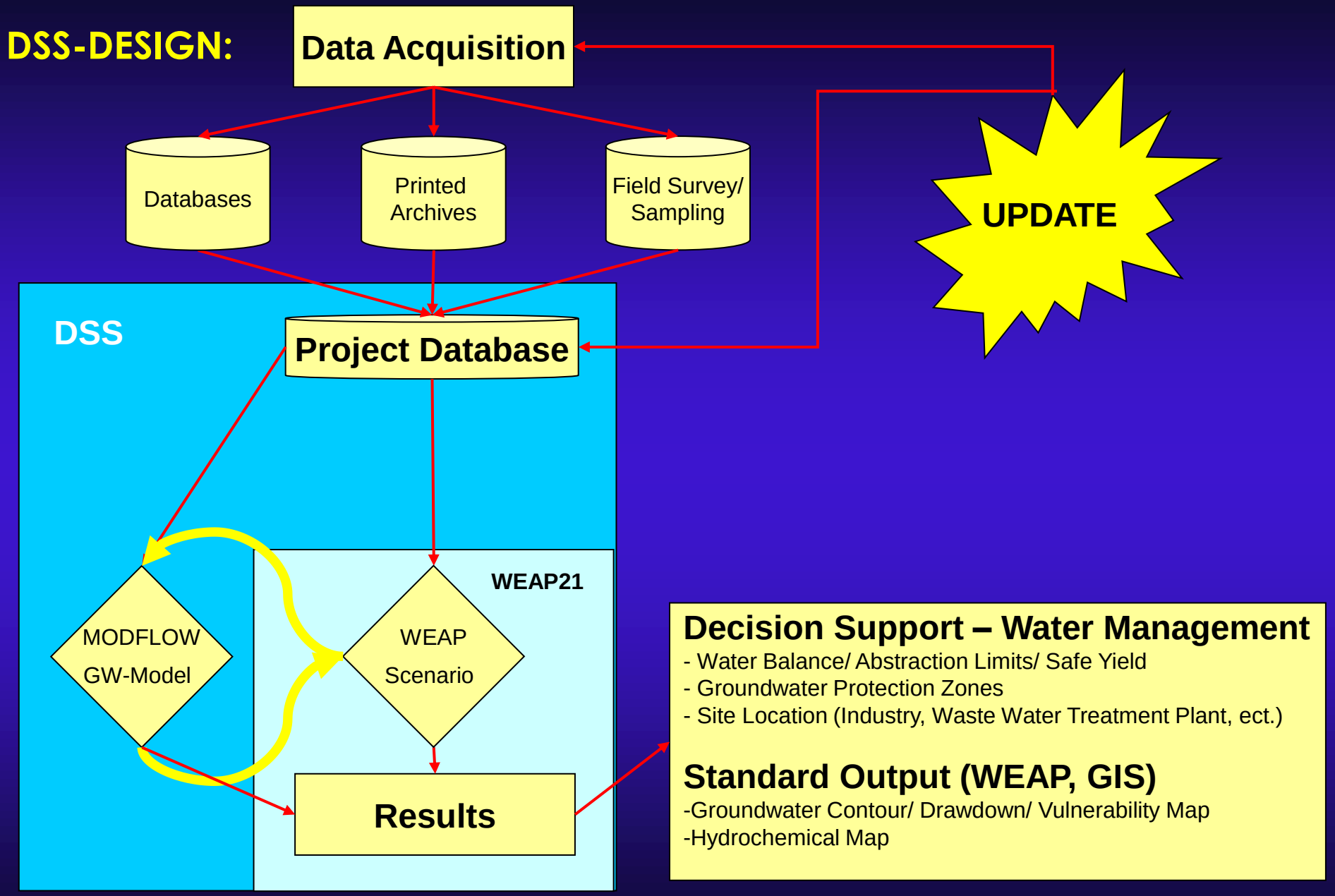
efficient

inexpensive

easily sharable

water planning and management tool

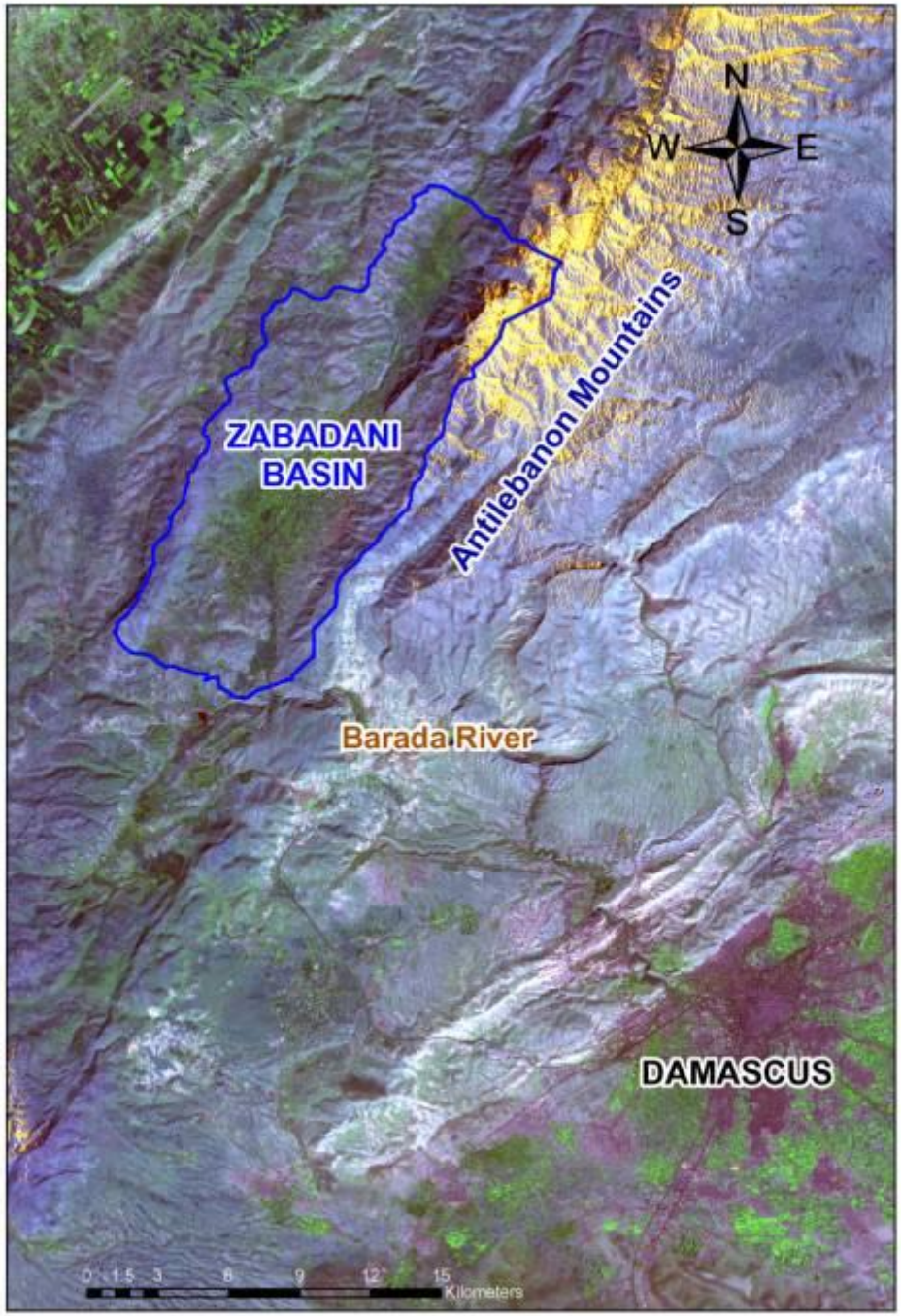
and make it available in order to work together towards a more integrated water resources management in the Middle East and beyond

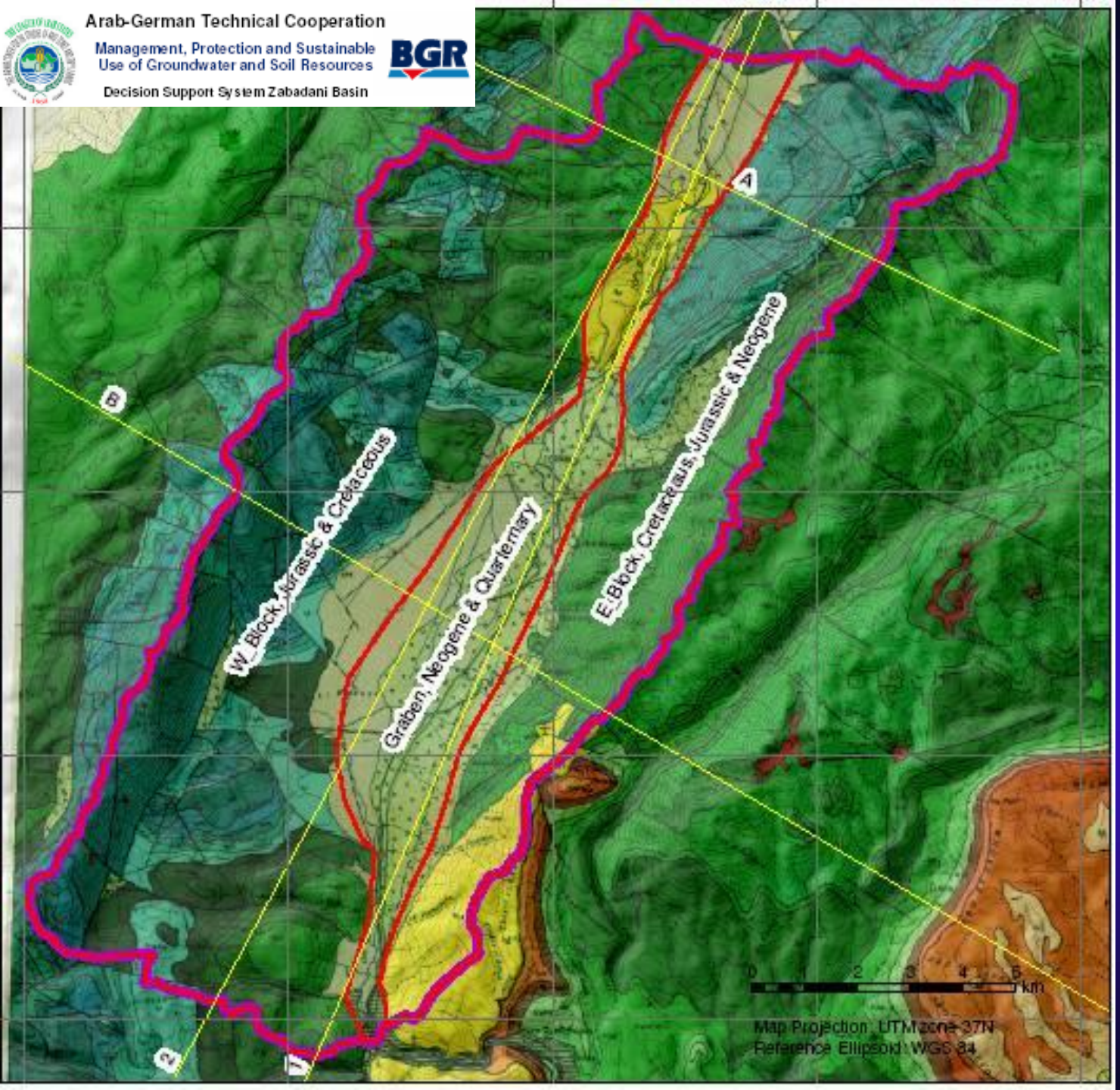

DSS-DESIGN:
Data Acquisition
Databases
Printed Archives
Field Survey/ Sampling
UPDATE
DSS
Project Database
WEAP21
MODFLOW
GW-Model
WEAP
Scenario
Results
Decision Support – Water Management
- Water Balance/ Abstraction Limits/ Safe Yield
- Groundwater Protection Zones
- Site Location (Industry, Waste Water Treatment Plant, ect.)
Standard Output (WEAP, GIS)
-Groundwater Contour/ Drawdown/ Vulnerability Map
-Hydrochemical Map

PILOT AREA I:

ZABADANI BASIN, SYRIA

- Area 165 km², Precip. 700 mm/a
- Existing Water Conflict between multi-groundwater users (Drinking Water – Damascus/ local, Agriculture, Tourism)





Complexe

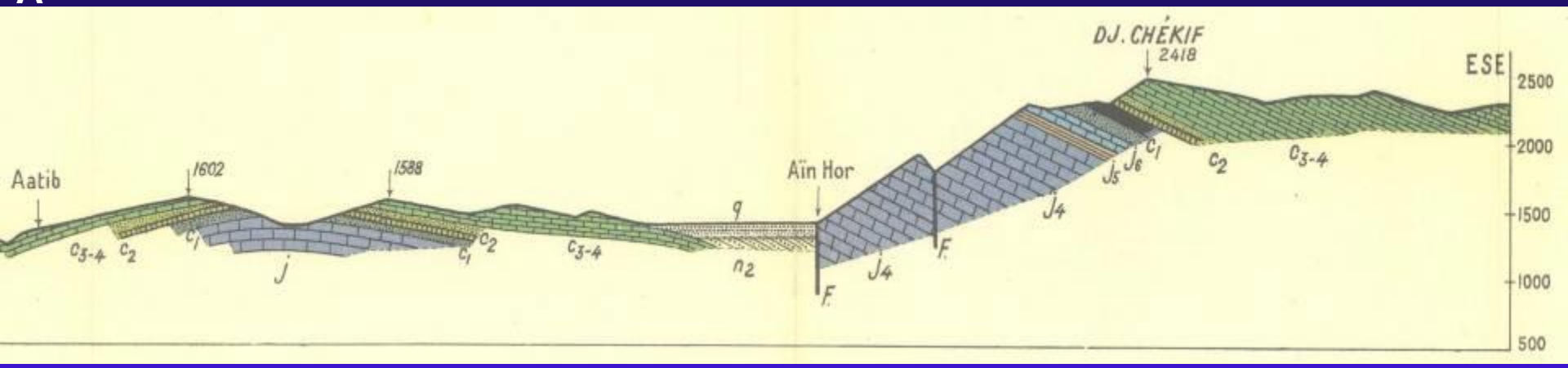
Tectonics,

Geology &

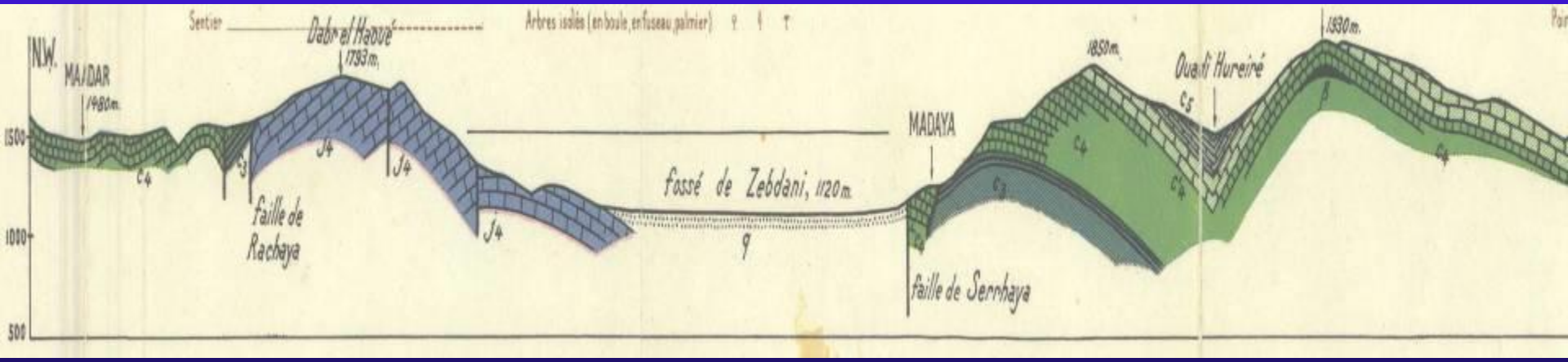
Hydrogeology

Cross Sections WNW-ESE

A



B



Chir Mansour Horst Anticline

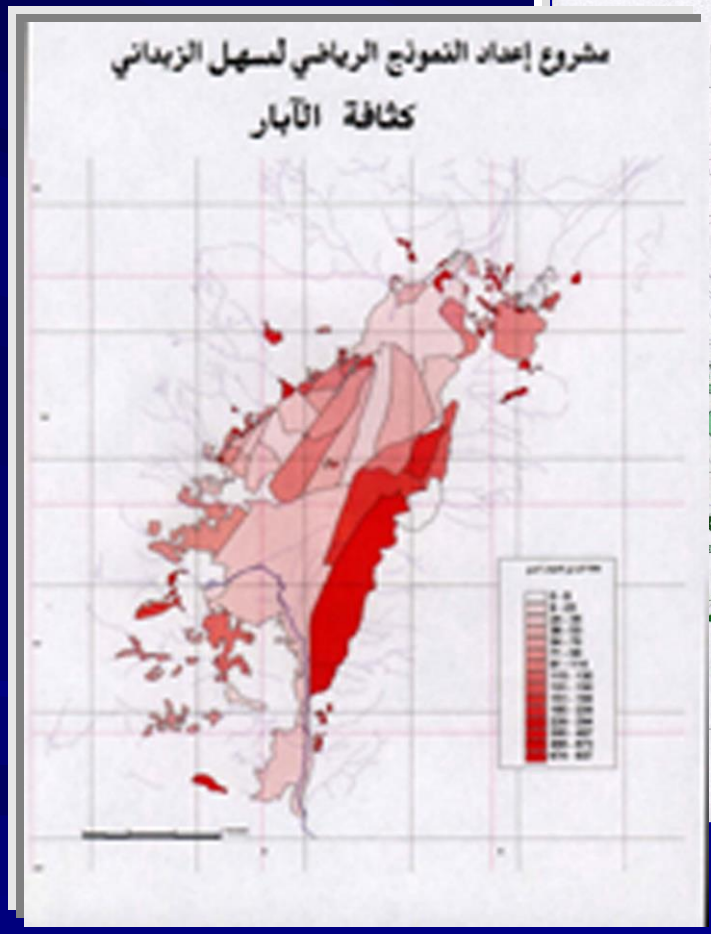
Zabadani Graben

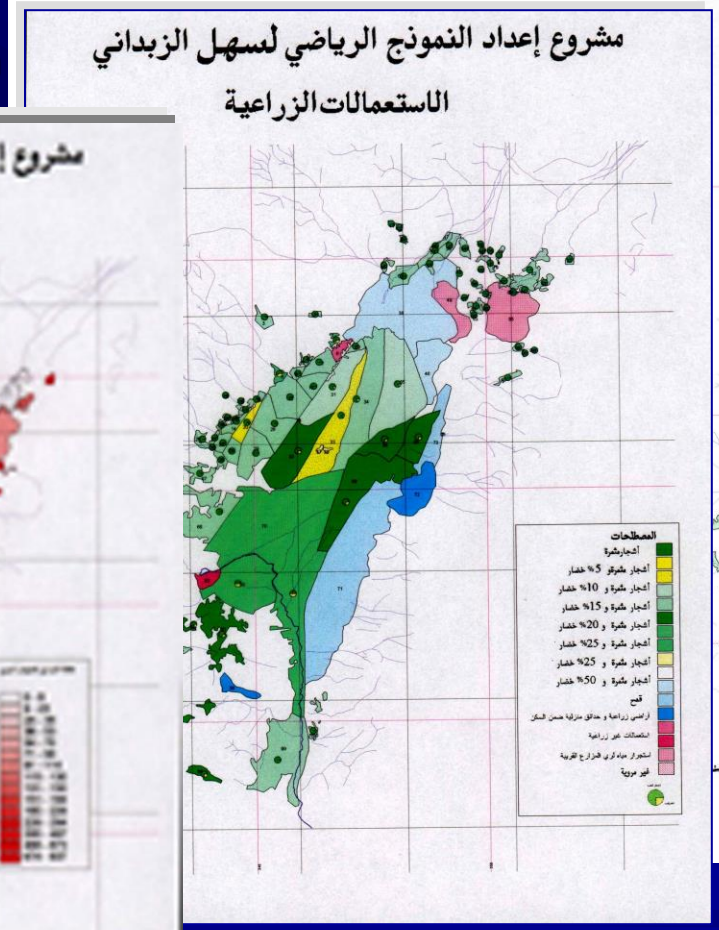
Cheqif Monocline

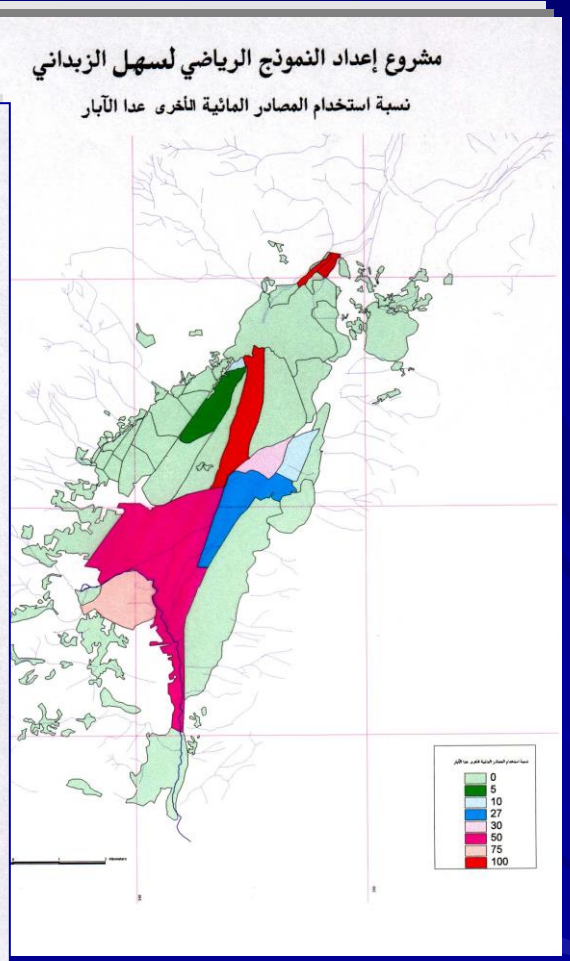
S.W. & Sewerage W. used for irrigation

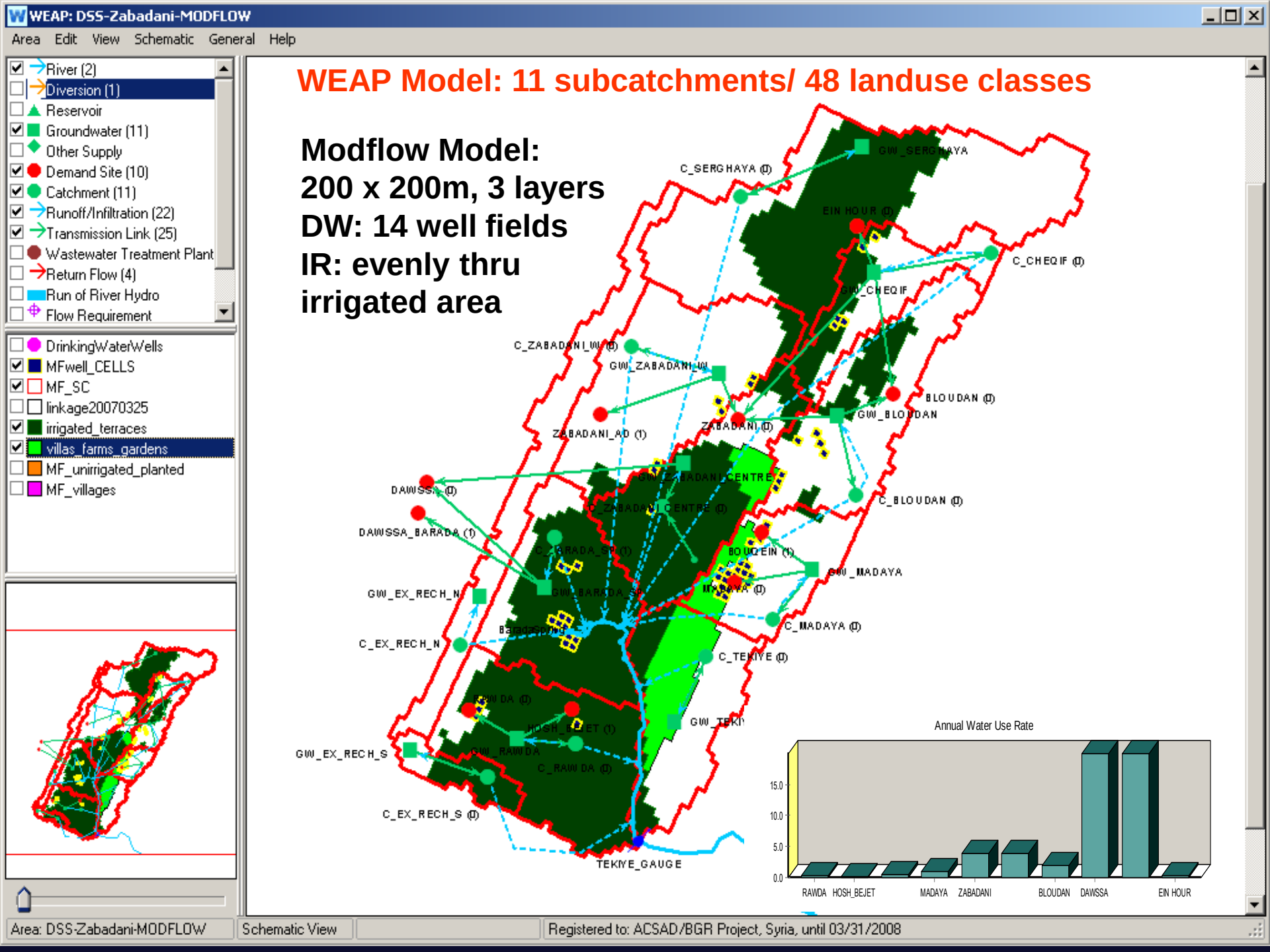
G.W. Use for irrigation

B.H. Density distribution





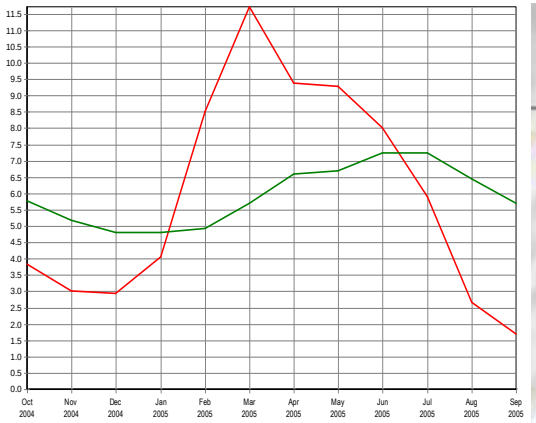



WEAP: DSS-Zabadani-MODFLOW
Area Edit View Schematic General Help
River (2)
Diversion (1)
Reservoir
Groundwater (11)
Other Supply
Demand Site (10)
Catchment (11)
Runoff/Infiltration (22)
Transmission Link (25)
Wastewater Treatment Plant
Return Flow (4)
Run of River Hydro
Flow Requirement
DrinkingWaterWells
MFwell_CELLS
MF_SC
linkage20070325
irrigated_terraces
villas_farms_gardens
MF_unirrigated_planted
MF_villages
WEAP Model: 11 subcatchments/ 48 landuse classes
Modflow Model:
200 x 200m, 3 layers
DW: 14 well fields
IR: evenly thru
irrigated area
C_SERGHAYA (D)
GW_SERGHAYA
EIN HOUR (D)
C_CHEQIF (D)
GW_CHEQIF
C_ZABADANI_W (D)
GW_ZABADANI_W
BLOUDAN (D)
GW_BLOUDAN
ZABADANI_AD (1)
ZABADANI (D)
DAWSSA (D)
C_BLOUDAN (D)
DAWSSA_BARADA (1)
BOUQEIN (1)
GW_MADAYA
GW_EX_RECH_N
MADAYA (D)
C_MADAYA (D)
C_EX_RECH_N
C_TEKIYE (D)
GW_EX_RECH_S
GW_RAWDA
C_RAWDA (D)
C_EX_RECH_S (D)
TEKIYE_GAUGE
Annual Water Use Rate
15.0
10.0
5.0
0.0
RAWDA
HOSH_BEJET
MADAYA
ZABADANI
BLOUDAN
DAWSSA
EIN HOUR
Area: DSS-Zabadani-MODFLOW
Schematic View
Registered to: ACSAD/BGR Project, Syria, until 03/31/2008

Groundwater balance

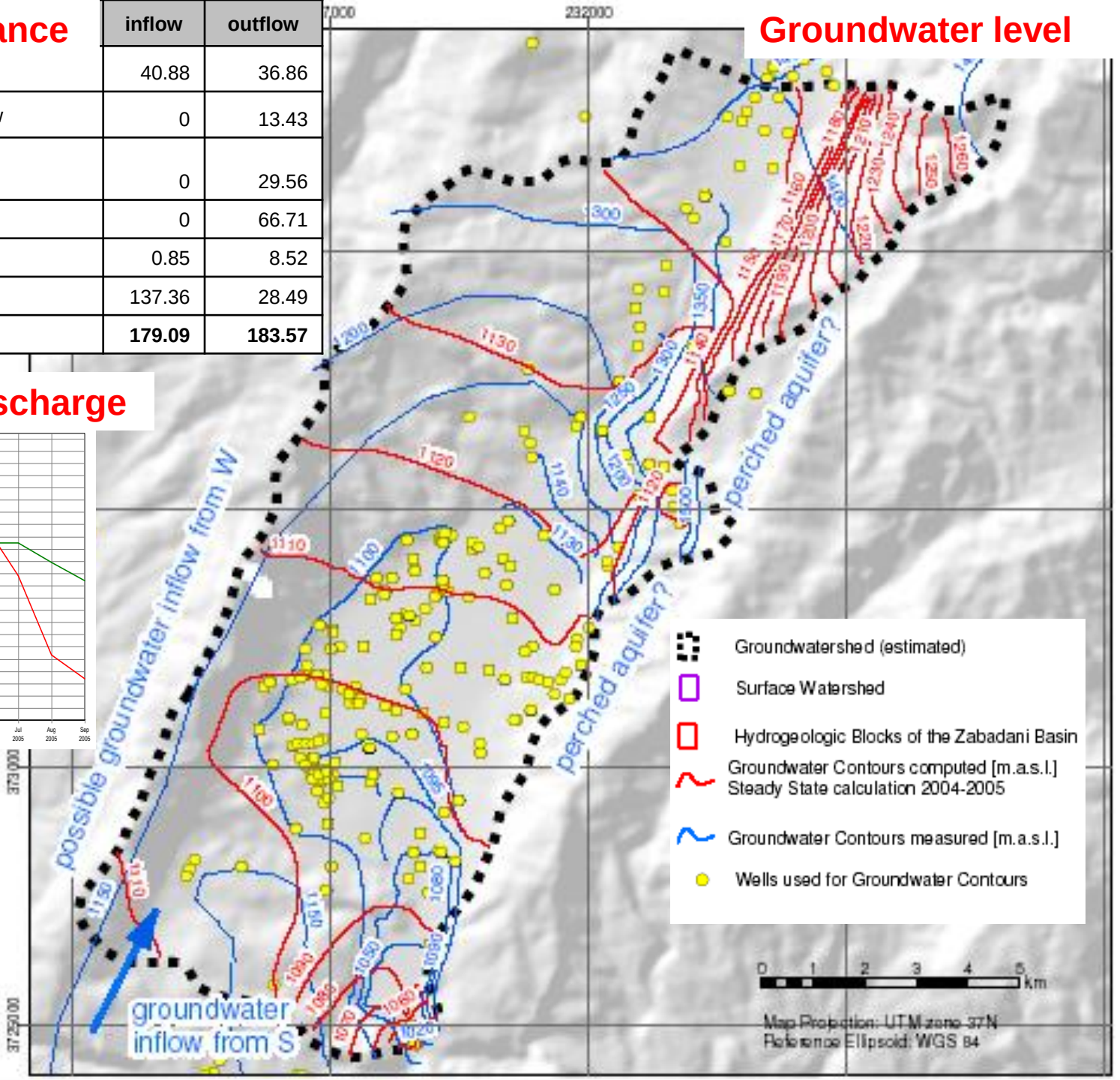
	inflow	outflow
Storage	40.88	36.86
Constant Head lateral GW-outflow	0	13.43
Wells (here drinking water wellfields)	0	29.56
Drains (Barada Spring)	0	66.71
River Leakage	0.85	8.52
Recharge (net sum of cell values)	137.36	28.49
TOTAL (all in Mm³)	**179.09**	**183.57**

Barada Spring discharge



GW-MODEL RESULTS (MODFLOW 2000)

Groundwater level



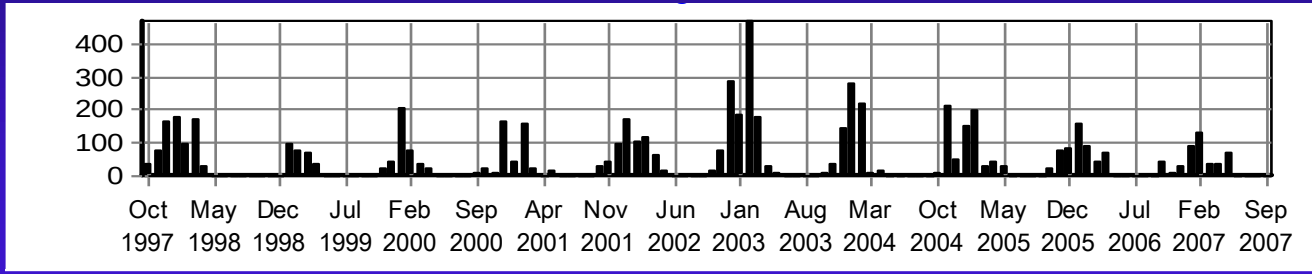
Preliminary Water Balance 2004/ 2005

Month	GW-Abstraction / Spring discharge				Rainfall	Recharge	BALANCE
	Barada Spring	Irrigation	Domestic	SUM			
10/2004	2.42	4.085	4.559	11.064	1.261	1.113	-9.951
11/2004	5.6	0.000	4.101	9.701	29.943	7.350	-2.351
12/2004	4.53	0.000	3.87	8.400	7.003	7.487	-0.913
01/2005	4.43	0.000	3.228	7.658	21.381	9.301	**1.643**
02/2005	7.52	0.000	0.766	8.286	27.494	11.408	**3.122**
03/2005	13.07	0.000	0.766	13.836	3.928	9.980	-3.856
04/2005	9.52	0.000	0.766	10.286	5.61	6.552	-3.734
05/2005	5.77	0.000	0.766	6.536	3.772	3.758	-2.778
06/2005	7.47	2.884	0.766	11.120		1.793	-9.327
07/2005	4.16	14.218	2.038	20.416		1.299	-19.117
08/2005	1.88	2.670	3.593	8.143		1.066	-7.076
09/2005	1.78	7.488	3.952	13.220		0.914	-12.306
SUM	**68.15**	**31.345**	**29.171**	**128.666**	**100.393**	**62.022**	**-66.644**

All units in Mm^3, irrigation and recharge volumes calculated in WEAP

RESULTS OF THE DSS-SYSTEM

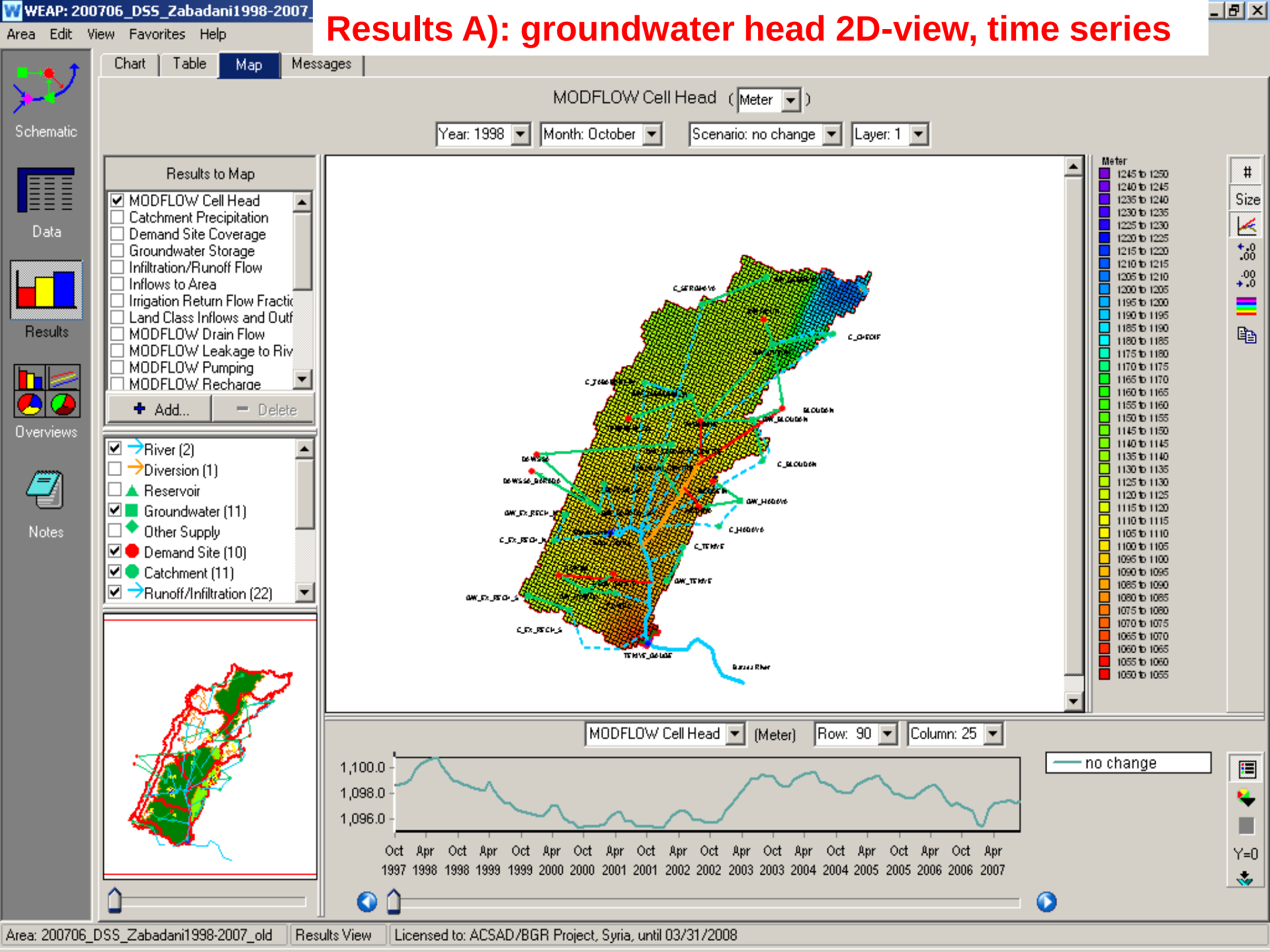
A) Historic scenario 1998 - 2007
to evaluate the DSS accuracy (wet/dry years)



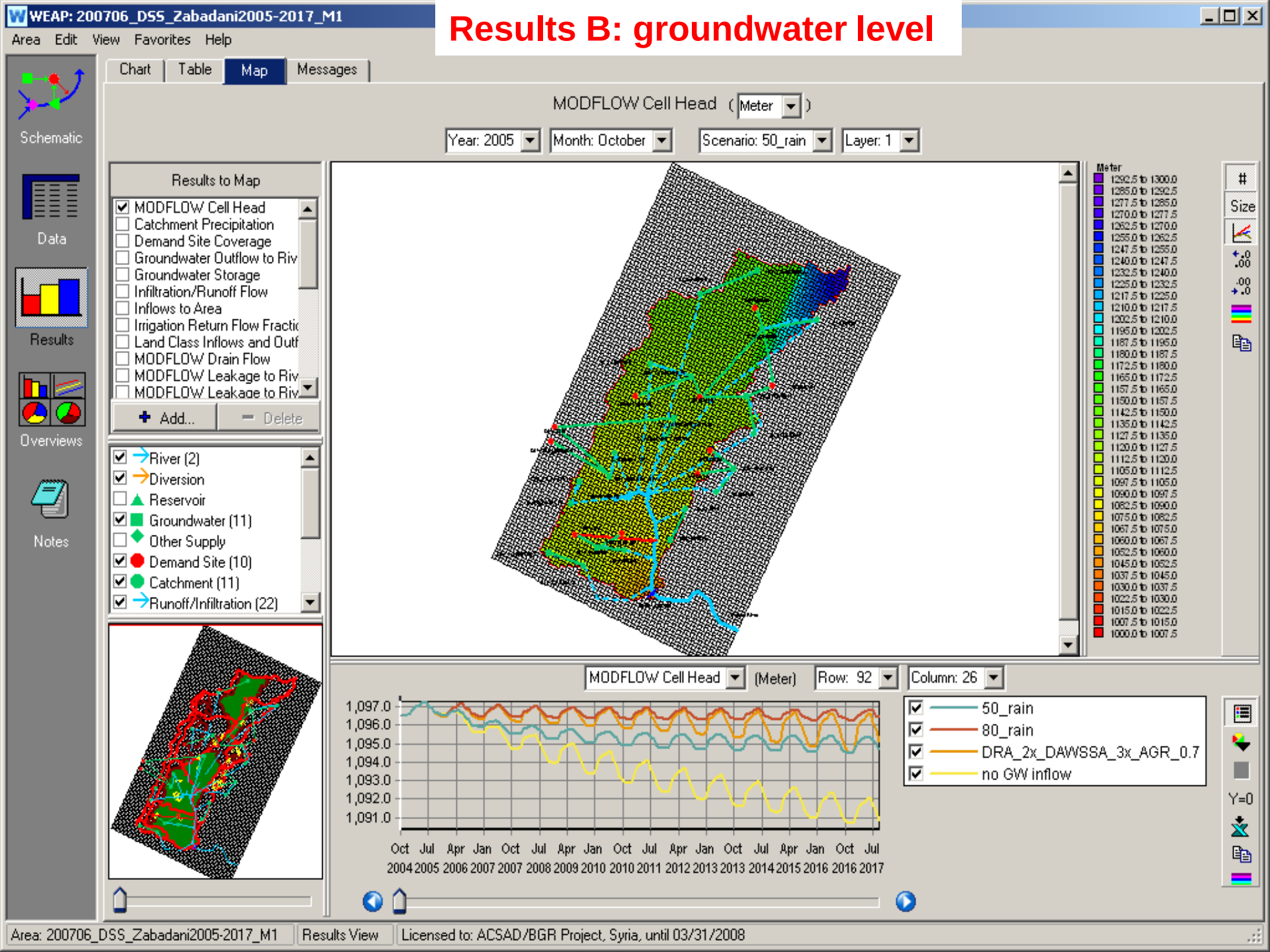
B) Planning scenarios 2005 – 2017
impacts of demand changes, climate change, boundary condition changes,…

1) 50_rain: 50% of the annual rain from 2005 onward
2) 80_rain: 20% decrease of annual rainfall within 12 years
3) DRA_2x_DAWSSA_3x_AGR_0.7: increase in drinking water abstraction/ reduction in irrigation
4) no GW – inflow: no groundwater inflow from outside the basin.

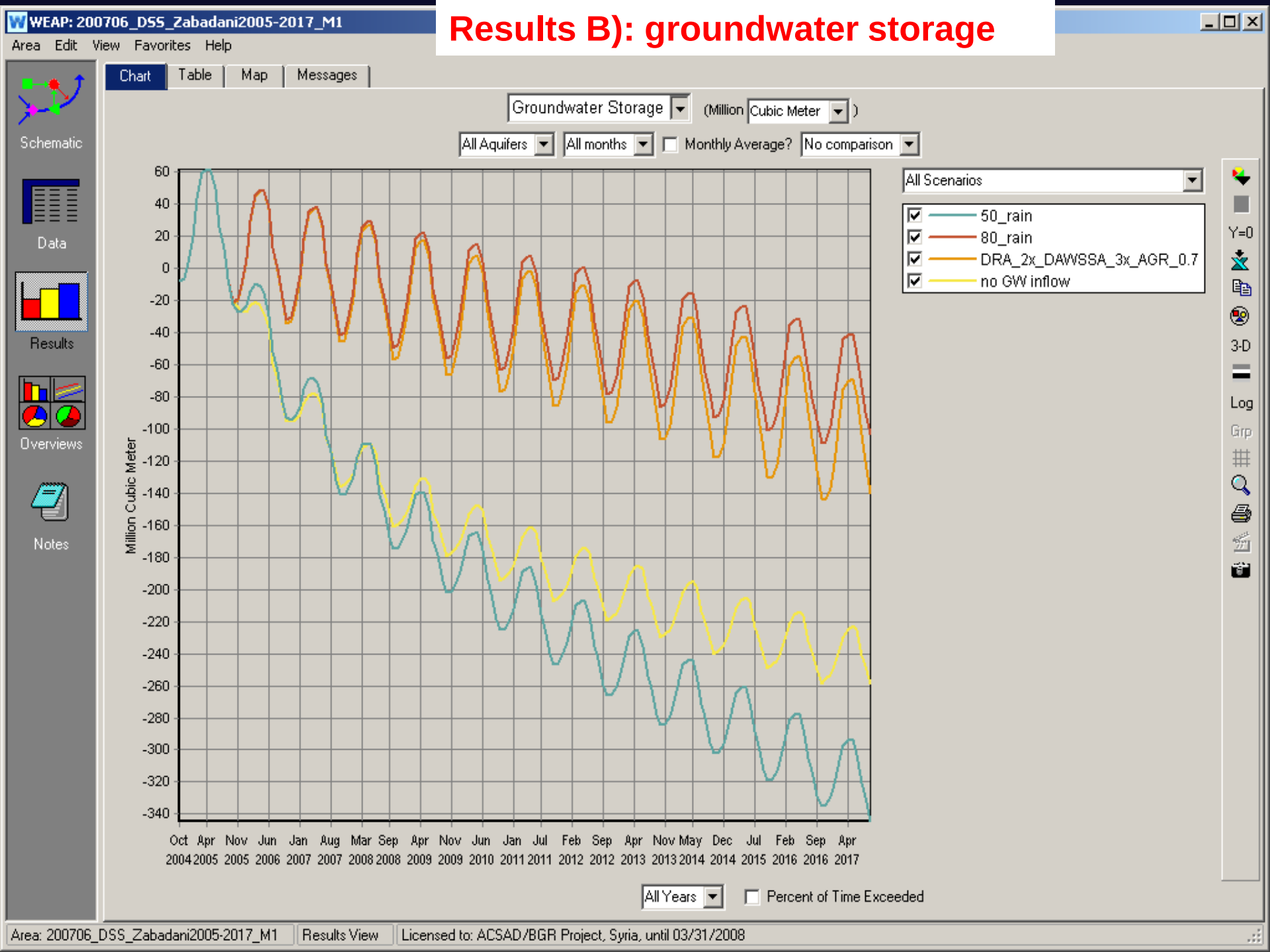
Results A): groundwater head 2D-view, time series



Results B: groundwater level



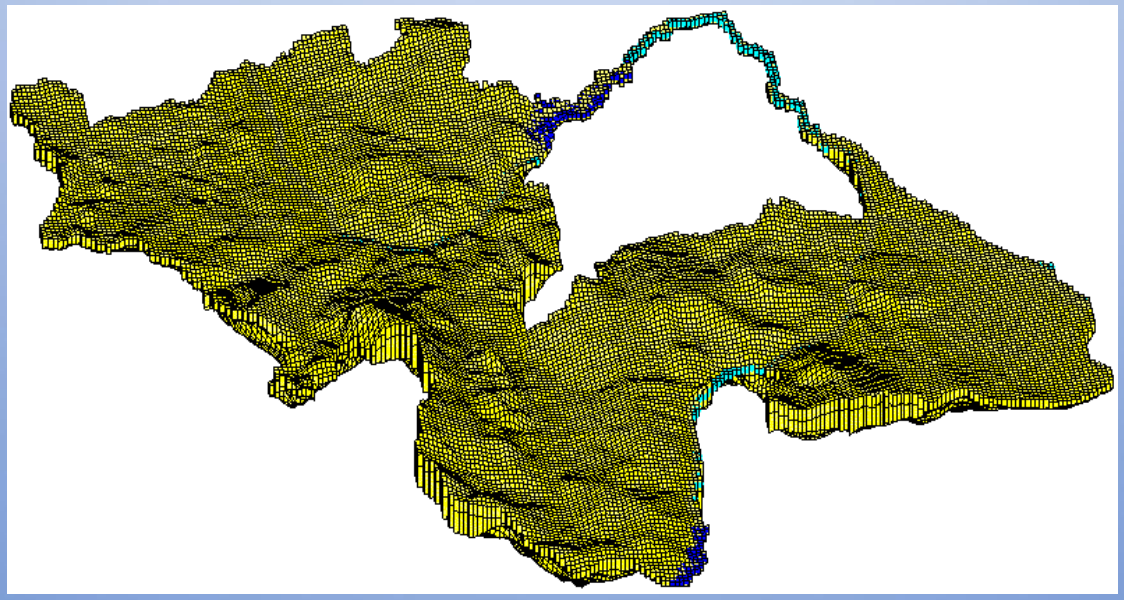
Results B): groundwater storage



Other case studies

Mathematical model of Nubian sandstone aquifer in Sudan

Northern, Nile river and Khartoum states

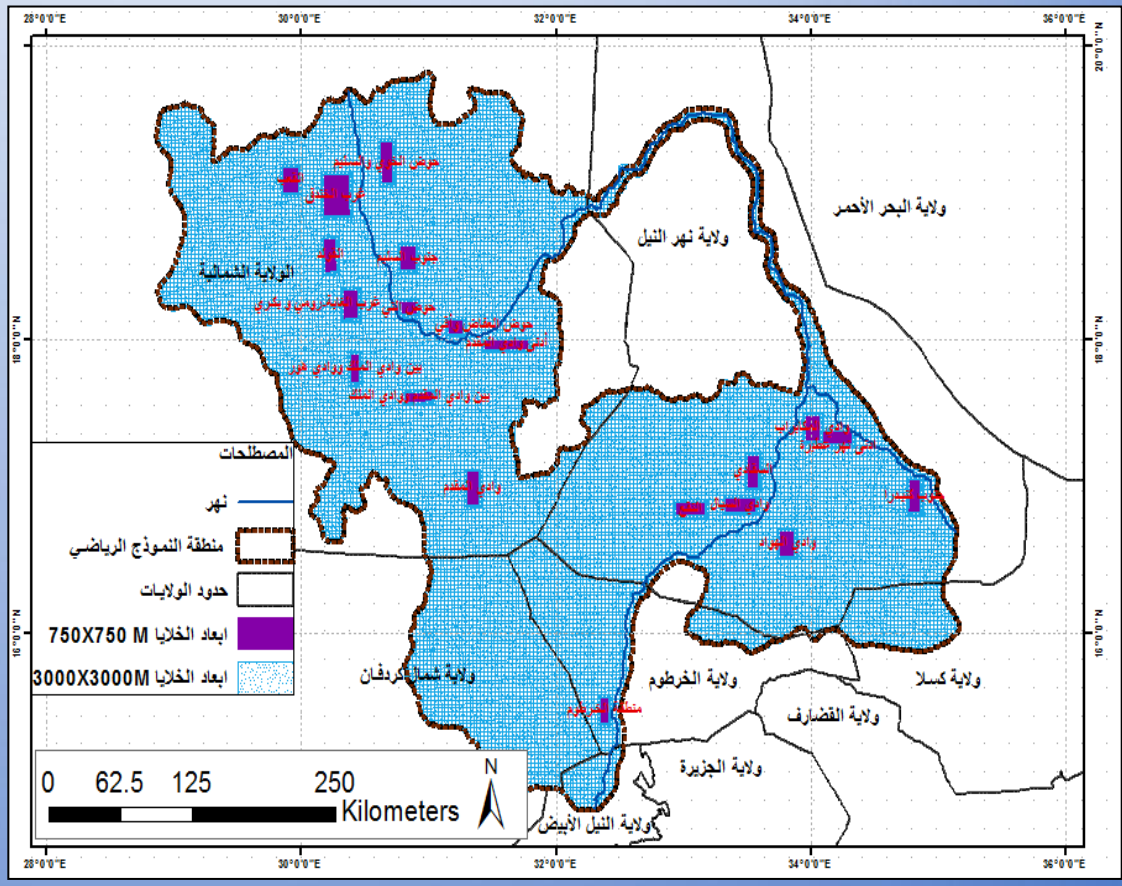


Local models in the promising areas

Local model were prepared for the proposed projects areas (20 projects) within the promising areas. The model cells were refined within the project area from 3000X3000 m to 750X750 m.

Refinement of model cells allow better representation of abstraction wells in term of distance between wells and its abstraction rate, and determination of radius of impact for each project and the safe distance between projects.

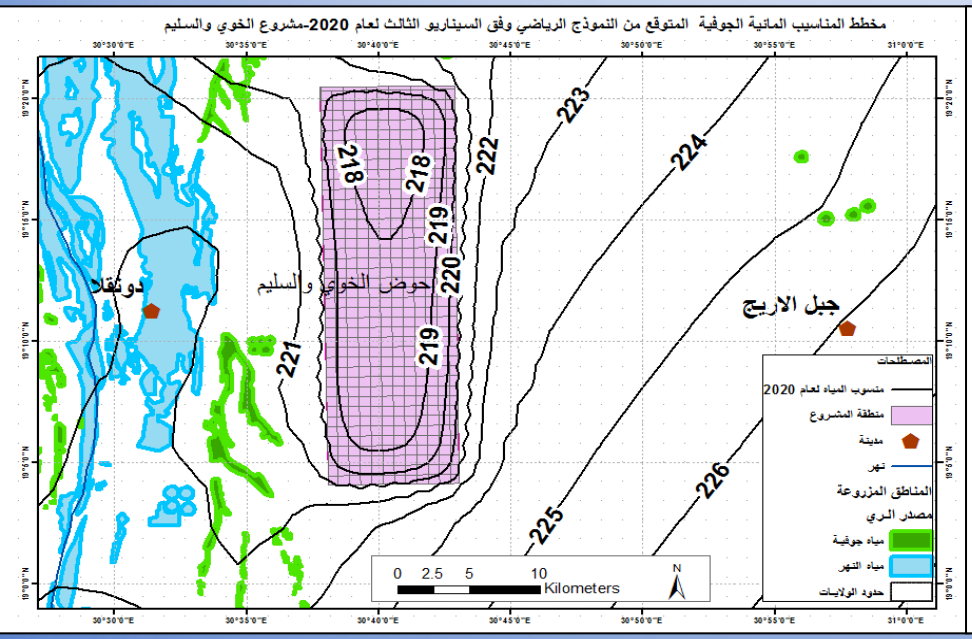
Also, it allows determination of radius of impact for single well and testing the effect of changing abstraction rate on the radius of impact and the drawdown development by time.



Local models for promising areas

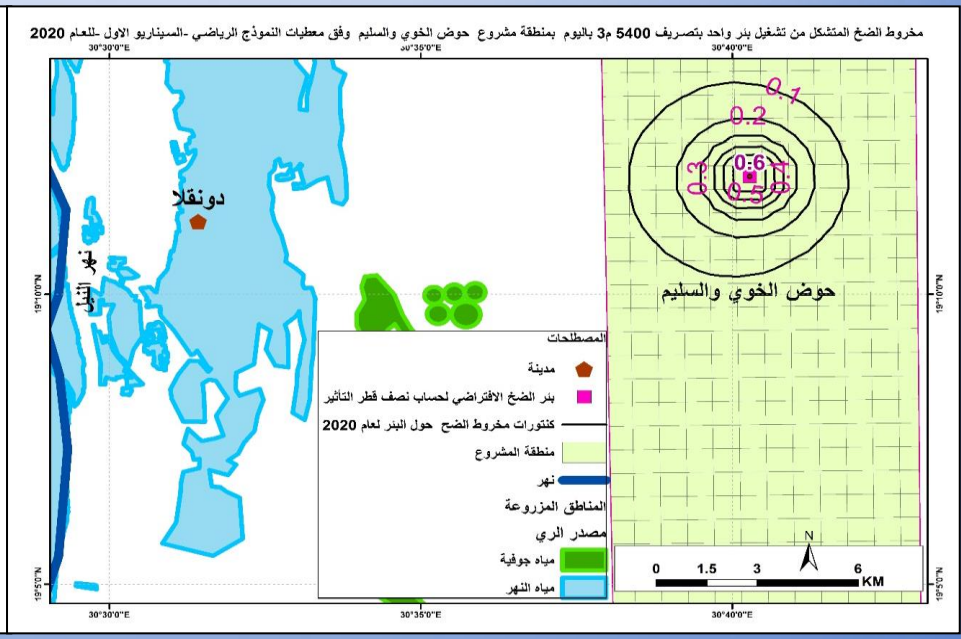
Determination the impact radius of single well and a project after one year in Alkhway sleem area

radius of impact for a project



radius of impact for the project about 10

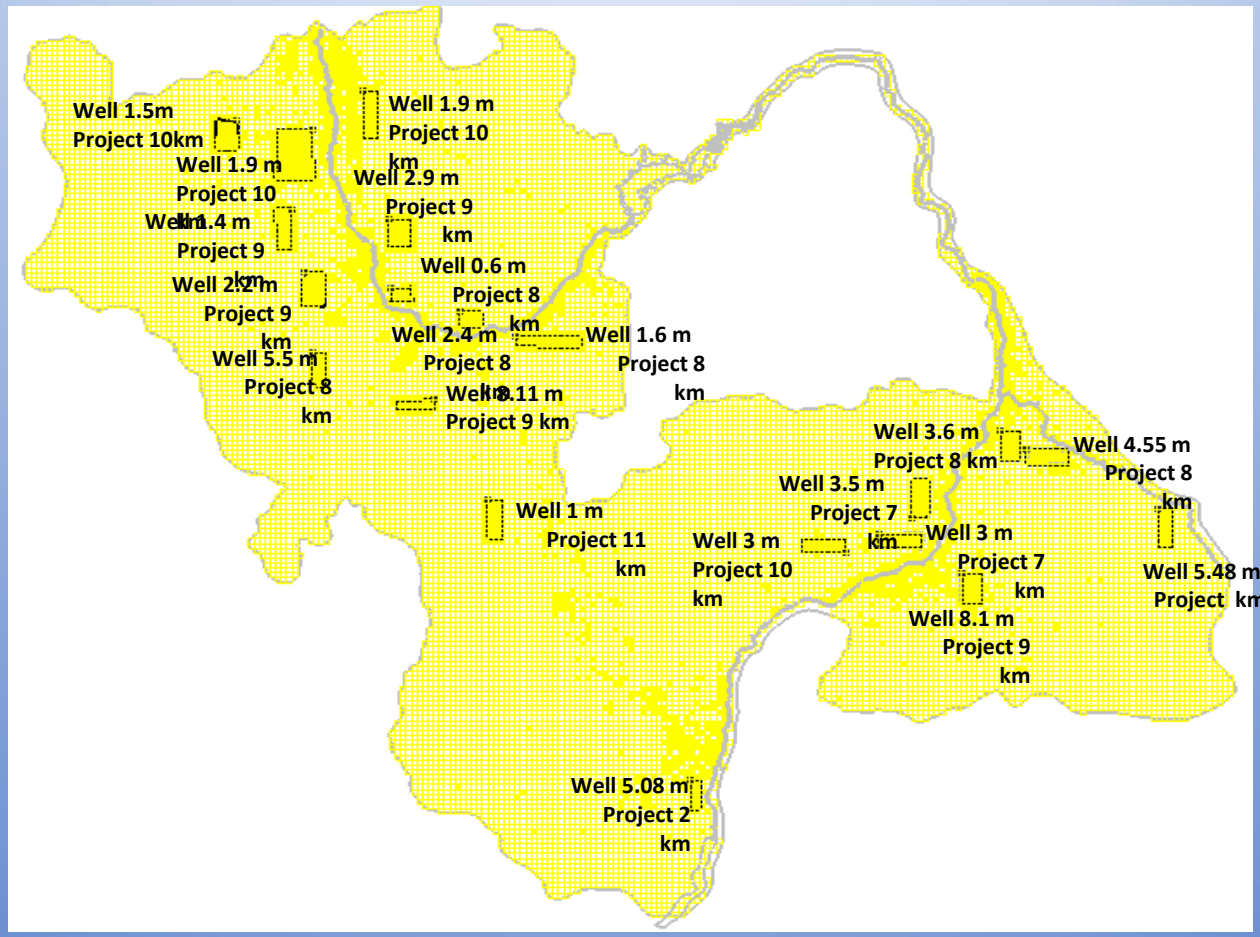
radius of impact for single well



radius of impact for single well about 2.3 km

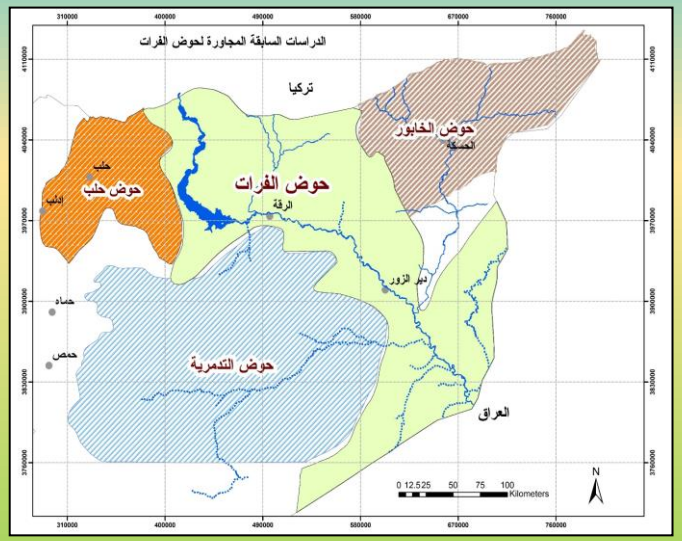
maximum drawdown 0.6 m

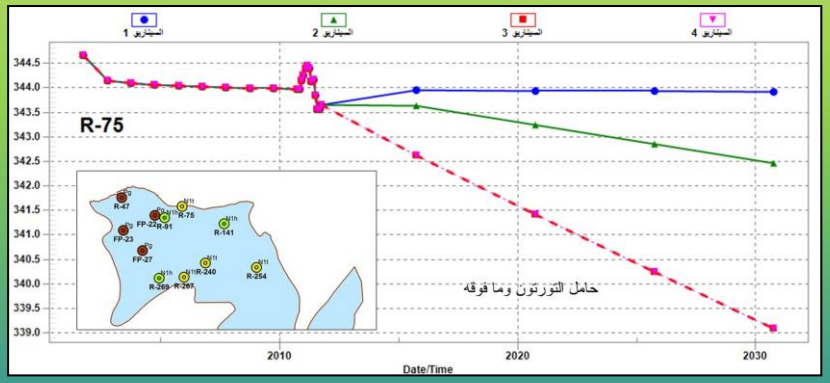
The Impact radius for the project, and drawdown at 0.5 km distance from single well discharges 5400 m3/day



Mathematical model for the groundwater reservoir in the Euphrates Basin

The objective of the project is to calculate the groundwater budget for the Euphrates basin, know the capacity of the groundwater resources in the basin, indicate the pumping volume of groundwater, indicate the effects of development plans proposed by local administrations and select the appropriate ones, and to determine and calibrate the spatial distribution of hydraulic parameters and their impact on the results of the mathematical model. Also to build human capacity capable of using these technologies to manage water resources in the future.



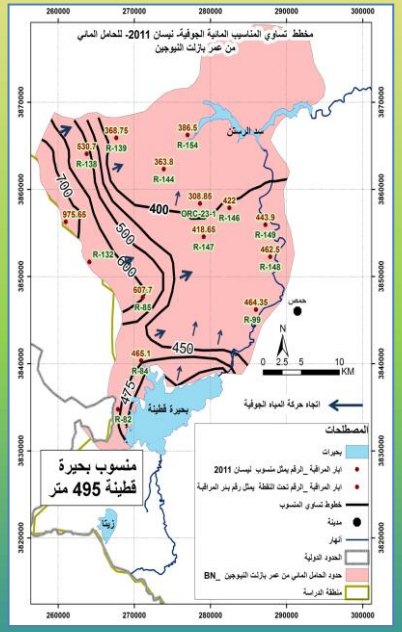


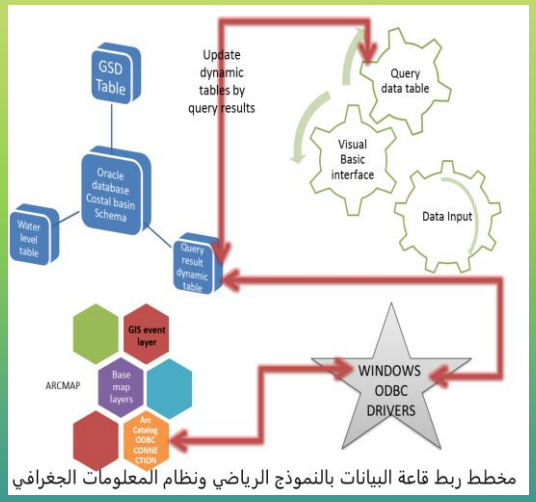
The Euphrates Basin is located in the eastern and northeastern region of the Syrian Arab Republic. The area of the basin is about (45.5) thousand km2. The international borders with Turkey form its northern border, its western borders with the Aleppo Basin, its southern borders with the Badia Basin, and its eastern borders with the Tigris and Khabur Basin and with Iraq. The Euphrates River penetrates the basin with a length of about 610 km and is fed by the Balikh River and then by the Khabur River.

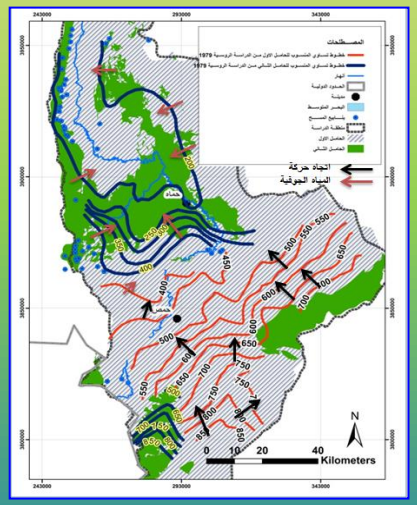
Mathematical Model of the groundwater Reservoir in the Orontes River Basin

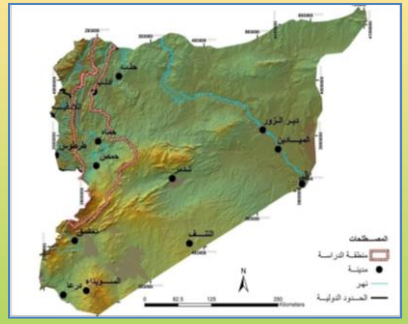
The objective of the project: To indicate direction, movement and hydrochemistry of groundwater, prepare a water budget for the surface and groundwater in the basin and the natural reserves of the aquifers, and clarify the hydrogeological relationship between the Orontes basin and the adjacent basins, in addition to identifying the promising areas for the occurrence of groundwater, and studying and evaluating the current and future environmental situation resulting from Implementation of the groundwater withdrawal plans.

Promising areas for groundwater pumping in the Orontes Basin were defined

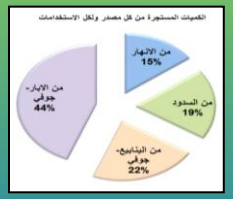






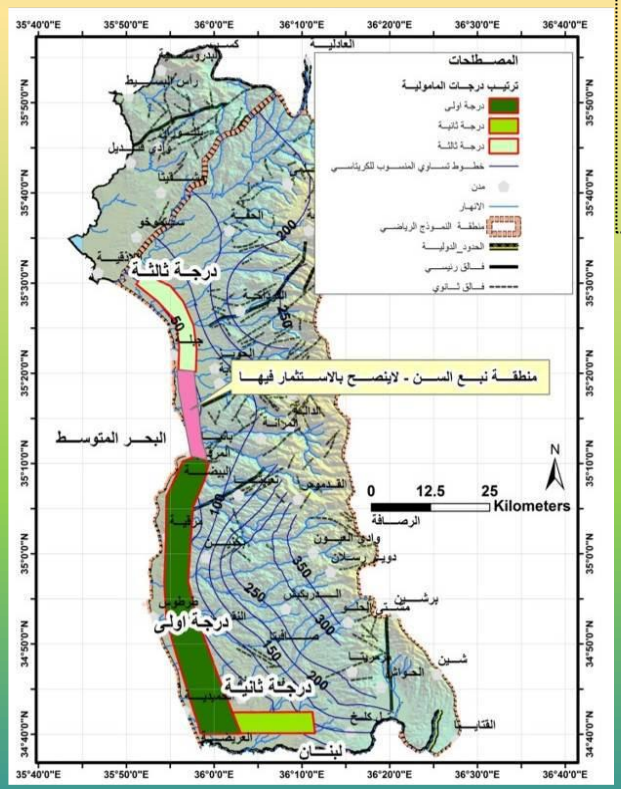


The study area is located in the central region of the Syrian Arab Republic, representing the Orontes River Basin

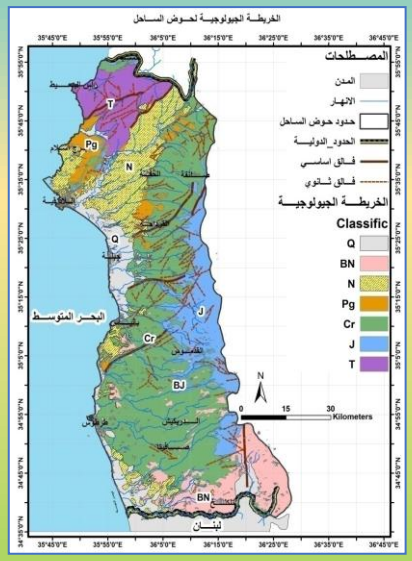


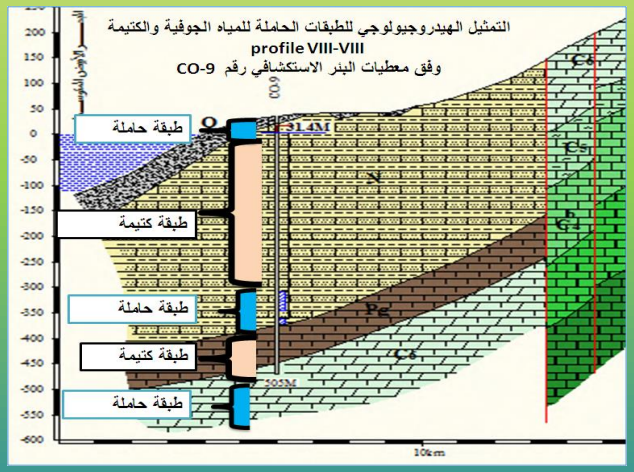
Mathematical model for aquifer system in the Syrian coastal basin

Promising areas for groundwater pumping in the coastal basin

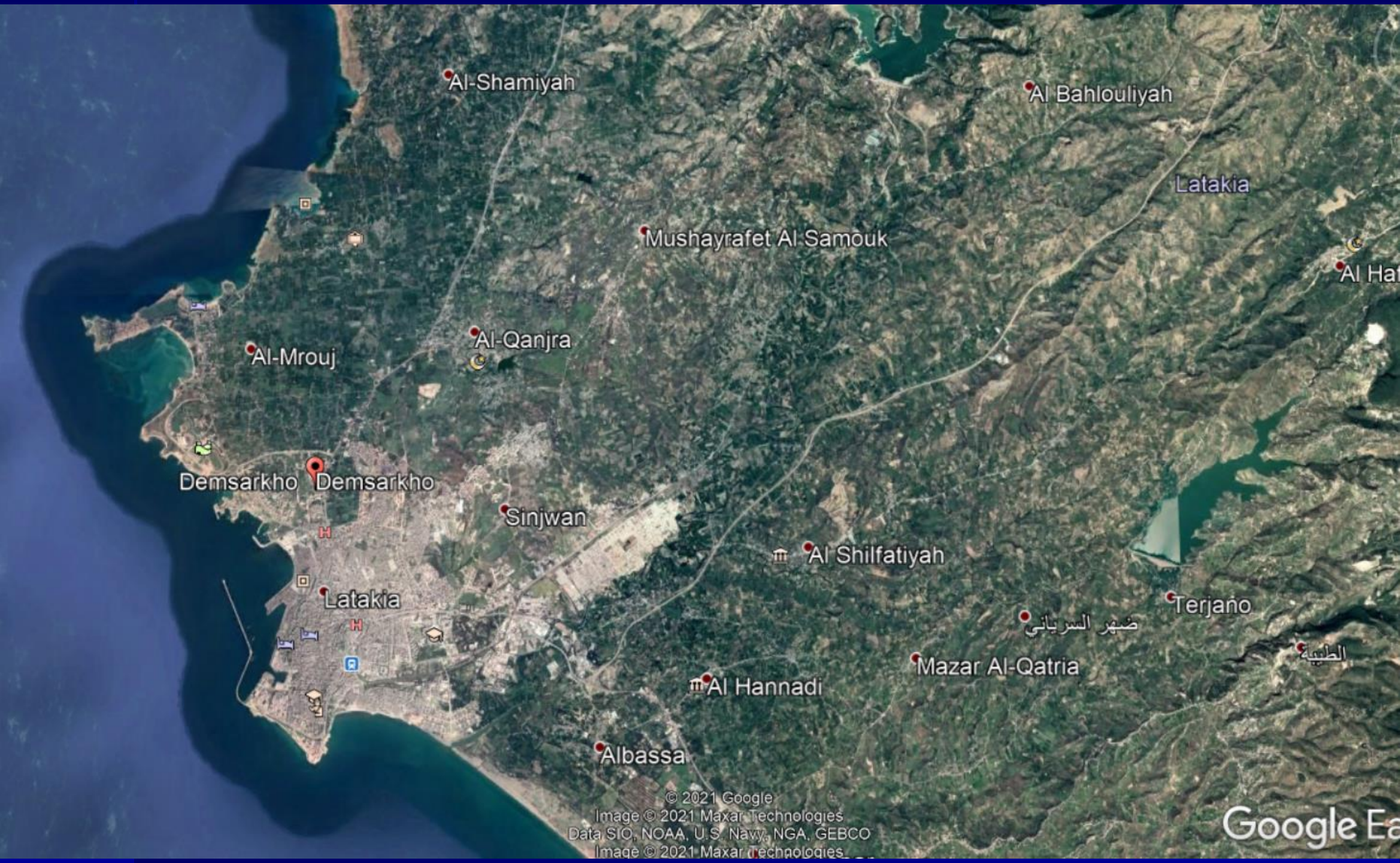


The project objective is to prepare a mathematical model for groundwater in the coastal basin, to be a tool that helps the administration in preparing future impact of existing or future groundwater withdrawal, and to study the alternatives plans,, improving the knowledge about water resources and groundwater in the basin.





The coastal basin is located in the far western and northwestern part of the Syrian Arab Republic, with an area of (5,049) km2 with a south-north extension along the shore of the Mediterranean Sea, with a length of about 125 km, and an average width of about 40 km. A large number of rivers and valleys penetrates the basin, some of which are flowing al over the year into the Mediterranean Sea.


Al-Shamiyah
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Latakia
Mushayrafet Al Samouk
Al-Qanjra
Al-Mrouj
Demsarkho
Demsarkho
Sinjwan
Al Shilfatiyah
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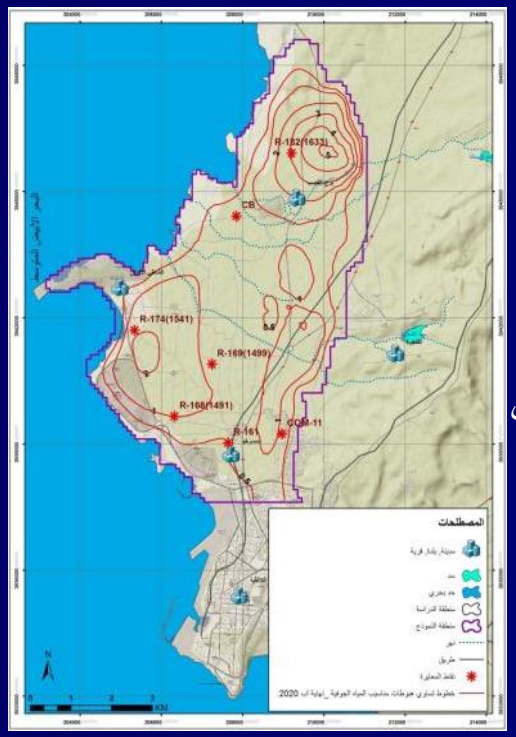
Sea water intrusion in the costal area - DemSarkho



الهدف:

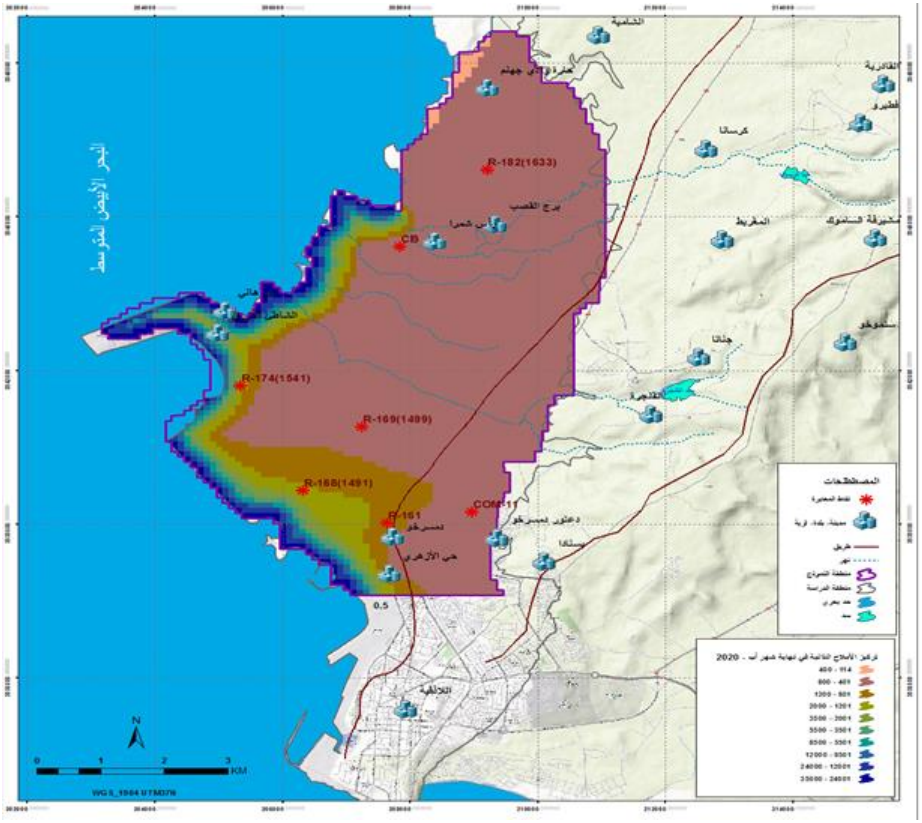
دراسة تداخل مياه البحر مع المياه الجوفية العذبة للحوامل المائية الساحلية، والتنبؤ بتغيرات نوعية المياه الجوفية في هذه المنطقة.

الإنجازات:

- إنجاز قاعدة بيانات نظام المعلومات الجغرافي GEODATABASE خاصة بمنطقة دمسرخو تشكل مرجعية للدراسات المستقبلية.
- إنشاء نموذج رياضي رقمي لتداخل مياه البحر مع المياه العذبة في منطقة دمسرخو
- اختبار عدة سيناريوهات افتراضية تعكس التبدلات المناخية وخطط الاستثمار المستقبلية وتحديد مقدار الهبوط في مناسيب المياه الجوفية ودرجة تركيز الأملاح الكلية الذائبة خلال السنوات الاستثمارية في عدة مواقع خاصة القريبة من ساحل البحر

جر المياه من سد 16 تشرين و استخدامه في الري حسن من نوعيه المياه الجوفيه

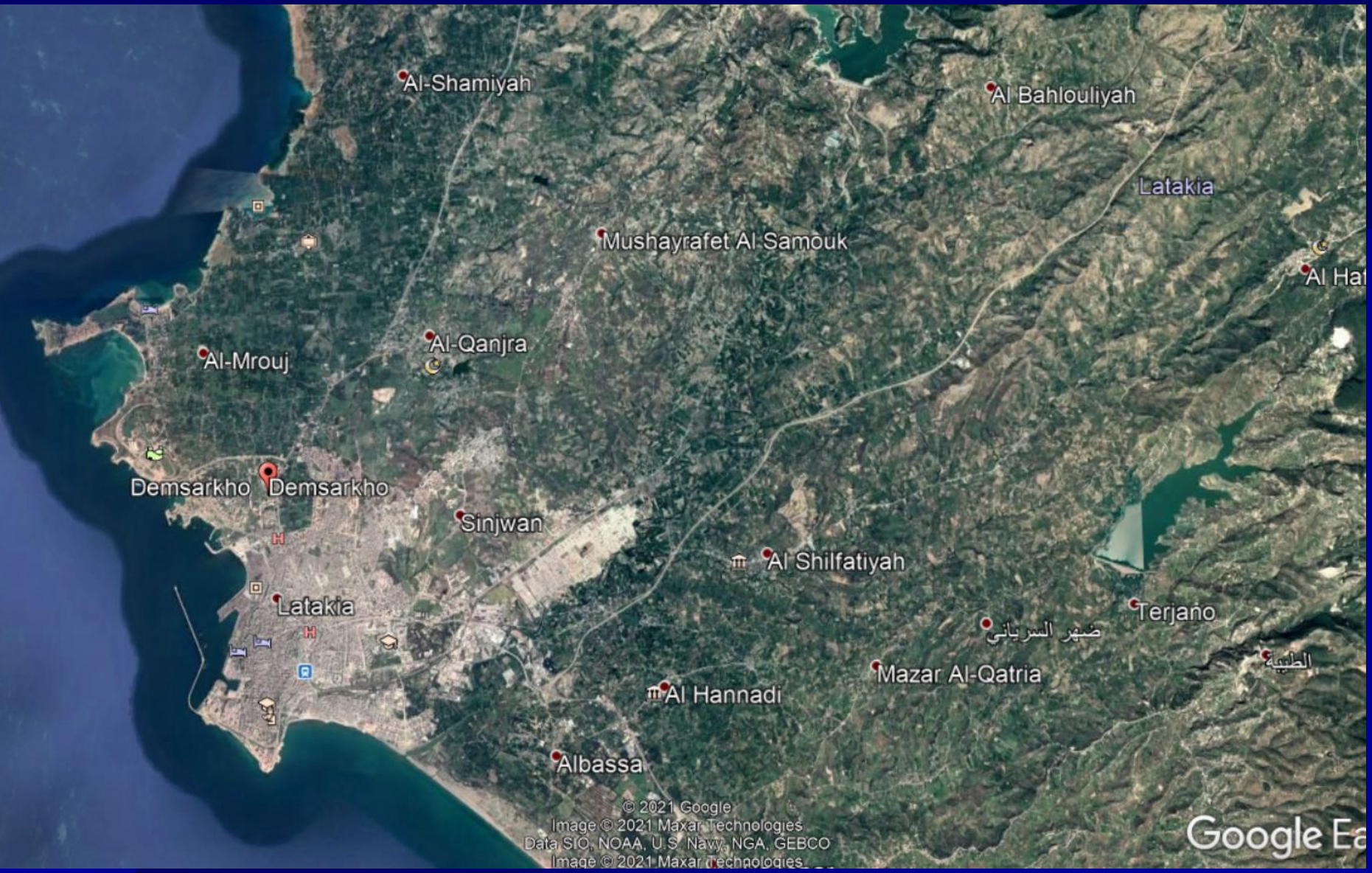
أولاً: برنامج الادارة المتكاملة للموارد المائية



مشروع النموذج الرياضي
لمنطقة دمسرخو

خريطة تركيز الاملاح نهاية
شهر آب 2020

ACSAD
Cairo 4-6/06/2014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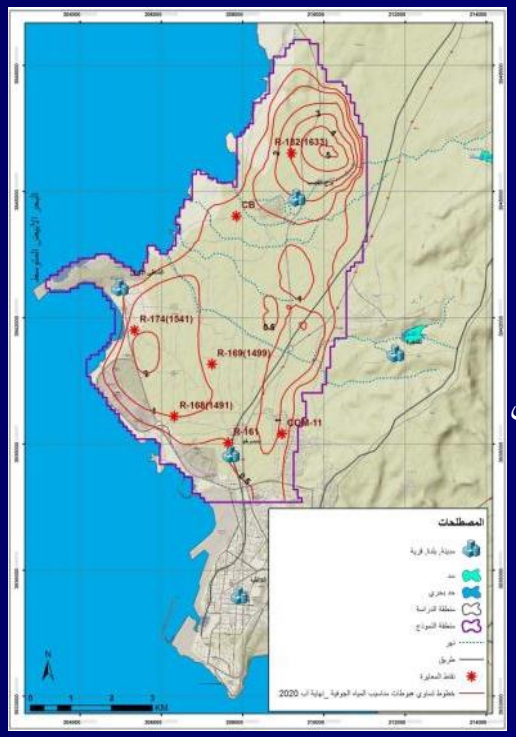

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شكرا لحسن استماعكم

Thanks For Your Kind Attention