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The role of groundwater resources in the sustainable development projects in the northwestern area of Libya

Dr. Yehia Lotfy Ismail [1]*, Dr. Mohamed Hamaed Mohamed [2],
Dr. Osama Omar Ahmaed [3]
[1] Department of Hydrology, Desert Research Center, Cairo, Egypt
[2] Department of Hydrology, Desert Research Center, Cairo, Egypt
[3] Department of Geography, Faculty of Arts, Asaba, University of Gharyan, Libya

دور موارد المياه الجوفية في مشاريع التنمية المستدامة في المنطقة الشمالية الغربية من ليبيا

يحي لطفي إسماعيل [1]*، محمد حمد محمد [2]، أسامة عمر أحمد [3]
[1]قسم الهيدرولوجيا، مركز بحوث الصحراء، القاهرة، مصر
[2] قسم الهيدرولوجيا، مركز بحوث الصحراء، القاهرة، مصر
[3] قسم الجغرافيا، كلية الآداب الأصابعة، جامعة غريان، ليبيا

*Corresponding author: *yehiashehata@hotmail.com*

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Abstract:
The sustainable development processes in the arid and semi-arid areas depend essentially on the potentiality of groundwater resources. This target concentrates on understanding aquifers' capability, considering water quantity and water quality. The study area is considered one of these arid areas, which lies in the northwestern portion of Libya. It covers an area of about 300 km^2 and lies between 10° 30' & 11° 50' E and 31° 30' & 32° 20' N. The study area comprises three water bearing formations, namely Jurassic Sandstone, fractured dolomitic limestone and Quaternary sand. The evaluation of the productivity of the wells for each aquifer and its water quality plays an outstanding role in the strategy of development priorities in the study area.
The distribution maps of productivity and salinity for Jurassic sandstone aquifer and Fractured Dolomitic Limestone aquifers show that the study area's western and northwestern portions are promising for sustainable development processes due to high productivity and good water quality.
Concerning the Quaternary aquifer, the productivity of wells and its water salinity increase in the same direction towards the east and northern east portions. So, these areas should be recommended for the activities which need brackish water type.

Keywords: Groundwater, Sustainable Development, Libya.

الملخص
تعتمد عمليات التنمية المستدامة في المناطق القاحلة وشبه القاحلة بشكل أساسي على إمكانات موارد المياه الجوفية في هذه المناطق. يركز هذا الهدف على فهم قدرة طبقات المياه الجوفية، مع الأخذ بعين الاعتبار كمية ونوعية المياه. تعتبر منطقة الدراسة إحدى هذه المناطق القاحلة التي تقع في الجزء الشمالي الغربي من ليبيا. تبلغ مساحتها حوالي 300 كيلومتر مربع وتقع بين 10° 30ˉ و11° 50ˉ شرقاً و31° 30ˉ و32° 20ˉ شمالاً. وتتكون منطقة الدراسة من ثلاث تكوينات حاملة للمياه، وهي الحجر الرملي الجوراسي والحجر الجيري الدولوميتي المكسور والرمال الرباعية. ويلعب تقييم إنتاجية الآبار لكل طبقة مياه جوفية ونوعية مياهها دوراً بارزاً في استراتيجية أولويات التنمية في منطقة الدراسة .
يتضح من خرائط توزيع الإنتاجية والملوحة لخزان الحجر الرملي الجوراسي وخزان الحجر الجيري الدولوميتي المتكسر، إن الأجزاء الغربية والشمالية الغربية من منطقة الدراسة واعدة لعمليات التنمية المستدامة بسبب الإنتاجية العالية ونوعية المياه الجيدة.
أما بالنسبة للطبقة الجوفية الرباعية فإن إنتاجية الآبار وملوحة مياهها تزداد في نفس الاتجاه نحو القسم الشرقي والشمالي الشرقي. لذا، ينبغي التوصية بهذه المناطق للأنشطة التي تحتاج إلى مياه قليلة الملوحة.

الكلمات المفتاحية: المياه الجوفية، التنمية المستدامة، ليبيا.

Introduction

Many areas of limited fresh water resources, the productive potential of surface water such as rivers, lakes and surface runoff are not sufficient to cover the increasing demands for fresh water. Therefore, exploitation of groundwater resources has greatly increased on a world large scale during the second half of 20th Century. Where, available in appropriate quantity and quality groundwater aquifers are convenient fresh water storage. The study area is considered one of these areas. It covers an area of about 300 km^2 and lies between 10° 30′ & 11° 50′ E and 31° 30′ & 32° 20′ N (Figure.1).

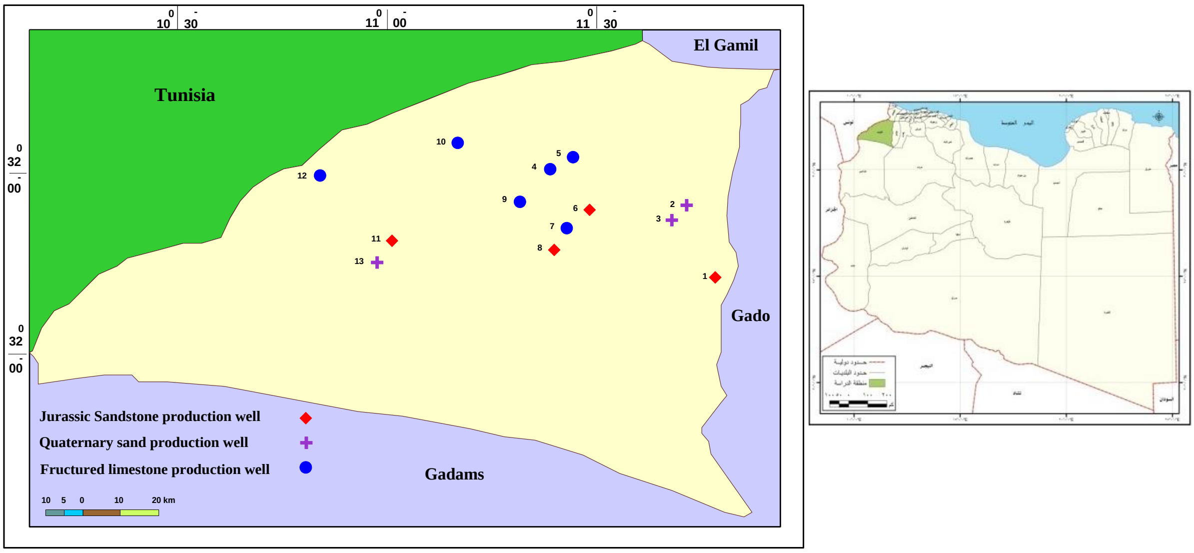


Figure (1): Key map of the study area.

Meteorologically, the study area is characterized by rainfall intensity varies from 250 m to 300 m at Gibil Naffousa and EL Gifara plain, which has an outstanding role in the agricultural purposes. Geologically, the fractured basement rocks are the main dominant geological features as in Gibil Naffousa, in addition, dolomitic formations of the Middle Triassic which have direct impact on the groundwater occurrence and its movement. Hydrogeologically, the investigated area comprises three water bearing formations namely from top to bottom, Quaternary sand deposits, fractured dolomite limestone and Jurassic sandstone. The recharge of these water bearing formations comes from the Pediment plain of Gibil Naffousa in the southern portion of EL Gifara plain. The flow direction is towards the north through the Tertiary and Quaternary deposits. The total annual recharge reaches about 200 million m^3 (Gischler, 1979). The pilot area includes 13 production wells tapping the investigated bearing formations (Figure.1 & Table 1).

Table (1): Technical data of the water points in the pilot area.

	Local Name	Total Depth (m)	Depth to Water (m)	Water bearing formation	Salinity (ppm)
1	El Rohybat	600	341.7	Jurassic Sandstone	2139
2	EL Haraba -1	250	88	Quaternary Sand	2325
3	EL Haraba -2	155	90	Quaternary Sand	2211
4	Tegi - 1	110	60	Dolomite Limestone	2991
5	Tegi - 2	109	45.5	Dolomite Limestone	5000
6	Tadamera	250	107	Jurassic Sandstone	1300
7	Tamzein -1	170	55.5	Dolomite Limestone	1346
8	Tamzein - 2	198	96	Jurassic Sandstone	1380
9	Kabawa - 1	175	72	Dolomite Limestone	1718

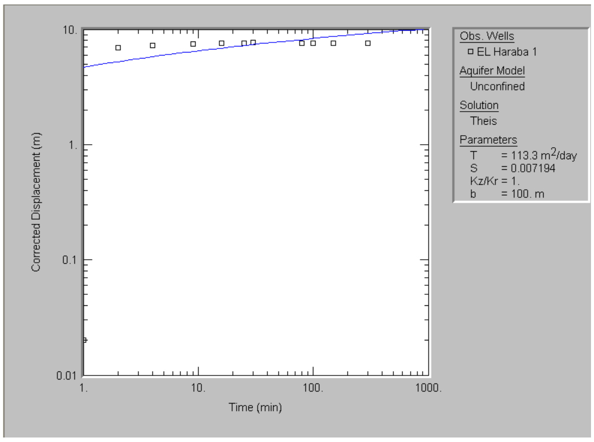
10	Robia	80	21	Dolomite Limestone	1400
11	Awlad Mahmoud - 1	437	275	Jurassic Sandstone	1412
12	EL Faraia - 2	132	34	Dolomite Limestone	1415
13	Nalout - 2	126	71.5	Quaternary Sand	1331

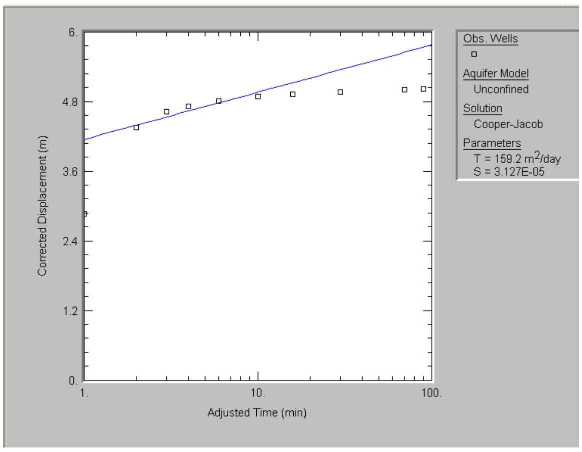
Aquifer systems

1 – Quaternary aquifer

1.1 Hydraulic parameters

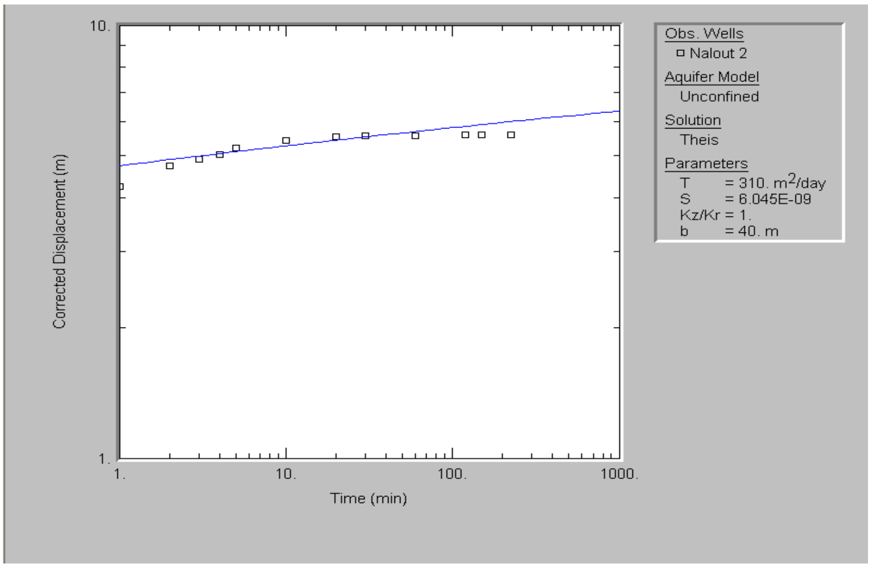
Quaternary aquifer consists of sandy deposits; with initial water depth varies from 71.5m to 90 m, while the total depth ranges between 126m and 250 m from the ground surface. The water quality reflects brackish water type (2211 ppm – 2325 ppm). In approach to evaluate and calculate the hydraulic parameters of the study aquifer ,3 pumping long duration tests have been carried out on the production wells nos(2, 3, &13). The obtained values reveal low to moderate capability of aquifer sediments to transmit water through it. This phenomenon could be attributed to the varieties of the hydraulic conductivity of aquifer sediments due to the heterogeneity of aquifer deposits laterally and vertically, as well as, the variation of saturated thickness of the study aquifer (Figure. 2 &Table 2).





EL Haraba – 1 well

EL Haraba – 2 well



Nalout – 2 well

Figure (2): Analysis of pumping tests of the production wells tapping Quaternary aquifer.

Table (2) Calculation of the hydraulic parameters of the Quaternary aquifer.

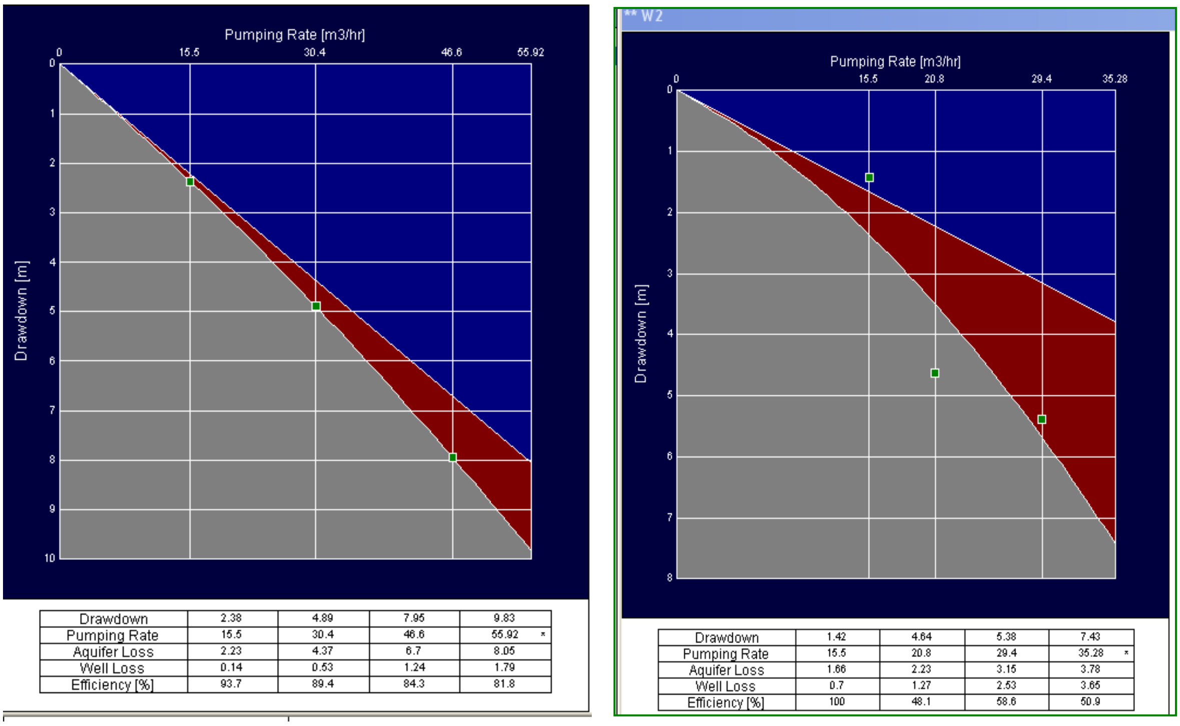
Well No.	Well Name	Transmissivity (m^2/ day)	Hydraulic Conductivity (m/day)	Storativity (dimensionless)
2	EL Haraba -1	113	0.71	$7.3*10^{-3}$
3	EL Haraba-2	159	2.4	$3.12*10^{-5}$
13	Nalout- 2	310	7.75	$6*10^{-6}$

1.2 Wells efficiency and its productivity

In order to focus some light on the efficiency and the productivity of the production wells, two step – drawdown tests have been carried out on EL Haraba -1 & EL Haraba -2 wells. The obtained values reveal good efficiency of the production wells (65.12% - 87.3%) and moderate productivity (Table 3 & Figure.3).

Table (3): Calculation of productivity and efficiency of the production wells.

Well Name	Well Loss (C) (hr^2/m^5)	Formation Loss (B) (hr/m^2)	Total Drawdown (m)	Well efficiency (%)	Well Productivity (m^3/hr)/m
El Haraba - 1	1.79	8.05	9.84	87.3	Moderate
EL Haraba - 2	3.65	3.78	7.43	65.12	Moderate



EL Haraba – 1 well EL Haraba – 2 well

Figure (3) Analysis of Step- Drawdown tests (Using GWW program).

2 – Fractured dolomite aquifer

2.1 Hydraulic parameters

The fractured dolomitic aquifer is the dominant water bearing formation in the study area. 6 production wells tapping this aquifer with the total depth varies from 80 m to 170 m. While, the depth to water ranges between 21 m and 60 m. On the other hand, it reflects water quality varies from slightly fresh water (1415 ppm) to slightly saline (5000 ppm). During the field work, an approach has been carried out to evaluate the hydraulic parameters of the aquifer through 5 long duration pumping tests (Figs. 4, 5, 6, 7&8 & Table 4).

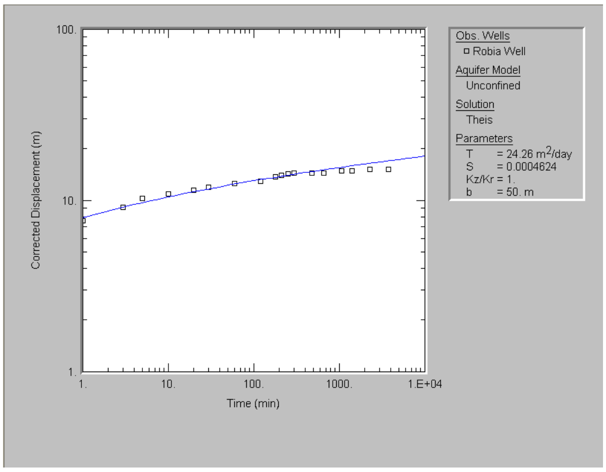


Figure (4): Analysis of pumping test of Tamzien well

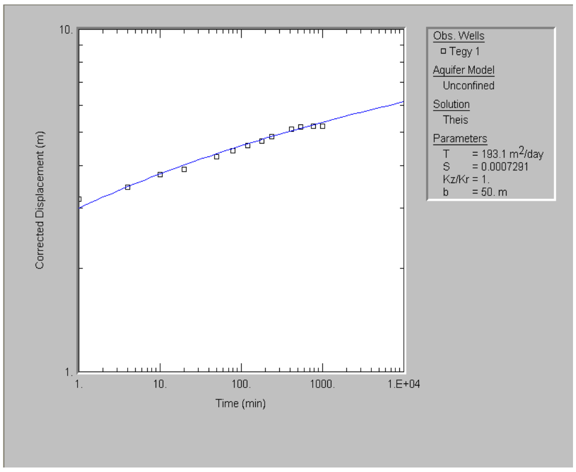


Figure. (5): Analysis of pumping test of Tegi -1

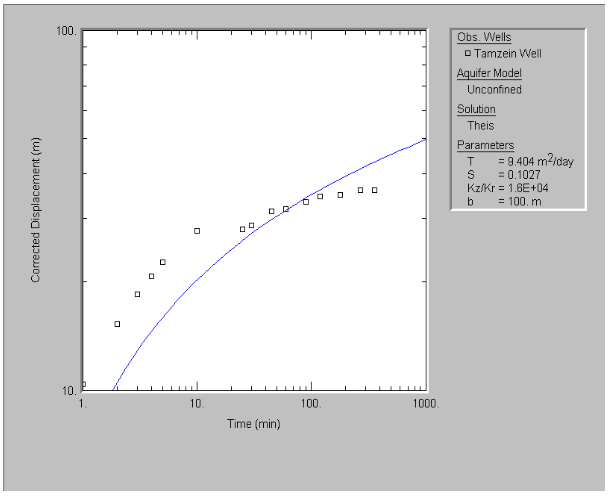


Figure (6): Analysis of pumping test of Robia well

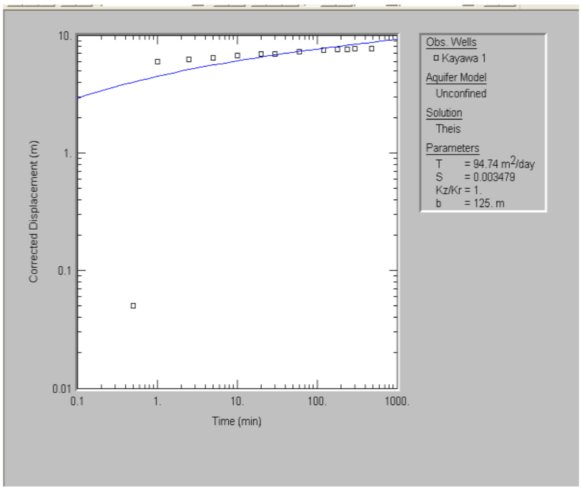


Figure (7): Analysis of pumping test of Kabawa -1 well.

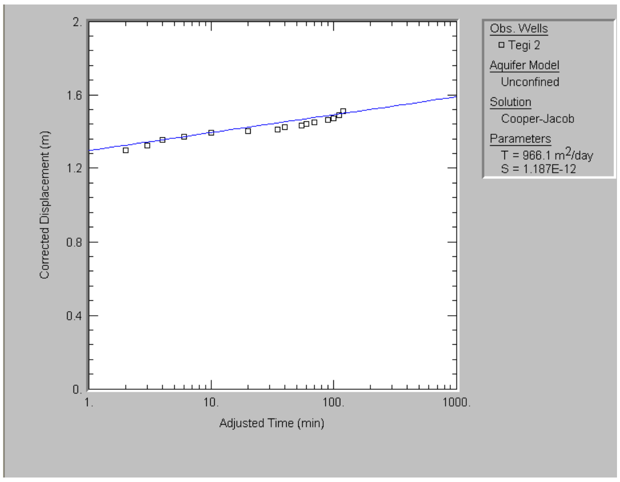


Figure (8): Analysis of pumping test of Tegi -2 well.

Table (4) Calculation of the hydraulic parameters of the fractured dolomitic aquifer**.**

Well No.	Well Name	Transmissivity (m^2/ day)	Hydraulic Conductivity (m/day)	Storativity (dimensionless)
4	Tegi - 1	193	3.86	$7.3*10^{-4}$
5	Tegi - 2	966	16.1	$1.18*10^{-12}$
7	Tamzien -1	9.4	0.23	0.10
9	Kabawa - 1	95	1.46	$3.5*10^{-3}$
10	EL Robia	24.3	1.62	$4.6*10^{-4}$

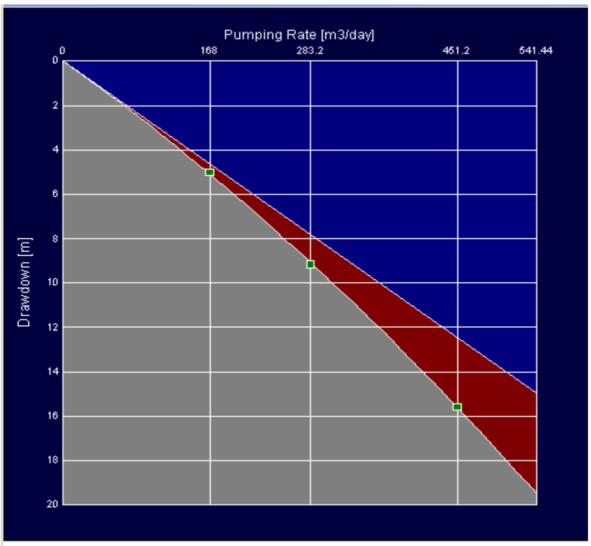
Generally, the calculated values display the low capability of aquifer to transmit water through it. This is phenomenon could be attributed to the compacted rocks of the dolomite limestone and low capability of fractured and jointed zones to transmit water, which have direct impact on the groundwater movements within it, except well no.5 which elucidates good transmitting property of aquifer rocks.

2.2 Wells efficiency and its productivity

In frame of the calculation and evaluation of the efficiency and productivity of the wells tapping the fractured dolomite limestone aquifer, 4 step- drawdown tests have been carried out on 4 selected wells. The calculated values have been shown in Table (5) and Figs (9).

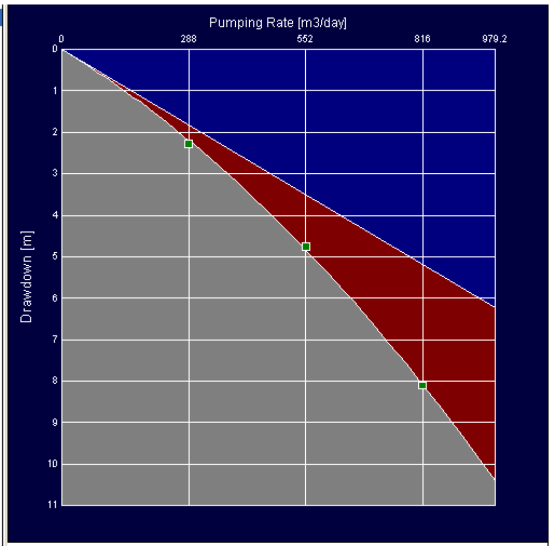
Table (5): Calculation of productivity and efficiency of the production wells**.**

Well Name	Well Loss (C) (hr^2/m^5)	Formation Loss (B) (hr/m^2)	Total Drawdown (m)	Well efficiency (%)	Well Productivity (m^3/hr)/m
Tegi - 1	3.37	4.06	7.43	68.42	Moderate
Tamzien - 1	53.79	8.43	62.22	22.0	Low
Kabawa - 1	4.17	6.22	10.39	72.85	Moderate
ELRobia	4.53	14.97	20.5	85.61	Moderate
EL Faria -2	3.96	3.90	7.86	65.19	Moderate



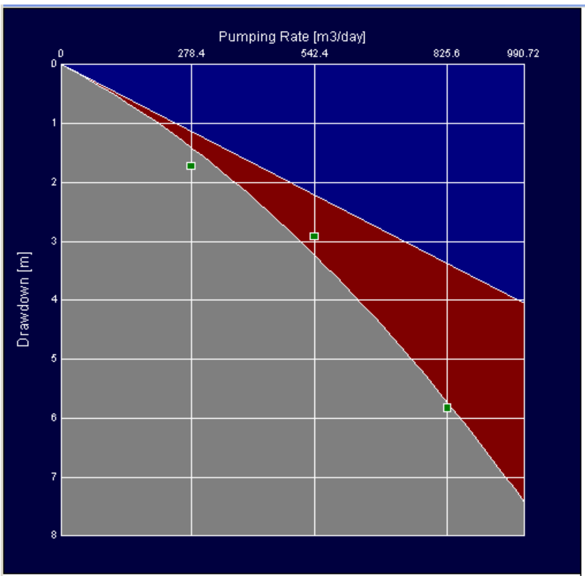
Drawdown	5	9.15	15.6	19.5
Pumping Rate	168	283.2	451.2	541.44 *
Aquifer Loss	4.64	7.83	12.47	14.97
Well Loss	0.44	1.24	3.15	4.53
Efficiency [%]	92.9	85.6	80	76.8

EL Robia Well



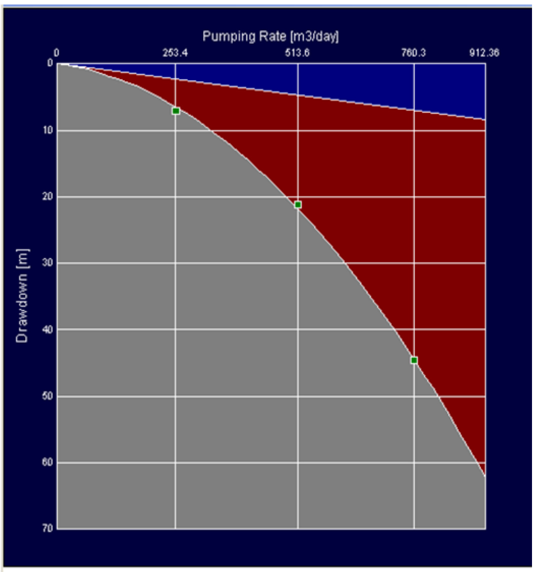
Drawdown	2.27	4.75	8.11	10.39
Pumping Rate	288	552	816	979.2 *
Aquifer Loss	1.83	3.51	5.18	6.22
Well Loss	0.36	1.33	2.9	4.17
Efficiency [%]	80.6	73.8	63.9	59.8

Kabawa -1 Well



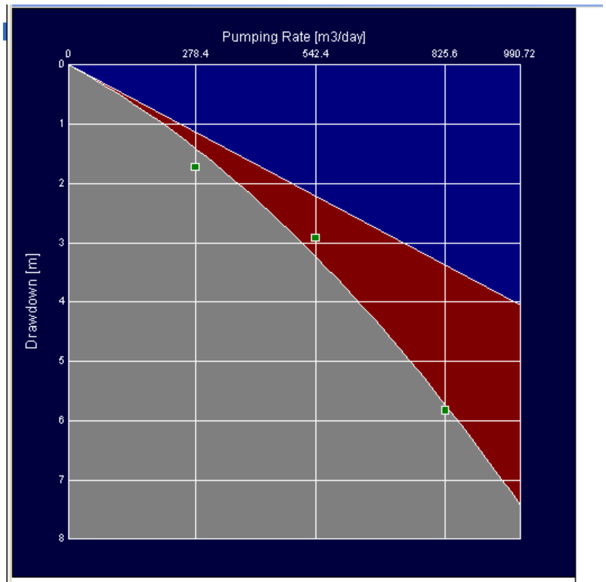
Drawdown	1.72	2.92	5.82	7.43
Pumping Rate	278.4	542.4	825.6	990.72 *
Aquifer Loss	1.14	2.22	3.38	4.06
Well Loss	0.27	1.01	2.34	3.37
Efficiency [%]	66.3	76.1	58.1	54.6

Tegi-1Well



Drawdown	7.1	21.17	44.59	62.22
Pumping Rate	253.4	513.6	760.3	912.36 *
Aquifer Loss	2.34	4.74	7.02	8.43
Well Loss	4.15	17.05	37.35	53.79
Efficiency [%]	33	22.4	15.7	13.5

Tamzien – 1 Well



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Aquifer Loss	1.14	2.22	3.38	4.06
Well Loss	0.27	1.01	2.34	3.37
Efficiency [%]	66.3	76.1	58.1	54.6

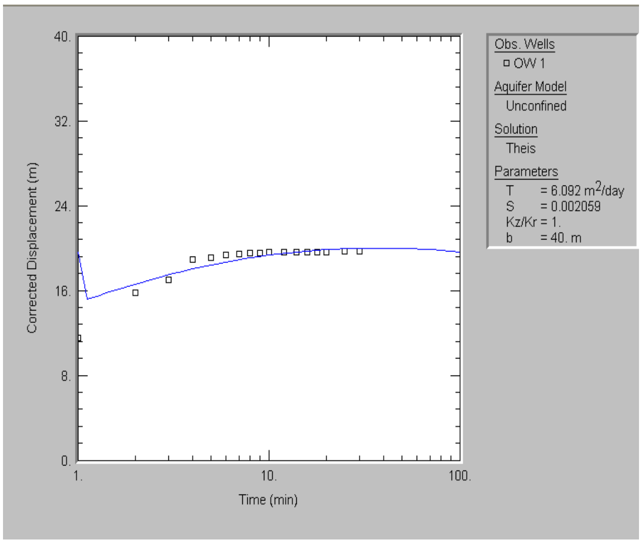
EL Faria -2

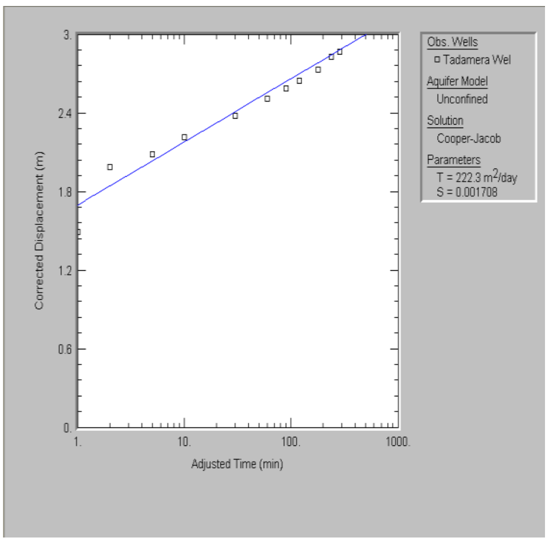
Figure (9): Analysis of Step- Drawdown tests (Using GWW program).

3 - Jurassic sandstone aquifer

3.1 Hydraulic parameters

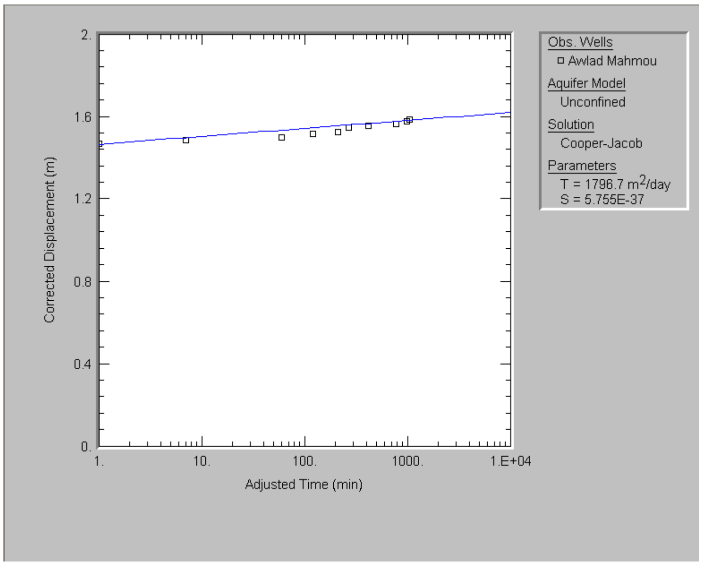
It is considered the deepest water bearing formation in the pilot area and consists of sandstone deposits. The depth to water varies from 90 m to 342 m from the ground surface. The water quality ranges from fresh water (1300 ppm) to slightly brackish (2139 ppm). In a trial to focus some light on the hydraulic parameters of this aquifer, 4 pumping long duration test has been carried out on the three production wells as shown in Fig. (10) and Table (6).





Tamzien 2 well

Tadamera well



Awlad Mahmoud Well

Figure (10) Analysis of pumping long duration tests of the production wells tapping Jurassic aquifer.

Table (6) Calculation of the hydraulic parameters of the Jurassic Sandstone aquifer**.**

Well No.	Well Name	Transmissivity (m^2/ day)	Hydraulic Conductivity (m/day)	Storativity (dimensionless)
6	Tadamera	222	0.63	$1.7*10^{-3}$
8	Tamzien 2	6.1	0.15	0.002
11	Awlad Mahmoud	1797	11.2	$5.75*10^{-3}$

It is obvious that there is a wide variation of the hydraulic parameters of the water bearing formation. This is could be attributed to the wide variation of the penetration depth and consequently the variation of the saturated thickness. In addition to the difference of the hydraulic conductivity, this has direct impact on the transmitting property of the study aquifer.

3.2 Wells efficiency and its productivity

Due to focus the light on the productivity and efficiency of the production wells tapping the investigated aquifer, two step – drawdown tests have been carried out on two selected production wells.

The calculated values illustrate high efficiency and moderate productivity Table (7) and Fig. (11).

Table (7): Calculation of productivity and efficiency of the production wells.

Well Name	Well Loss (C) (hr^2/m^5)	Formation Loss (B) (hr/m^2)	Total Drawdown (m)	Well efficiency (%)	Well Productivity (m^3/hr)/m
Tadamera	0.67	2.09	2.76	84.8	Moderate
Awlad Mahmoud	0.22	1.61	1.83	92.92	Moderate

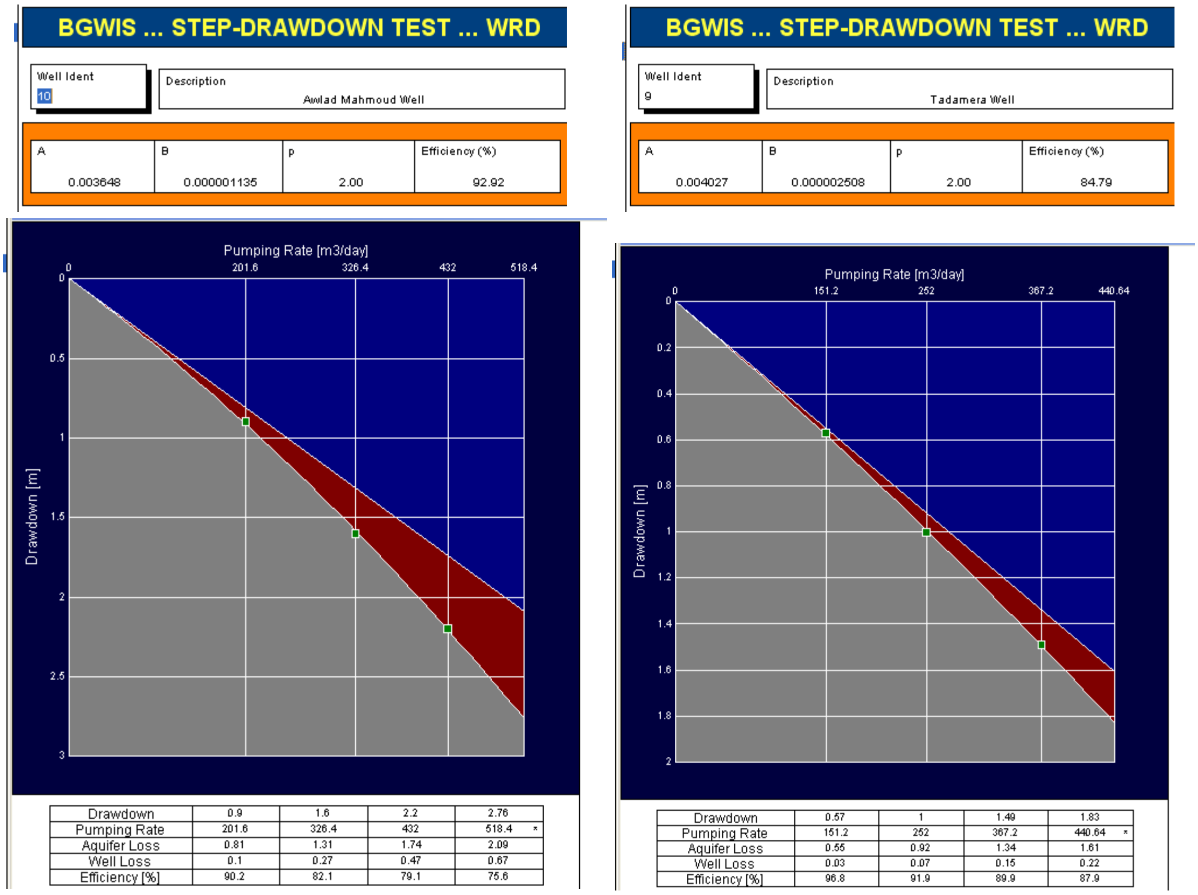


Figure. (11) Analysis of step – drawdown tests of selected wells tapping Jurassic aquifer.

Priorities of development

To improve and maintain the necessary development conditions in the pilot area, it is important to have a proper understanding of the aquifers potentialities. This target concentrates on understanding the capability of aquifers tacking into consideration water quantity and water quality. Therefore, the evaluation of productivity of the wells for each aquifer and its water quality plays an outstanding role in the strategy of development priorities in the study area (Figs 12,13&14).

It is obvious from the matching maps of productivity and salinity for Jurassic sandstone aquifer and Fractured Limestone aquifers, that the western and northwestern portions of the pilot area are promising for sustainable development processes due to high productivity and good water quality.

Concerning the Quaternary aquifer, the productivity of wells and its water salinity increase in the same direction towards the east and northern east portions. So, these areas should be recommended for the activities which need brackish water type

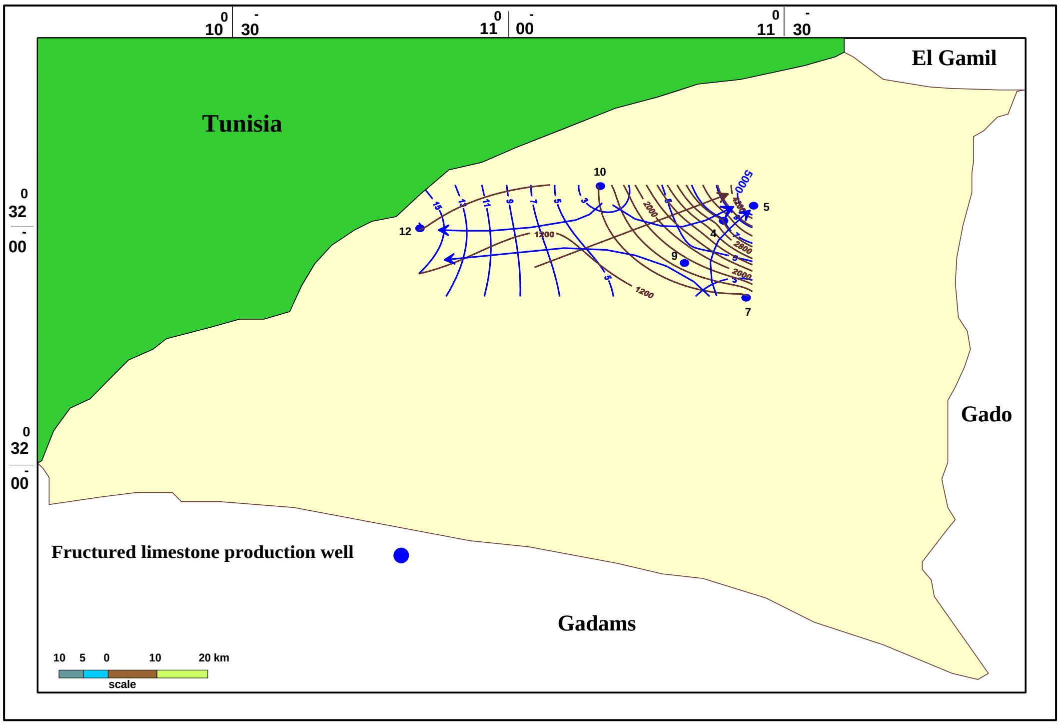


Figure (12): Matching contour map of productivity and water salinity of fractured Dolomitic limestone aquifer.

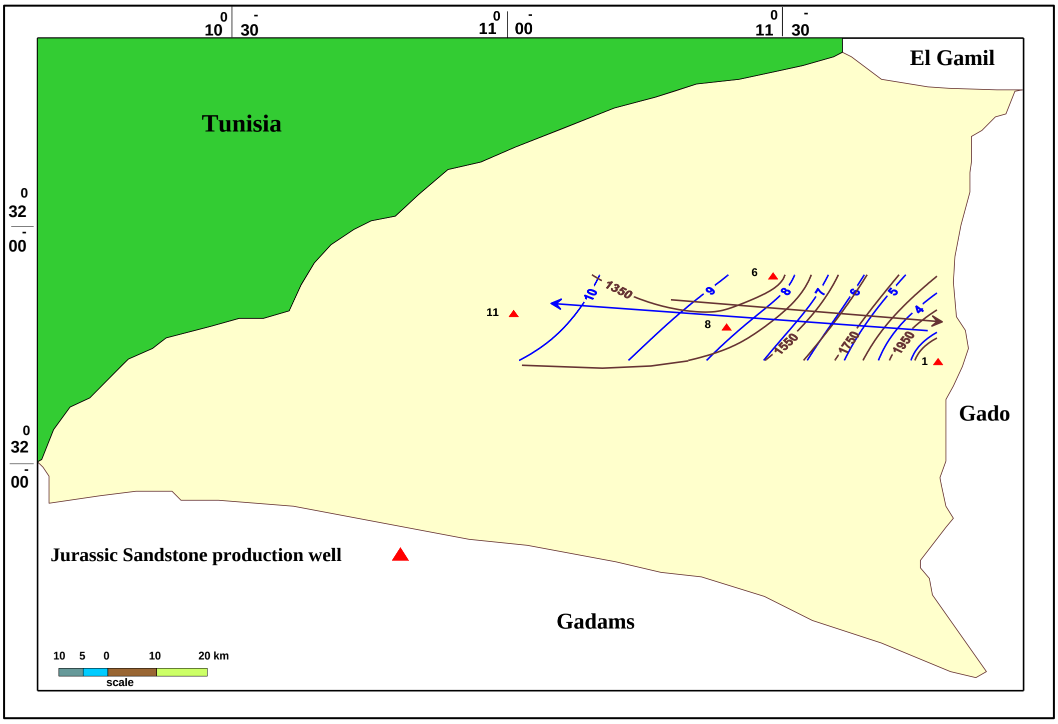


Figure (13): Matching contour map of productivity and water salinity of Jurassic sandstone aquifer.

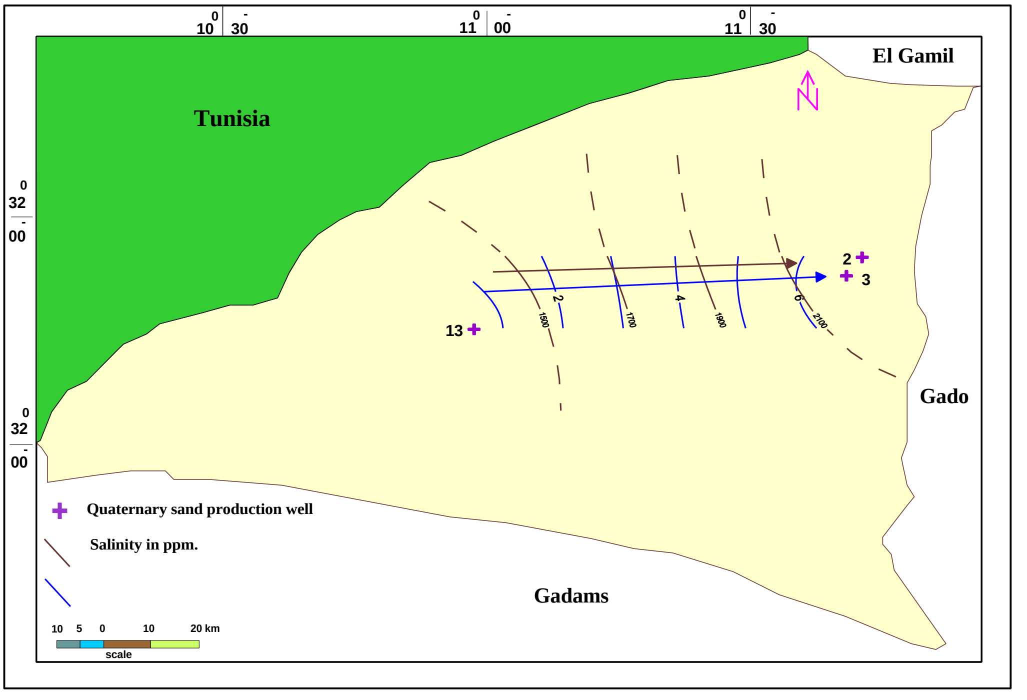


Figure (14): Matching contour map of productivity and water salinity of Quaternary sand aquifer.

References

[1] Gischler, C.E., " Water resources in the Arab Middle East and North Africa" Middle East & North Africa studies Press Ltd., Cambridge, U.K,1979.

[2] AQTESOLV. Program “Aquifer Test Solve Program for Windows Version 4.0 (Feb. 21, 2006).

[3] GWW: Groundwater under Win