

HYDROGEOLOGICAL SETTING, HAZARD AND MITIGATION OF RECLAIMED AREA IN WADI EL- SAYDA NORTH ASWAN, EGYPT

Ahmed F. YOUSEF

Geology Department, Desert Research Center, El Matareya, Cairo, Egypt,
ahmedfawzy63@yahoo.com

ABSTRACT

Owing to the excavation of irrigation and drainage systems and utilizing the flood method for irrigation the reclaimed area in Wadi El Sayda (WS) north Aswan governorate, a lot water ponds and new water bearing are formed. The article aimed to identify the hydrogeological setting, hazards and solutions. There are two groundwater aquifers in WS namely; Quaternary and Nubian Sandstone. Different piezometers have been drilled in Quaternary for detection aquifer extension, observation water level and monitoring salinity with time. The groundwater level increases about 1.8 cm from 14/1/2010 to 9/2 owing the continuous recharge from irrigation canals and seepage from irrigation of sugar cane, while slightly increases 1.255 cm from 9/2 to /4 may due to stop irrigation of sugar cane. The salinity decreases from 14/1 to 9/2, while slightly increases from 9/2 to 1/4 due to the stop irrigation of sugar cane and upward leakage through fault systems. Seven water points are recorded in Nubian sandstone aquifer, three of them are flowing with salinity varies from 1920 ppm and 2717 ppm, while the others are pumped with salinity ranges from about 986 ppm to 2381 ppm. The variation of salinity may due to the different sources of recharge. The main problems of WS are due implementation, random land reclamation, flood irrigation, bad maintenances, water logging and design. The solutions of these problems are re-design the irrigation system, connection between drains, excavate new drainage, excavate new tile drainage system, maintenances of irrigation and drainage systems, and decreasing the groundwater level.

1 INTRODUCTION

Egypt has a total area of about one million square kilometer, which is a desert land with the exception of a small cultivated area restricted in the Nile Valley and delta. Owing to the limited nature resources, and the alarming rate of over growing population, horizontal expansion of agricultural land is must to aluminizing this problem and to narrow the gab that exist between food production and consumption. Therefore, to get an excellent solution to overcome these problems, the Egyptian authorities' strategy adopted to cope with this situation to expand and extend land productivity in horizontal and vertical aspects. In this accord, tremendous efforts and huge investments are under way, with the assistance of the national and international agencies and organizations, by bringing new lands under cultivation. Among the areas

suitable for such agricultural expansion in the western desert is Wadi El Sayda (WS) area due to its water and land potentialities.

WS area occupies a portion of the Western Desert. It is located between longitudes $32^{\circ} 39' 00''$ and $32^{\circ} 50' 00''$ E and latitudes $24^{\circ} 50' 00''$ and $25^{\circ} 8' 00''$ N. It is bounded in the northern side by El Sabiya village, in the southern side by Idfu - Aswan western high way, in the eastern side by Idfu and River Nile (RN) and in western side by a Sin El-Kaddab plateau (Fig. 1). The new project in WS aimed to reclaim 30000 feddans and divided it into 8 villages namely; El Shahama, Amr Ebn El AS, El Samaha, El Ashraf, El Eman, El Nemo, El Esrar and El Nedat. The topographic map of the reclaimed area in WS varies from about 128 m in the western part to about 86 m near RN (Fig.2). The ground slope is relatively gentle in the western and eastern parts, while it is relatively steep in the middle. There is a series of Nubian Sandstone isolated hills (NSIH) with elevation reach to about 130 m.

According CLAC (2010) meteorological station at Aswan (70 km to 50 the south), WS falls under desert climate and its characterized by a long dry summer with high temperature and evaporation rate, and a short mild winter with very little rainfall in autumn. Where, the highest monthly mean temperature (40.0°C) is recorded in July, while the lowest one (16.7°C) in January. Rainfall occurs in very extremely low amount during the year with annual precipitation of about 0.07 mm. Evaporation is usually very high and ranges between 14.4 mm in January and 27.3 mm in June. The relative humidity is low and ranges between 13 and 37%. The new reclaim area (30000 feddans) in Wadi El Sayda (WS) north Aswan governorate changed the hydrogeological setting and the newly occurrence a lot phenomena which face the future development. Thereby, this article aimed to identify the hydrogeological situations, problems and solutions of this area.

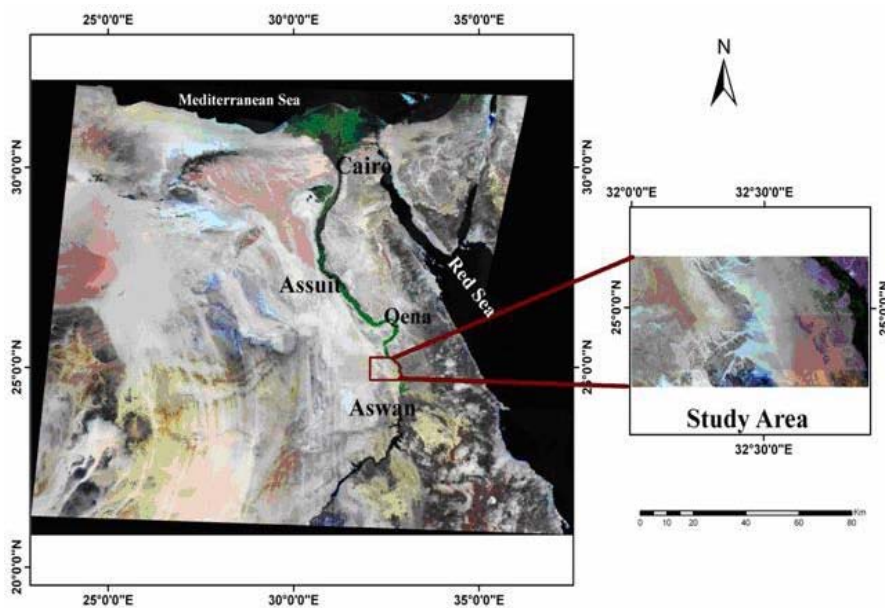


Figure 1. Location map of Wadi El Sayda area.

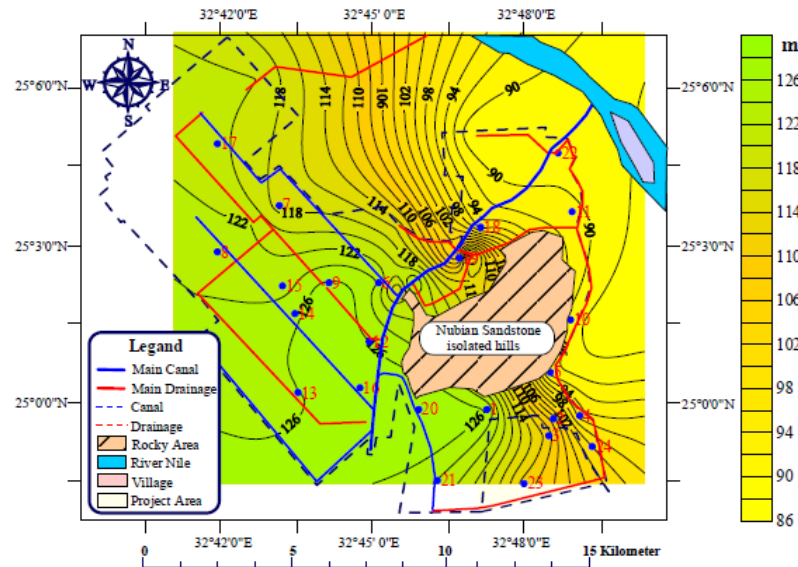


Figure 2. Ground elevation of the study area.

2 MATERIALS AND METHODS

Initially, in order to understand the geomorphology and surface geology of the SA, different information from satellite images, geologic maps of USAID(1978) and Klitzsch et al. (1978), and topographic maps were collected followed by processing, field observations and measurements. A lot of lithological description, mechanically analyses, well logging and composite logs data of some drilled groundwater wells and 24 piezometers were collected to shed light on hydrogeological condition.

To recognize the general variation in surface and groundwater 75 samples were collected. A Magellan global positioning system (GPS) was used to mark the location by noting down the latitude and longitude. Five (5) water samples are represented all irrigation system and fourteen (14) samples are represented drains and pools. The Quaternary aquifer is represented by sixty one (61) water samples during January, February and April 2010. Nubian Sandstone aquifer (NSA) is represented by five (5) water samples that collected during January 2010.

In-situ measurements included EC, pH and bicarbonate which were measured using a portable field kit and titration respectively as per WHO (1996) recommendations as these parameters change with storage time. Major cations like Ca^{2+} and Mg^{2+} were analyzed by titration, while Na^{+} and K^{+} were measured on a AIMIL Flame Photometer (PE I). Chloride ion was analyzed by titration and the SO_4^{2-} was measured by spectrophotometer. The chemical analysis was carried out as per the standard procedure given by ASTM (2002).

3 GEOLOGICAL FEATURES

3.1 Geomorphology

The geomorphology of Aswan Governorate was made by UNDP/ UNSCO/ NARSS/ EGSMA (2000) and enhanced by Elwan 2008 in WS using Landsat ETM+7 satellite image (Fig. 3). It divided into four geomorphic units namely; structural plateau (plateau surface, escarpment face and wadi El Rimidin), bajada plain (colluvial and pavement plains), eroded Nubian old surface (peneplain) and Nile alluvial plain (Nile terraces and flood plain).

Structural plateau occupies the western part of the mapped area and rises to more than 450 m above sea level and composed mostly of hard limestone. It is bounded on the eastern side by a precipitous escarp (cuesta) that dissected by a number of wadis which are directed eastward to RN. The most remarkable wadis are El Rimidin and El Ramady.

Bajada plain starts from the foot slopes of the escarpment face (Cuesta) and divided into colluvial and lower pavement plains. Higher colluvial plain ranges from 268 to 335 m above sea level and composed of coarse textured driven from the plateau and escarpment. The new reclaimed area is located in lower pavement plain which has elevation ranges from 90 to 170 m above sea level and composed mainly of medium textured material that driven from the plateau.

The eroded Nubian old surface (peneplain) occupies much of the elevated plain bordering the Nile valley. It composed of brownish sandstone beds belonging to the Nubian sequence with elevation reach to about 130 m above sea level. The old Nile terraces occupy 100 a relatively wide area to the east of the Nubian and composed of old Nile alluvial deposits. Nile flood plain occupies the lowest portion around the Nile Valley with elevation reach to 86 above sea level and composed mainly of Nile silt deposits.

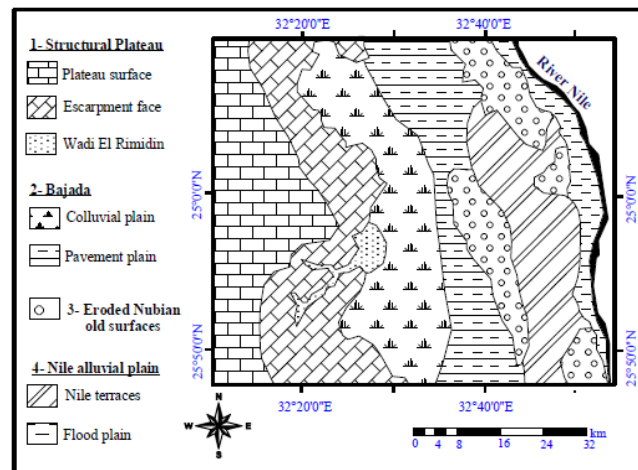


Figure 3. Geomorphological map of WS (after UNDP/UNSCO/NARSS/ EGSMA, 2000 599 and Elwan 2008).

3.2 Geology

The main outcrop rock units in WS are Taref, Dakhla, Thebes, Idfu and Qena Formations as well as Holocene sediments (Fig. 4). Taref Fm is the oldest rock unit and located as strep isolated hills parallel to RN and composed mostly of fine to medium sandstone. Dakhla Fm (U. Cretaceous – L. Paleocene) restricted to the north of Taref Fm and consists mostly of shale in the lower part and limestone in the upper part. Thebes Fm (L. Eocene) occupies most of the western part that consists of limestone, chalky limestone and marls (Said, 1960). The Pliocene sediments are recorded in the northern part and represented by Eonile deposits that consist of clay and fine sand interbedded series.

Quaternary deposits occupy most of the eastern part of WS that differentiated into Pleistocene and Holocene. The Pleistocene sediments are represented by Protonile (Idfu Fm) and Prenile (Qena Fm). The new reclaimed area is located in Idfu Fm which consists of coarse and medium sand of fluvial origin embedded in reddish brown matrix. Qena Fm is located in the northern part and composed of fluvatile sands with thin clay interbeds. The Holocene sediments comprise unconsolidated deposits under different environmental conditions. These sediments include Nile silt around the Nile Valley, recent wadi in the main wadis, and occasional eaolian deposits.

Based on Abd el Razzik et al. (1972), Klitsch et al. (1979) and El Gamili (1982); the main structural elements are anticline which is represented by NSIH parallel to RN, syncline in the new reclaimed area and around the RN. The fault systems are mostly 124 NW which control the structural plateau and NE that controlled the drainage pattern.

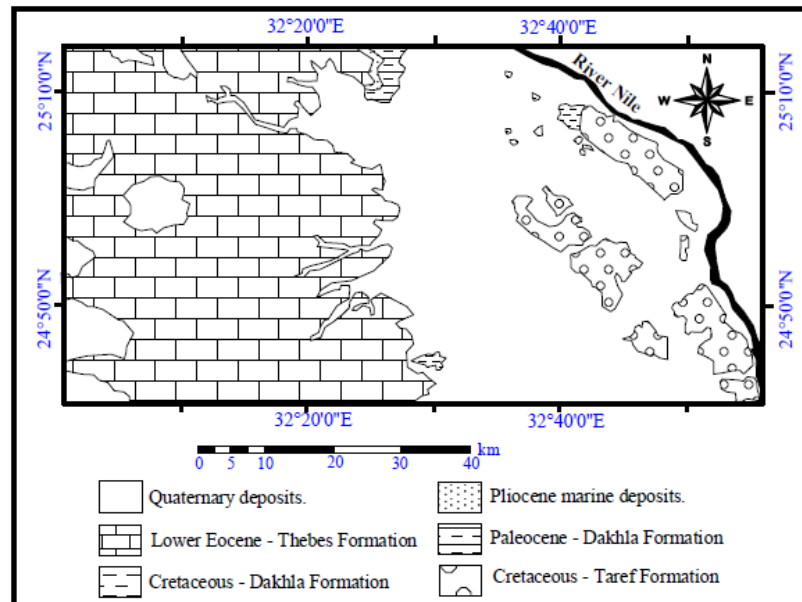


Figure 4. Geological map of WS (after USAID, 1978).

4 Water Resources Aspect

4.1 Surface water

The project design to depending on RN water through five pump stations to elevate water from +84 to +129 m above sea level through main lining canal (Fig. 5) which has depth 3 m, width 8 m and extended 9 km (GARPAD 1986). Each pump station has five pumps with variable discharge between 12.2 m³ / Sec to 17.4 m³ / Sec to transport about 330 X 106 m³ / year to irrigate 30000 feddans using drip and sprinkler method. The average salinity of the RN is 166 ppm (Table 1), while changed to about 290 ppm at pump station no. 2 owing to it receives the drain water of El Eman drain (922 ppm) and drain No. 4 (320 ppm). The main canal divided into four lining canals namely; Amr Ebn Al As, El Shahama, El Nemow and El Eman with salinities about 400, 575, 580 and 590 ppm. The area is dissected also by system of drainage to receive the excess of water. The main drains are drain nos. 2, 3, 4, 5 and El Eman which vary in salinity from the start to the end. Where, they are about 1410, 801, 960, 1280 and 2390 ppm at the start, but at the end are about 1430, 1018, 420, 574 and 920 ppm. The decrease of salinity in drain no.4 is due to the seepage from the main canal, while decrease of El Eman salinity owing the sewage of Nag El Arab and Kalh El Gabal villages. Due the bad connection between the drains and utilizing flood irrigation system, some pools are formed such as Amr and Mahgar with salinity reach to about 2560 and 21120 ppm. Owing to the bad selection of some villages sites such as El Eman, they are affected by water logging. The administration of the project excavated three drains in the west, middle and east of the village to decrease the water level with salinity about 4518, 2387 and 1997 ppm.

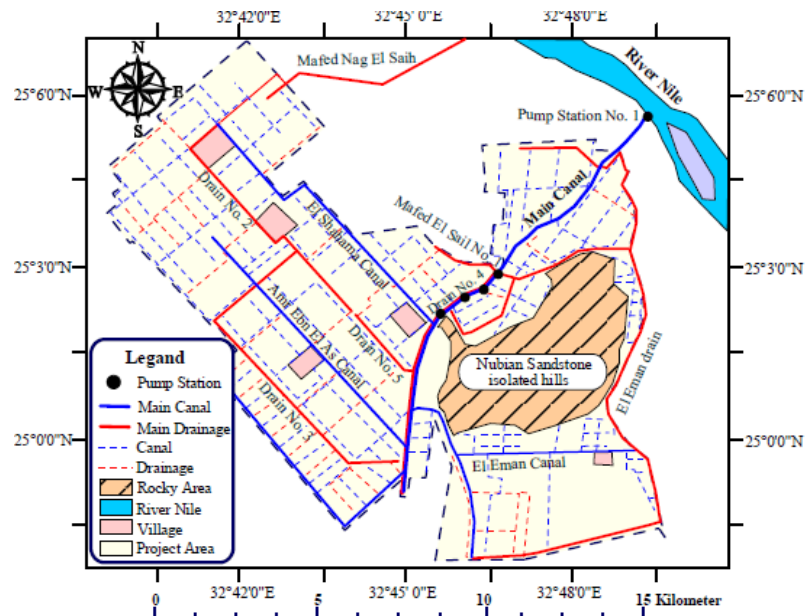


Figure 5. Irrigation and drainage systems of WS.

Table 1. Chemical analysis of irrigation and drainage systems in 14/1/2010

Pizometer	EC (mmohs/cm)	TDS (ppm)	PH	Cations				Anions			
				K ⁺	Na ⁺	Mg ⁺⁺	Ca ⁺⁺	Cl ⁻	SO ₄ ⁼	HCO ₃ ⁻	CO ₃
Irrigation Canal											
River Nile	0.26	166.4	8.55	4.0	29	6	14	26	31	50	10
Main canal after pump 2	0.46	294.4	8.67	5.0	57	10	20	60	56	70	12
Amr Ebn Al As Canal	0.62	396.8	7.94	7.8	82	11	30	82	80	90	20
El Shahama Canal	0.93	595.2	8.11	8.0	120	16	45	150	58.4	183	14.4
El Eman Canal	0.90	576.0	7.56	3.4	117	15	45	150	35.5	190.3	0.0
Drainage											
Drain No. 2 at El Samaha	2.20	1408.0	8.16	15.6	320	40	80	420	298	146	24
Drain No. 2 at El Ashraf	2.24	1433.6	8.09	14.8	340	42	73	470	278	152.5	12
Drain No. 3	1.48	947.2	7.51	3.9	165	38	85	210	170	300	5
Drain No. 5 at the end	2.00	1280.0	8.46	13.0	290	30	75	298	342	195	12
Start Drain No. 4	1.499	959.4	8.55	10.0	160	40	80	225	206	207	12
End Drain No. 4	0.50	320.0	8.67	5.0	57	10	20	60	56	70	12
Start El Eman drain	3.73	2387.2	8.23	16.0	600	62	105	690	700	146	0
End El Eman drain	1.442	922.9	8.44	8.0	160	42	75	165	260	195	30
West El Eman village drain	7.06	4518.4	7.37	5.7	860	132	420	1450	837	537	36
Mid El Eman village drain	3.73	2387.2	8.23	16.0	600	62	105	690	700	146	1.0
East El Eman village drain	3.12	1996.8	8.10	3.4	340	85	164	475	422	476	0.0
Amr pool	4.0	2560.0	7.95	37.4	1428	168	50	1330	1570	500	24
Mahgar pool	33.0	21120.0	7.55	257.0	5775	258	870	7000	5900	30	1.0

4.2 Groundwater

The previous hydrogeological studies such as Abd El-Kreem (2000) and Zaid (2002) reveal that the restriction of Quaternary aquifer around RN only. It has a direct relationship with RN and their canals. No water points were recorded before in the new reclaimed area of WS. The recent survey at 14/1/2010 shows the occurrences of seven water points in Nubian sandstone, three of them are flowing. Also, two water points of Quaternary are recorded to the east of new reclaimed area. Owing to the excavation of irrigation and drainage systems, and utilizing the flood method of irrigation, a lot water ponds and new groundwater aquifer are formed in the reclaimed area. Different pizometers have been drilled to detect aquifer extension and observe the fluctuation of water level with time (Fig. 6 a). Based on the available data sets of available wells, hydrogeological cross sections, hydrogeochemical analyses (Tables 2, 3 and 4) and literature, the main groundwater aquifers are Quaternary (QA) and Nubian Sandstone (NSA) in WS.

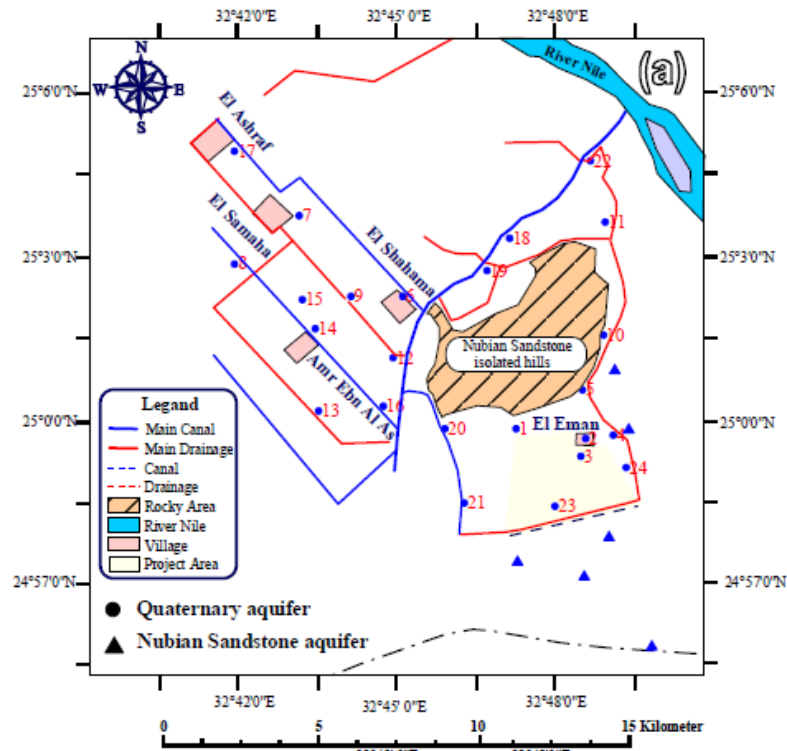


Figure 6 a. Location map of the pizomters and water points of El Sayda area.

4.2.1 Quaternary Aquifer

The Quaternary aquifer in the new reclaimed area consists of Pleistocene graded sand and gravel with thin clay intercalations and underlain by fine grained Pliocene sediments (impermeable layer) i.e. unconfined aquifer. The aquifer thickness ranges from about 5 m in the western part to about 25 m. It is thin in compared with the QA around NR which ranges from 40 and 120 m (Abdel Kreem, 2000). The main source of recharge is the seepage from irrigation and drainage systems, the percolation from excess irrigation water of field. The aquifer is discharged mostly to low laying area forming pools and to El Eman drain as well as other aquifers. The groundwater salinity varies from about 557 ppm in the southwestern part to about 22080 ppm eastward owing leaching process and bad drainage.

a. Fluctuation of groundwater levels with time

The groundwater level (GWL) map at 14/1/2010 (Fig. 6b) is relatively affected by the ground elevation of the study area (Fig. 2). It shows the direction of water flow from southwestern part to the eastern part with higher rate in the middle. Where, the water level decreases from about 126.1 m at P 20 to about 86 m at P 22. The main sources groundwater recharges are the irrigation and drainage systems and the higher rate was recorded in the southwestern part and cultivated area by sugar cane. GWL at 9/2/2010 (Fig. 6c) shows the same direction of groundwater flow, but with relatively higher level

which recorded mostly in southwestern part owing the effect irrigation canals. The relatively low level in far area may due to the stop irrigation of 10000 feddans sugar cane.

Table 2. Chemical analysis of Quaternary Aquifer in 14/1/2010

Pizometer	EC (mmohs/cm)	TDS (ppm)	PH	Cations				Anions			
				K ⁺	Na ⁺	Mg ⁺⁺	Ca ⁺⁺	Cl ⁻	SO ₄ ⁼	HCO ₃ ⁻	CO ₃ ⁻
P1	1.17	748.8	7.4	1.8	105.0	32.0	66.0	160.0	91.58	231.8	0.0
P11	1.54	985.6	7.28	2.3	170.0	42.0	84.0	200.0	200.0	317.2	0.0
P13	1.59	1017.6	7.51	3.9	185.0	38.4	90.0	220.0	168.0	370.0	0.0
P16	3.42	2188.8	7.31	9.7	380.0	88.8	172.0	628.5	220.0	512.4	12.0
P20	1.45	928.0	7.32	2.8	147.0	38.4	82.0	175.2	208.8	268.4	0.0
P21	0.87	556.8	7.69	1.8	78.6	23.4	50.0	100.1	94.9	170.8	0.0
P22	1.57	1004.8	7.52	3.9	180.0	39.6	82.0	215.0	168.05	341.6	0.0
P6	2.8	1792.0	7.68	6.0	340.0	62.4	150.0	420.0	397.66	451.4	0.0
P7	2.47	1580.8	7.77	9.0	290.0	54.0	132.0	330.0	358.7	427.0	0.0
P12	2.43	1555.2	7.10	10.4	290.0	51.6	134.0	330.0	365.0	414.8	0.0
P15	3.85	2464.0	7.43	5.7	425.0	102.0	196.0	600.0	532.32	512.4	24.0
P19	4.45	2848.0	7.56	5.1	490.0	103.2	262.6	680.0	670.00	524.6	36.0
P23	6.68	4275.2	7.20	3.9	709.0	187.2	390.0	700.0	1200.0	1100.0	84.0
P2	5.9	3776.0	7.31	17.2	600.0	175.2	348.0	1085.0	862.48	544.6	36.0
P4	9.26	5926.4	7.59	24.0	970.0	261.6	558.0	2400.0	670.3	549.0	48.0
P5	34.5	22080.0	7.90	38.0	3400.0	1036.8	2200.0	9350.0	2918.7	719.8	60.0
P8	29.2	18688.0	7.22	57.0	2750.0	960.0	1800.0	7600.0	1979.6	707.6	60.0
P9	15.94	10201.6	7.90	53.0	1600.0	426.0	1054.0	4000.0	1485.4	561.2	48.0
P10	2.72	1740.8	7.44	10.4	300.0	75.0	140.0	400.4	380.0	439.2	0.0
P18	39.4	25216.0	7.63	31.0	4000.0	1115.0	2500.0	9360.3	4500.0	841.8	60.0
Hager drink	19.2	12288.0	7.23	5.7	1990.0	513.6	1258.0	5850.0	736.5	610.0	48.0

Table 3. Chemical analysis of Quaternary Aquifer in 9/2/2010

Pizometer	EC (mmohs/cm)	TDS (ppm)	pH	Cations				Anions			
				K ⁺	Na ⁺	Mg ⁺⁺	Ca ⁺⁺	Cl ⁻	SO ₄ ⁼	HCO ₃ ⁻	CO ₃ ⁻
P1	1.80	1153.9	7.79	2.31	290	30	60	365.0	152.4	256.2	7.20
P11	2.26	1446.4	7.69	3.36	280	52	120	300.0	262.8	450.0	36.0
P13	1.25	801.3	8.03	6.32	150	30	65	185.0	107.9	290.0	36.0
P16	3.37	2156.8	7.99	14.07	450	70	150	500.0	370.0	600.0	21.6
P20	1.74	1113.0	7.69	6.97	225	40	80	300.0	160.0	256.2	21.6
P22	1.10	705.3	8.04	4.49	130	30	55	190.0	67.8	241.6	28.8
P6	3.90	2496.0	7.94	8.97	470	100	200	700.0	587.4	395.3	43.2
P7	4.88	3123.2	8.11	6.32	600	120	250	1150.0	441.3	307.4	43.2
P12	2.22	1420.8	7.70	8.29	240	60	130	375.1	272.3	278.2	21.6
P15	4.61	2950.4	7.80	11.82	600	100	228	900.0	518.3	431.9	36.0
P19	9.98	6387.2	7.86	11.82	1300	230	450	2400.0	980.0	400.0	36.0
P23	5.07	3244.8	7.88	5.09	670	120	230	900.0	520.0	695.4	64.8
P2	7.42	4748.8	7.64	19.65	900	180	380	1700.4	850.0	358.7	28.8
P4	11.83	7571.2	7.49	15.62	1350	300	700	3000.0	1300.0	388.0	0.00
P5	40.60	25984.0	7.07	74.41	5655	780	1900	10627.7	4321.4	834.5	0.00
P8	34.90	22336.0	7.11	53.73	4570	540	1700	8000.0	4800.0	102.5	0.00
P9	6.37	4076.8	7.91	3.91	800	140	340	1450.0	780.0	322.1	14.4
P18	1.30	832.0	7.35	1.82	170	30	60	280.0	137.8	22.0	36.0

Table 4. Chemical analysis of Nubian Aquifer in 9/2/2010

Location	EC (mmohs/cm)	TDS (ppm)	pH	Cations				Anions			
				K ⁺	Na ⁺	Mg ⁺⁺	Ca ⁺⁺	Cl ⁻	SO ₄ ⁼	HCO ₃ ⁻	CO ₃ ⁻
Der 2	1.93	1237.8	8.58	8	300	28	75	300	290	180	54
Der 3	2.06	1318.4	8.57	8	310	32	80	280	315	230	54
Idfo Spring	3.0	1920.0	8.34	11	598	20	40	500	390	390	36
Der 1	3.72	2380.8	8.58	10	680	36	85	570	686	370	18
Hager El Arab Spring	4.24	2713.6	7.65	39	455	88	250	970	135	525	24
Kalh El Gabal P11	1.54	985.6	7.28	23	170	42	84	200	200	317	0
Nubia Sediments extract (1:1)	4.07	2604.8	7.28	35	625	50	155	1000	200	458	0

The GWL at 1/4/2010 (Fig. 6d) shows the same trend of groundwater flow, but with slightly increase may owe continuous recharge from irrigation canals and stop irrigation of sugar cane. The difference of groundwater levels from 14/1 to 1/4/2010 (Fig. 6e) shows increase in the western part (around the main irrigation canals and the area characterized by cultivation of sugar cane) and decrease in other parts especially around NSIH. The higher rate of increase was recorded in P. 23 may owing to the upward

leakage from deep Nubian Sandstone water bearings (DNSWB) and other factors, where near this pizometer old tributary was recorded (Fig. 6f). Before that time earthquake was recorded by National Research Institute of Astronomy & Geophysics (NRIAG) 2010 that causes the increase rate of spring discharge such as Idfu spring. Generally, the increase of water level takes N-S (parallel to the River Nile) and E-W (perpendicular to the River Nile) trends may due to the effect of upward leakage through the fault systems.

b. Variation of groundwater salinity with time

The groundwater salinity (GS) map at 14/1/2010 (Fig. 7a) shows mostly the increase of salinity with direction of flow. Where, the lower values are recorded in the southwestern part which is less than 1000 ppm and the higher salinities are detected in the bad drainage areas in the eastern part that reach to more than 25000 ppm. The variation of GS is owing to the variation of source of recharge and the salinity of sediments. The higher salinity area takes trend parallel to the River Nile, which means the probability of upward leakage from NSA. The distribution sulphate shows also the restriction of higher values in the same trend that supports the idea of upward leakage from DNSWB.

The GS mostly decrease in 9/2 (Fig. 7b) in the recharged area in the southwestern part, while increase eastward. Generally, the GS increase with same trend but with higher rate in 1/4/2010 (Fig. 7c) may owing to the stop irrigation of about 10000 feddans of sugar cane and upward leakage through fault systems. The comparison between the GS in 14/1 and 1/4/2010 (Fig. 7d) shows the decrease of salinity in western part and increase eastward owing leaching processes, bad drainage and may due to the effect of upward leakage from DNSWB.

4.2.2. Nubian Sandstone Aquifer

NSA is represented by Taref water bearing which consists of fine to medium sand with thin clay intercalations. It is outcropped in the reclaimed area and overlain by younger sediments in the eastern part, while overlain by Dakhla shale to the north of WS i.e. unconfined to semi confined. The thickness of Taref water bearing varies from about 30 m to more than 220 m. The main sources of recharge are the upward leakage from deep water bearings through fault system, new Quaternary aquifer and may RN. The aquifer discharged by the extraction through wells for irrigation system. Seven water points are recorded in the aquifer (Fig. 6a and table 4). The total depth of the drilled wells varies from 32 m to 215 m from the ground surface. Three of them (Ain Idfu, Nag El Arab and Nag El Balales) are flowing with salinity varies from 1920 ppm and 2717 ppm, while the others are pumped with salinity ranges from about 986 ppm to 2381 ppm. The variation of salinity may due to the different sources of recharge.

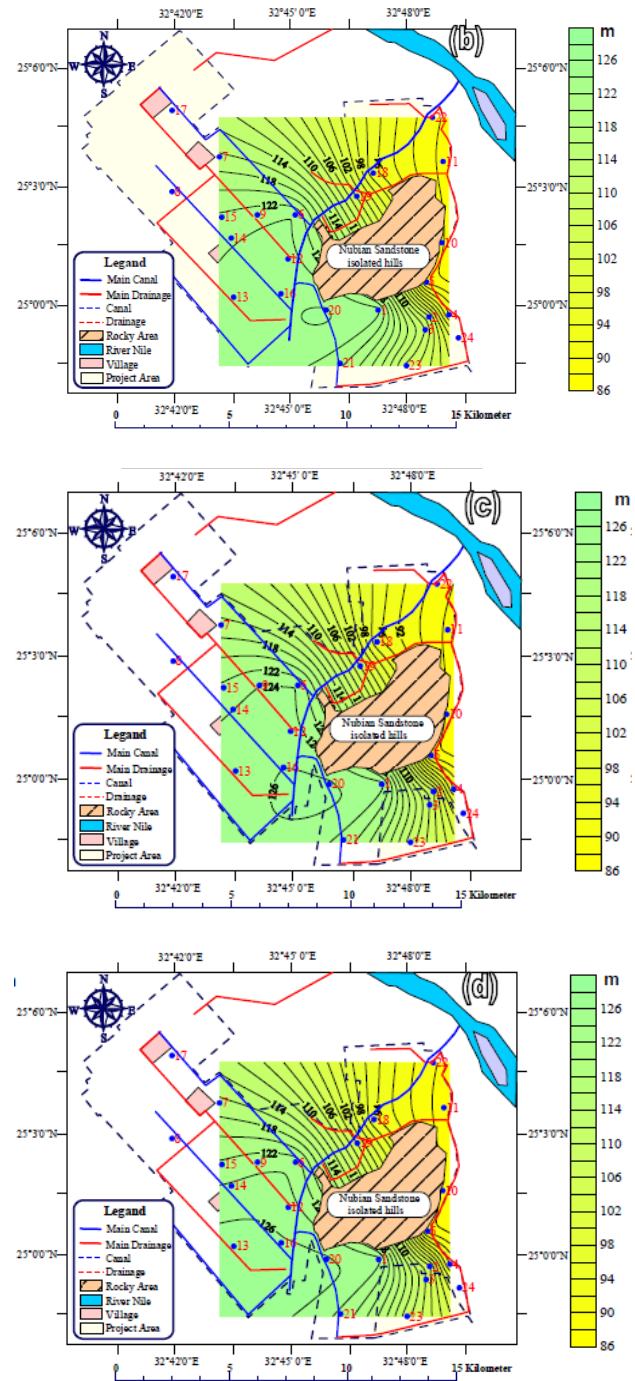


Figure 6. Water level at 14/1/2010 (b), water level at 9/2/2010 (c), water level at 1/4/2010 (d).

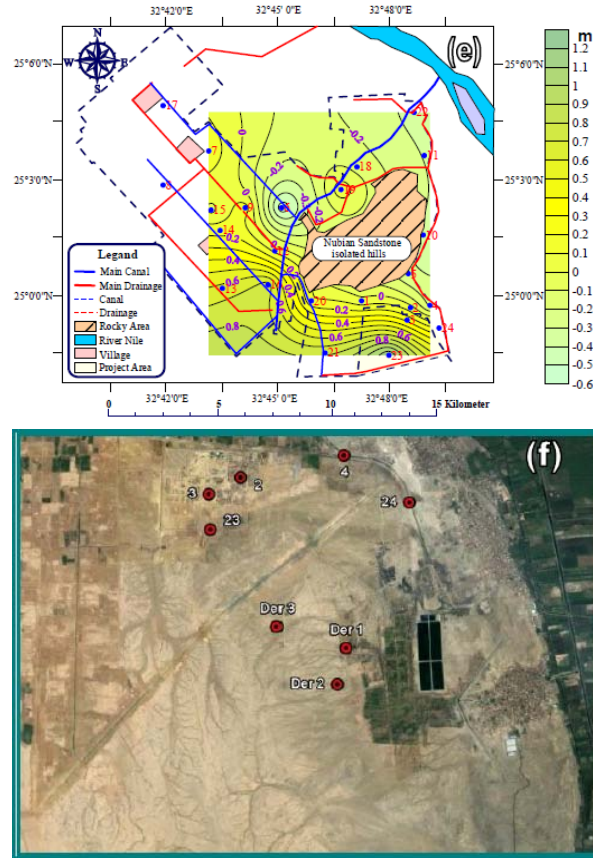


Figure 6. Rates of increase and decrease of water level from 14/1 to 1/4/2010 (e) and satellite image showing old tributaries parallel to the River Nile south El Eman village and P. 23 and W-E tributaries around Der (f).

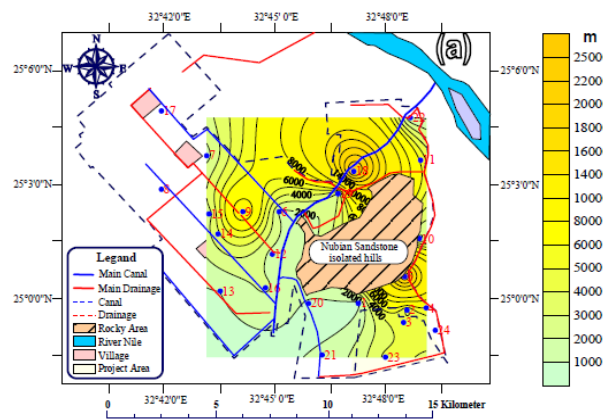


Figure 7a. Groundwater salinity of El Sayda area at 14/1/2010.

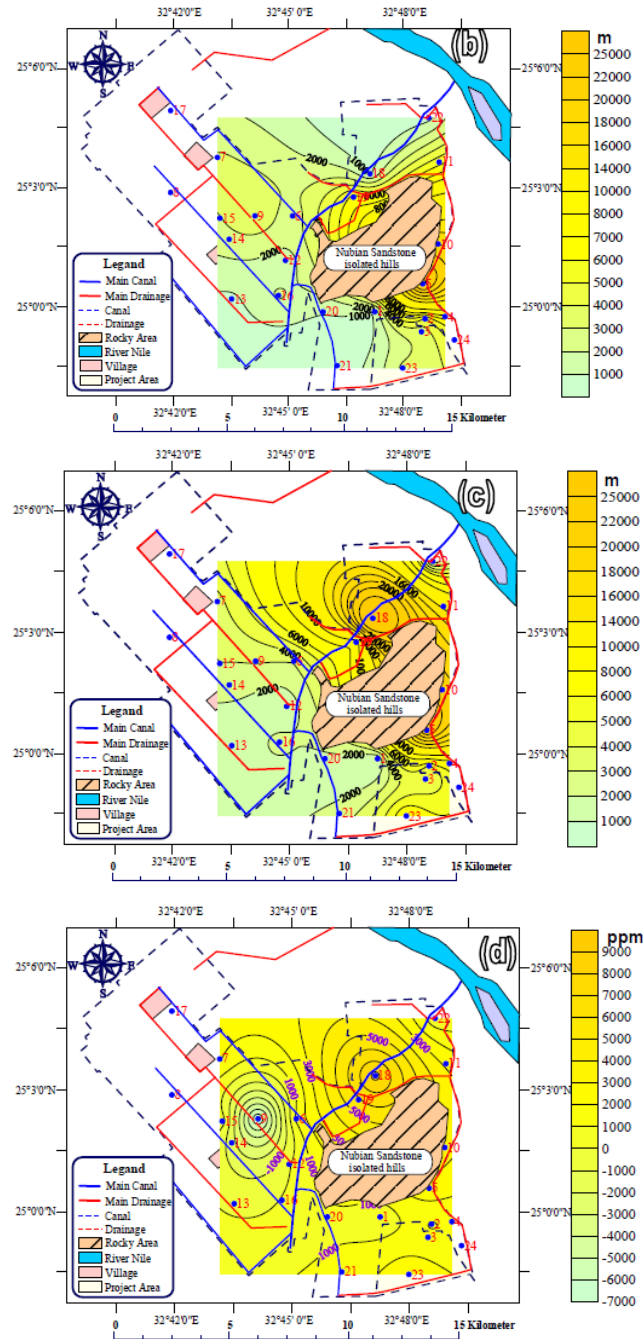


Figure 7. Groundwater salinity of El Sayda area at 9/2/2010 (b), GS at 14/1/2010 (c) and the distribution of the rate of increase and decrease of salinity in from 14/1 to 1/4/2010.

4.3 Hydrogeochemistry

4.3.1 Surface Water

a. Irrigation

- The pH values ranges from 7.56 (El Eman canal) to 8.67 (main canal after pump no. 2).
- The TDS of the pumped water from the River Nile to the north of Idfu Town is about 166 ppm and after mixing with El Eman drain (922.9 ppm) and drain no. 4 (320 ppm), it become 294 ppm at pump station No. 2. The TDS of Amr Ebn Al As, El Shahama and El Eman are about 397, 595 and 576 ppm may due to the bad lining which act as a drain of shallow groundwater.
- The dominance ion sequences are $\text{Na} > \text{Ca} > \text{Mg} - \text{HCO}_3 > \text{Cl} > \text{SO}_4$.
- The hypothetical salt dominances are NaCl, $\text{Ca} (\text{HCO}_3)_2$, $\text{Na}_2 \text{SO}_4$ and $\text{Mg} (\text{HCO}_3)_2$ except El Shahama and El Eman canals which are NaCl, $\text{Ca} (\text{HCO}_3)_2$, $\text{Mg} (\text{HCO}_3)_2$ and $\text{Na}_2 \text{SO}_4$ owing to they act as a drain of groundwater in some parts.

b- Drainage

- The pH values varies between 7.37 (west El Eman village drain) and 8.67 (end drain no. 4).
- The TDS varies from about 923 ppm (the end of El Eman drain) to about 2387 ppm (mid El Eman village drain) owing to the sewage of Kalh El Gabal and Naga El Balalis villages. El Eman village drains changes from about 4518 ppm in the west to about 1997 ppm eastward may due to the effect of recharge from the nearby cultivated area. On the other hand, the TDS of Amr pool is 2560 ppm due to the continuous recharge from Amr Ebn Al As canal and surrounding cultivated land, while Mahgar pool is 21120 ppm owing 249 their very low topography, recharge from drain no. 3, evaporation as well as the effect of groundwater salinity.
- The dominance ion sequences are $\text{Na} > \text{Ca} > \text{Mg} - \text{Cl} > \text{SO}_4 > \text{HCO}_3$, while the end of drain no. 4 are $\text{Na} > \text{Ca} > \text{Mg} - \text{Cl} > \text{HCO}_3 > \text{SO}_4$ due to the effect of nearby main canal, the end of El Eman drain are $\text{Na} > \text{Ca} > \text{Mg} - \text{SO}_4 > \text{Cl} > \text{HCO}_3$ owing to the effect of eastern village sewage, and Amr pool are $\text{Na} > \text{Mg} > \text{Ca} - \text{Cl} > \text{SO}_4 > \text{HCO}_3$ due to the effect of high evaporation.
- The hypothetical salt dominances are NaCl, $\text{Ca} (\text{HCO}_3)_2$, $\text{Na}_2 \text{SO}_4$ and $\text{Mg} (\text{HCO}_3)_2$ with variable concentration from drain to another depending the connection with groundwater or not and the impact of soil salinity. The higher percentages of CaSO_4 salts are recorded mostly in Mahgar pool and west drain in El Eman village may due to the effect of upward leakage from Nubian deep water bearings.

4.3.2 Groundwater

a. Quaternary Aquifer

- The pH values ranges from 7.1 (P 12) to 7.9 (P 5).
- The main TDS values of the southwestern part around the main canals vary from about 557 ppm (P 21) to about 1018 ppm (P 13) in 14/1/2010. On the other hand, the TDS of other pizometrs far from the canals varies from about 1555 ppm (P 12)

to 22080 (P 5). In 9/2/2010, the TDS of southwestern part vary from about 705 ppm (P 22) to about 1446 ppm (P 11) which means increase of groundwater salinity due to stop irrigation of 10000 feddans of sugar cane. On the other hand, the salinity of other pizometers increases from about 1421 ppm (P 12) to 25984 ppm (P 5) to the stop irrigation of sugar cane and leaching processes as well as upward leakage from deep Nubian water bearings.

- The dominance ion sequences in 14/1/2010 are mostly $\text{Na} > \text{Ca} > \text{Mg} > \text{Cl} > \text{SO}_4 > \text{HCO}_3$ except pizometers near and around irrigation canal which are $\text{Na} > \text{Ca} > \text{Mg} > \text{Cl} > \text{HCO}_3 > \text{SO}_4$ due to the higher rate of recharge and P 23 which are $\text{Na} > \text{Ca} > \text{Mg} > \text{SO}_4 > \text{Cl} > \text{HCO}_3$ may owing to the upward leakage from deep Nubian water bearings. In 9/2/2010, the dominance sequences are the same of 14/1 except P 23 which changed to $\text{Na} > \text{Ca} > \text{Mg} > \text{Cl} > \text{HCO}_3 > \text{SO}_4$ due to the effect of continuous recharge from the irrigation system in the southwestern part.
- The hypothetical salt dominances of the recharged area to the southwestern part are mostly NaCl , $\text{Ca}(\text{HCO}_3)_2$, $\text{Mg}(\text{HCO}_3)_2$ and Na_2SO_4 , while in the far from the area of recharge are mainly NaCl , $\text{Ca}(\text{HCO}_3)_2$, MgCl_2 and CaSO_4 .

a. Nubian Sandstone Aquifer

- The pH values varies from 7.28 (Kalh El Gabal) to 8.58 (Der no. 2).
- The TDS of the extract water from Nubian sediments (1:1) is about 2605 ppm. The TDS varies from about 986 ppm in kalh El Gabal due to the effect of continuous recharge from irrigation and drainage system as well as the effect of recharge from Quaternary aquifer, to about 2714 ppm in Hager El Arab spring. The TDS to the south of the reclaimed area varies from about 1238 ppm (Der no. 2) to about 2381 ppm (Der no. 1); the variation may owing to the depth and rate of upward leakage and the effect of recharge from Idfu sewage pools (Fig. 6f).
- The dominance ion sequences of the extracted water from Nubian sediments are $\text{Na} > \text{Ca} > \text{Mg} > \text{Cl} > \text{HCO}_3 > \text{SO}_4$ which the same dominances of Hager El Arab flowing and Kalh El Gabal wells. On the other hand, owing the upward leakage and the effect of Idfu sewage pools, the dominance sequences become $\text{Na} > \text{Ca} > \text{Mg} > \text{Cl} > \text{SO}_4 > \text{HCO}_3$ south the reclaimed area.
- The dominance sequences of the extracted water from Nubian are NaCl , $\text{Ca}(\text{HCO}_3)_2$ and MgSO_4 . The hypothetical salt dominances are mostly NaCl , Na_2SO_4 and $\text{Ca}(\text{HCO}_3)_2$ to the south of reclaimed project, while the dominances in others that affected by irrigation system are mostly NaCl , $\text{Ca}(\text{HCO}_3)_2$ and Na_2SO_4 except Hager El Arab flowing which are NaCl , $\text{Ca}(\text{HCO}_3)_2$ and MgCl_2 may due to the effect of evaporates.

4.3.3 Trilinear diagram

Piper (1944) suggested trilinear diagram from which certain distinct water can be easily discriminated by the chemical constituents of water samples. Most of surface and groundwater samples of different aquifers are attributed to infiltration (meteoric type) and the chemical compositions of the aquifers reflect the influence of aquifer sediments.

One of the main purposes of this water analysis diagram is to show the different types of water in the area. From the trilinear for the studied water samples, several types of points alignments were distinguished. These zones can be classified as follows:

- Zone A of the irrigation water.

- Zone B of the drainage system except the end of drain no. 4 which is located in zone A. The start of drain 4, west and east of El Eman village drains are located in zone C of the Quaternary aquifer due to they excavated to decrease the groundwater level in El Eman village.
- Zone C of the Quaternary aquifer which divided into three parts of recharge. A of high recharge, B of moderate recharge and C of less recharge.
- Zone D of Nubian aquifer, except Hager El Arab and Kalh El Gabal wells which are located in zone C due to the continuous recharge from irrigation and drainage systems as well as the Quaternary aquifer.

According to Stuyfzand (1986 and 1989) classification, the main compounds of surface water are mix and the chemical processes are refreshing except drain No. 2, west El Eman village drain and Mahgar pool which the main compound are NaCl. There are three zones of recharge in Quaternary aquifer, zone A of highly recharge around the main canals in the southwestern part, zone B of moderate recharge around the main drainage and zone C of less recharge in bad drainage area around NSIH. The main compound of NSA water are mix and the chemical processes are refreshing may due to the effect of recharge from irrigation and drainage systems, Idfu sewage pools and upward leakage from deep seated Nubian water bearings.

Most of surface water samples are deep meteoric water according Sulin (1944) diagram. Also, the groundwater samples of zones A and B in QA are deep meteoric, while zone C samples are shallow marine water. NSA in the southern part are deep meteoric water, while are shallow marine water near the reclaimed area.

According Ovitchinkov Graph, most of surface water and Quaternary groundwater zones A and B water samples are meteoric affected by leaching processes of sediments, except water samples of zone C around NSIH are marine water of artesian springs leaching to sediments. The southern samples of NSA are marine water of artesian springs except the northern samples which are meteoric surface water leaching of sediments due to the effect of recharge from irrigation and drainage systems. This supports the idea of upward leakage from deep water bearings.

5 MAIN HAZARD OF THE

The main hazards in the reclaimed area of WS are the following:

5.1 Problems due implementation

During implementation the infrastructures of the project were modified such as:

- The depth and width of main canal decreased to 2.5 and 5 m which decrease transport water by about 20% of 330×10^6 m³/year into 268×10^6 m³/ year. Also, declined the canal elevation to +127 m which causes the lack of water in the higher parts.
- Bad lining of the irrigation canal.
- Changing the elevations, depths, widths and slopes of main drainage, cause the accumulation of water in most of them, salinization and water logging of the surrounding areas.

5.2 Random land reclamation

The occurrence of relatively good soil outside the project and the excess of water in the start encourage farmers to reclaimed new areas that increase with time to about 10000 feddans in 2010. They excavated their irrigation canals without lining to carrying water from the project and utilizing flood method for irrigation coarse texture soil as well as cultivate voracious crop water such as sugar cane. The violations use a lot of water that cause lack of water in other areas and seepage high quantity of water to the groundwater.

5.3 Changing drip and sprinkler irrigation method to flood

Farmers in the project and the random reclamation (10000 feddans) changed the proposed drip and sprinkler irrigation method into flood. Thereby, the water requirement with assumption 7000 m³/feddan/year changed to become 280 X 10⁶ m³/year for 40000 feddans, while the available net result is about 171.52 X 10⁶ m³/year. Also, utilizing flood irrigation method causes the seepage of excess irrigation water to the low land areas that decrease their productivity and salinization as well as water logging with time.

In 2010, the total cultivated area in the project (30000 feddans) is about 12000 feddans which cultivated mostly by plants that needs a reasonable water requirements. It needs about 78 X 10⁶ m³/year with assumption 6500 m³/feddan. The Violations on the project 370 reach to about 10000 feddans that are mostly cultivated by sugar cane, with assumption water requirement of each feddans is about 10000 m³/year, the requirements are 100 X 10⁶ m³/year. The requirements of the cultivated area in WS are 178 X 10⁶ m³ / year. On the other hand, the quantity of evaporation from the surface water is 0.044 X 365 X 6000000 = 0.096 X 10⁶ m³/year and the quantity of evapotranspiration is 0.079 X 365 X 4200 = 2.66 X 10⁶ m³/year. These means that the total requirements of the cultivated area (22 000 feddans) are 180.76 X 10⁶ m³/year. The available water in the project for irrigation is 171.5 X 10⁶ m³ / year and the shortage reach to 9.26 X 10⁶ m³/year.

5.4 Bad maintenances

Owing bad lining of irrigation systems, different types of grasses were growths that decrease the water flow. Also, utilizing mechanical method for removal grasses break lining and cause seepage to groundwater. Lack of drainage maintenances causes a deterioration of vast areas. Due to bad maintenance of the main canal, three pumps of each work station work only that led to decrease the transported water in the main canal by at least 20 % of 268 X 10⁶ m³ / year into 214.4 X 10⁶ m³ / year. Also, violations on the project with unlined canals and bad maintenances of irrigation and drainage system, the proposed water transport to the project decreased by 20% of 214.4 X 10⁶ m³/year into 171.52 X 10⁶ m³/year.

4.5 Water logging problem

Due to the bad lining and maintenances of irrigation system, bad connection between drains and utilizing flood irrigation method for irrigation coarse soils, more that 20% of 268 X10⁶ m³/year that reach to about 53.6 X 10⁶ m³/year seepage to the groundwater. Some of the drainage system acts as a drain, while most of them are a source of recharge. The monthly measure of water level in the excavated pizometers shows the rate of increase varies from about 21.8 cm/year in January that is about 44.15

$\times 10^6 \text{ m}^3/\text{year}$ to about $15.06 \text{ cm}/\text{year}$ in February after stop sugar cane irrigation which is about $30.366 \times 10^6 \text{ m}^3/\text{year}$ with average $18.43 \text{ cm}/\text{year}$ and $37.26 \times 10^6 \text{ m}^3/\text{year}$. These means the seepage from sugar cane (10000 feddans) is about $13.79 \times 10^6 \text{ m}^3/\text{year}$.

5.6 Problems of design

The designer selected the low laying areas for the proposed villages of farmers. With changing the drip and sprinkler method of irrigation to flood and bad maintenances of the project and increase the groundwater level with time until the accumulation of water in some villages such as El Eman. For combating this problem, the administration of the project excavated five drains in the village (west, middle and east) to cut and decrease the groundwater level.

6 SOLUTION OF THE PROJECT PROBLEMS

To solve the main problems of the project the following solutions (Fig. 8) must be done:

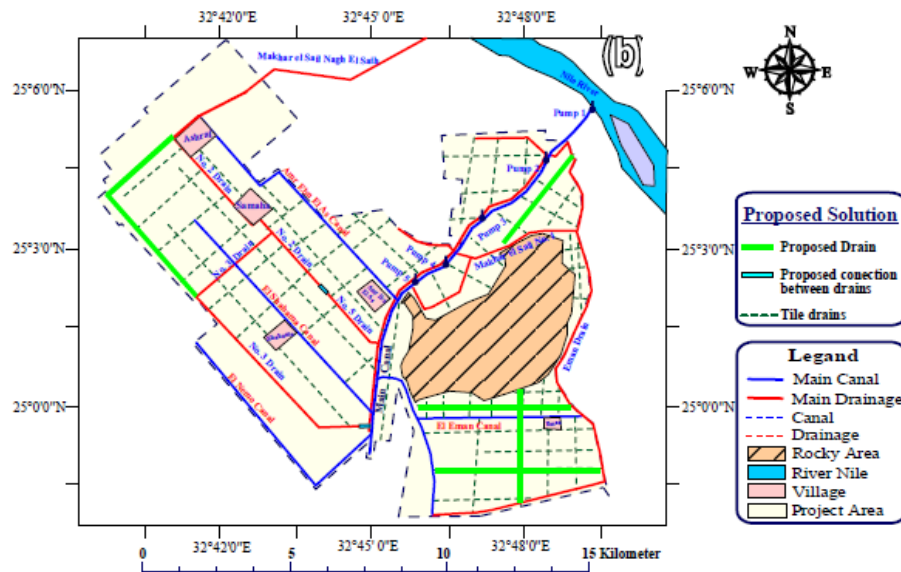


Figure 8. Solution of problems in El Sayda area.

6.1 Re-design the irrigation system

The designer must be:

- Redesign the main canal with their pump stations to irrigate about 60000 feddans (double the area of the project) and the water requirements become $420 \times 10^6 \text{ m}^3/\text{year}$ depending on flood method of irrigation. Redesign also the irrigation system to become suitable for topography, geological conditions and types of soil.
- Redesign the existing drains to become connected with each.

6.2 Connection between drains

The connection between drain No. 5 and drain No. 2 will release the excess of water in drain No. 2 in El Samaha and El Ashraf villages. Also, the connection between drain No. 3 and drain No. 4 will decrease the release of drain No. 3 to drain No. 2.

6.3. Excavate new drainage

The main areas that face water logging and salinization problems are north reins of El Eman village, the area between main canal and Makar El Sail No. 1 and the area between drain No. 3 and drain No. 2. To solve these problems, some new drains (Fig. 8b) must be excavating as follows:

- New drain to connect drain No. 3 and Mafed Nag El Saih to decrease the release water from drain No. 3 to drain No. 2.
- New drain in the mid area between main canal and Mafed El Sail No. 1 to drain the excess of water and decrease the groundwater level into El Eman drain.
- New drain south NSIH to decrease the water logging and salinization in this area.
- New drain between high and low land area in reins of El Eman and connect it with the proposed drain south NSIH to decrease the groundwater level that causes the water logging in El Eman village.

6.4 Excavate new tile drainage system

The occurrence of ferruginous hard pans with different depths (about 30 to 100 cm from the ground surface) prevent the seepage of excess of water to the ground water and lead to salinization, water logging and accumulation of water in vast areas. Owing to the topography, geological conditions and characteristics of hard pans, the reasonable method for solving this problem is excavation a tile drainage network as shown in figure (8b) continuously with re- design and connection between drains. The designer must be take in your consideration the distance between tile drainage lines, characteristics of soils, slopes and maintenances.

6.5 Maintenances of irrigation and drainage systems

The mechanical method for maintenance of irrigation system breaks lining and caused seepage a lot of water to the groundwater. The re-lining and completely prevent lines in between by hydrocarbon materials will prevent the growth of grasses. The project can use mechanical or chemical methods only for maintenance the drainage system

6.6. Decreasing the groundwater level

The calculation of the seepage to the groundwater that reach to about 53.6×10^6 m³/year, the construction of El Eman main drain cut the groundwater flow in the eastern part. The more decrease of the bottom level by 50 cm will more decrease the groundwater level will increase the gain of water to irrigate other areas. The connection between drains, excavation of new drains and till drainage network as well as re-building lining of irrigation canal, will decrease the seepage to the groundwater.

7 SUMMARY AND CONCLUSION

Excellent solution to overcome of over growing population, horizontal expansion of agricultural land is must to aluminizing such as Wadi El Sayda (WS) north Aswan governorate. The new reclaim project (30000 feddans) in WS changed the hydrogeological setting and some phenomenons were recorded that face the future development. Thereby, the article aimed to identify the hydrogeological setting of the new reclaimed area and their problems as well as solutions. The project design to depending on river Nile (RN) water through five pump stations to elevate water from +84 to +129 m through main lining canal to transport about $330 \times 10^6 \text{ m}^3/\text{year}$. The average salinity of the RN is 166 ppm, while changed into about 290 ppm at pump station no. 2 owing to it receives the drain water of El Eman and drain No. 4. The main canal divided into four lining canals namely; Amr Ebn Al As, El Shahama, El Nemow and El Eman with salinities about 400, 575, 580 and 590 ppm. The area is dissected also by system of drainage to receive the excess of water. The main drains are drain nos. 2, 3, 4, 5 and El Eman which vary in salinity from the start to the end. Where, they are about 1410, 801, 960, 1280 and 2390 ppm at the start, but at the end are about 1430, 1018, 420, 574 and 920 ppm. The decrease of salinity in drain no.4 is due to the seepage from the main canal, while decrease of El Eman salinity owing sewage of eastern villages.

No water points were recorded before in the new reclaimed area of WS. Owing to the excavation of irrigation and drainage systems, and utilizing the flood method of irrigation, a lot water ponds and new groundwater aquifer are formed. Different pizometers have been drilled to detect the Quaternary aquifer extension and observe the fluctuation of water level with time. It consists of Pleistocene graded sand and gravel with thin clay intercalations and underlain by fine grained Pliocene sediments i.e. unconfined aquifer. The main source of recharge is the seepage from irrigation and drainage systems, the percolation from excess irrigation water of field. The groundwater salinity varies from about 557 ppm in the southwestern part to about 22080 ppm eastward owing leaching process, bad drainage and may due to upward leakage from deep Nubian water bearings (DNWB). The groundwater level (GWL) measured monthly from January to April 2010 to detect the fluctuation with time. GWL at 14/1 is relatively affected by the ground elevation, the direction of water flow from southwestern part to the eastern part and the higher rate was recorded in the southwestern part and cultivated area by sugar cane. The same trend is extended at 9/2 but with relatively higher level owing the continuous recharge from irrigation canals, but with slightly increase at 1/4 may owe continuous recharge from irrigation canals and stop irrigation of sugar cane. The groundwater salinity (GS) monitoring through the same period shows the increase of salinity eastward from less than 1000 ppm in the southwestern part to more than 25000 ppm at 14/1/2010 may owing to the variation of source of recharge and the salinity of sediments. The higher salinity that takes trend parallel to RN may support the occurrence of upward leakage from DNWB. The GS mostly decrease at 9/2 while increase at 1/4/2010 may owing to the stop irrigation of about 10000 feddans of sugar cane and upward leakage through fault systems.

NSA is represented by Taref water bearing of thickness varies from about 30 m to more than 220 m and which consists of fine to medium sand with thin clay intercalations i.e. unconfined to semi-confined. The main sources of recharge are the upward leakage from deep water bearings through fault system and new Quaternary aquifer. Seven water points are recorded in the aquifer with total depth varies from 32 m to 215 m. Three of them are flowing with salinity varies from 1920 ppm and 2717 ppm, while the others are pumped with salinity ranges from about 986 ppm to 2381 ppm. The variation of salinity may due to the different sources of recharge.

There are three zones of recharge in Quaternary aquifer, zone A of highly recharge around the main canals in the southwestern part, zone B of moderate recharge around the main drainage and zone C of less recharge in bad drainage area around Nubian Sandstone isolated hills(NSIH). The main compound NSA water are mix and the chemical processes are refreshing may due to the effect of recharge from irrigation and drainage systems, Idfu sewage pools and upward leakage from DNWB. NSA in the southern part are deep meteoric water, while are shallow marine water near the reclaimed area. Most of QA zones A and B water samples are meteoric affected by leaching processes of sediments, except water samples of zone C around NSIH are marine water of artesian springs leaching to sediments. The southern samples of NSA are marine water of artesian springs except the northern samples which are meteoric surface water leaching of sediments due to the effect of recharge from irrigation and drainage systems. This supports the idea of upward leakage from DNWB.

The main problems in the reclaimed area of WS are problems due implementation, random land reclamation outside the project, changing drip and sprinkler irrigation method to flood, bad maintenances, water logging problem and problems of design. To solve these problems the following solutions must be done: re-design the irrigation system, connection between drains, excavate new drainage, excavate new tile drainage system, maintenances of irrigation and drainage systems, decreasing the groundwater level.

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