

ANNEX C13: GEOLOGY AND HYDROGEOLOGY-WATER QUALITY OF DISI-MUDAWARRA AQUIFER SYSTEM

1 DISI-MUDAWARRA AQUIFER SYSTEMS

Based on the outcrop geology of the Mudawarra Southern Desert groundwater basin, the different rock units overlying the basement complex of the Precambrian Era are subdivided into two main groups; the lower group is called Rum Group and the upper group is the Khreim Group. The Rum Group represents the main aquifer system which consists from different formations. These formations, from bottom to top, are Saleb, Burj, Um Ishrin, Disi and Um Sahm formations. On the other hand, the Khreim Group consists, from bottom to top, of Sahl Suwaan, Um Tarifa, Trabeel, Batra and Alna formations. The rock formations constituting the Rum Group compose the Rum Aquifer System, which is the dominant fresh aquifer system in Southern Jordan while the rock formations constituting the Khreim Group represent the confining layer where Sahl Suwaan Formation occur. The rest of the formations form a leaky aquitard containing relatively highly saline water.

The Rum Aquifer System represents an unconfined aquifer system in the area in which no deposition of Khreim Group occurring and it represents a confined aquifer system in the areas where Khreim Group overlies the Rum Sandstone deposits. The aerial distribution of unconfined – confined aquifer type of the Rum Aquifer System is shown in **Figure 1**.

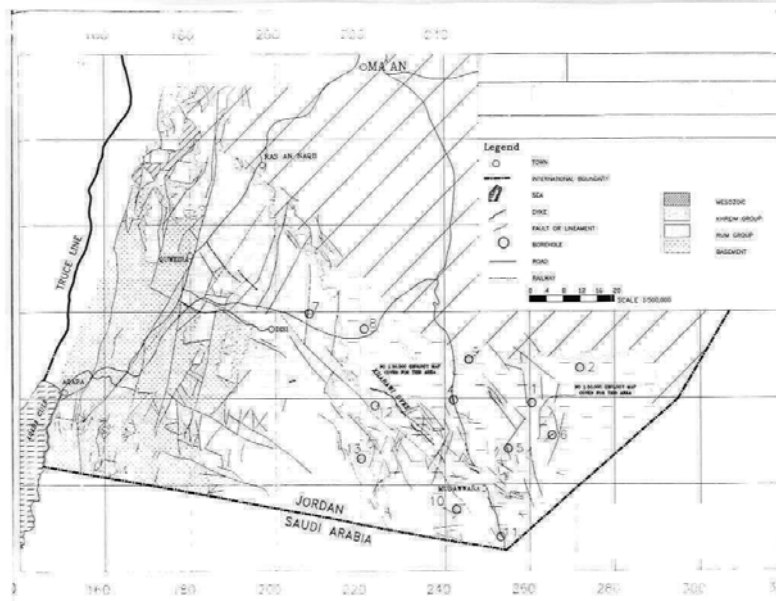


Figure 1: Geology of the Disi-Mudawarra area (Source: Haiste and Scott Wilson, 1995)

1.1 Geology and Hydrogeology of Disi-Mudawarra

According to the exposed rock formations in Southern Jordan presented in **Figure 1**, the Precambrian basement complex represents the base of the Rum Aquifer System. The Rum aquifer system represents an unconfined aquifer in the areas between where it directly overlies the basement and it directly underlies the Khreim Group (**Figure 1**). Generally, the Disi-Mudawarra area (**Figure 1**) is bisected by many faults with different directions. The two major directions are Northwest-Southeast and Northeast – Southwest and the two minor fault systems

are in the direction of North – South and East-West. The inter-relationship between the Rum Aquifer and Khreim Aquitard is represented in a simplified hydrogeological cross section (**Figure 2**). The Rum Group is extended to the south where it is exposed in Saudi Arabia and similarly forms unconfined and confined aquifer systems. The Rum aquifer system in southern Jordan is extended into Saudi Arabia where it is known as Saq Aquifer System and both actually form one aquifer system. Generally, the groundwater flows from the Saudi Arabia in the south towards north east Jordan and in Central Jordan it deviates to north west and lastly towards west where it discharges its water in the Dead Sea and in the deep wadis draining the eastern highlands towards the Rift Valley (**Figure 3**). The most important feature of the Rum Aquifer is its homogeneity in the grain size of the different formations constituting the aquifer except local lateral finer grains especially in Um Sahm formation. The total thickness of the Rum Aquifer is about 1,200 m and this thickness is usually decreased towards its marginal exposure in the west. A confining layer, the Haswa Shale of Khreim Group, overlies the Rum Aquifer. The thickness of this confining layer is almost uniform of 50 m. The rest of the formations of the Khreim Group represent a leaky layer of a thickness ranging between 400 m and 1,200 m and normally contain saline water. The depths to be penetrated to reach the top of the Rum Aquifer in Disi-Mudawarra area are shown in **Figure 4**.

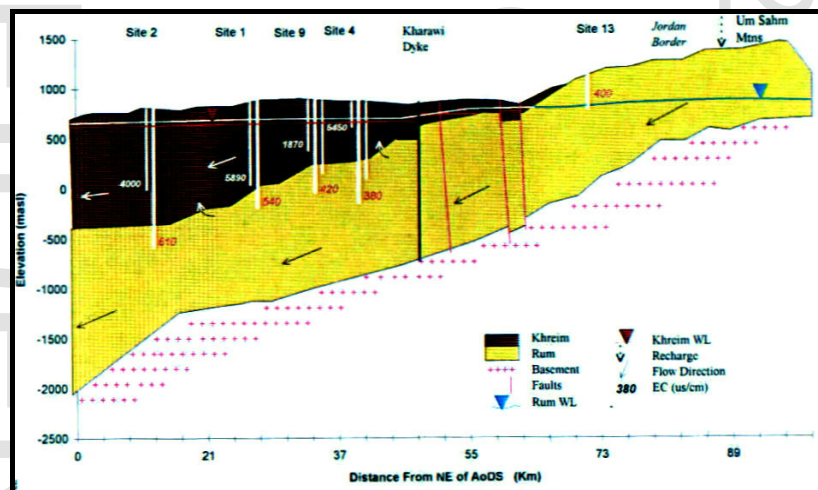


Figure 2: Simplified hydrogeological cross-section showing the inter-relationship between Rum Aquifer and Khreim Aquitard (Source: Haiste and Scott Wilson, 1995)

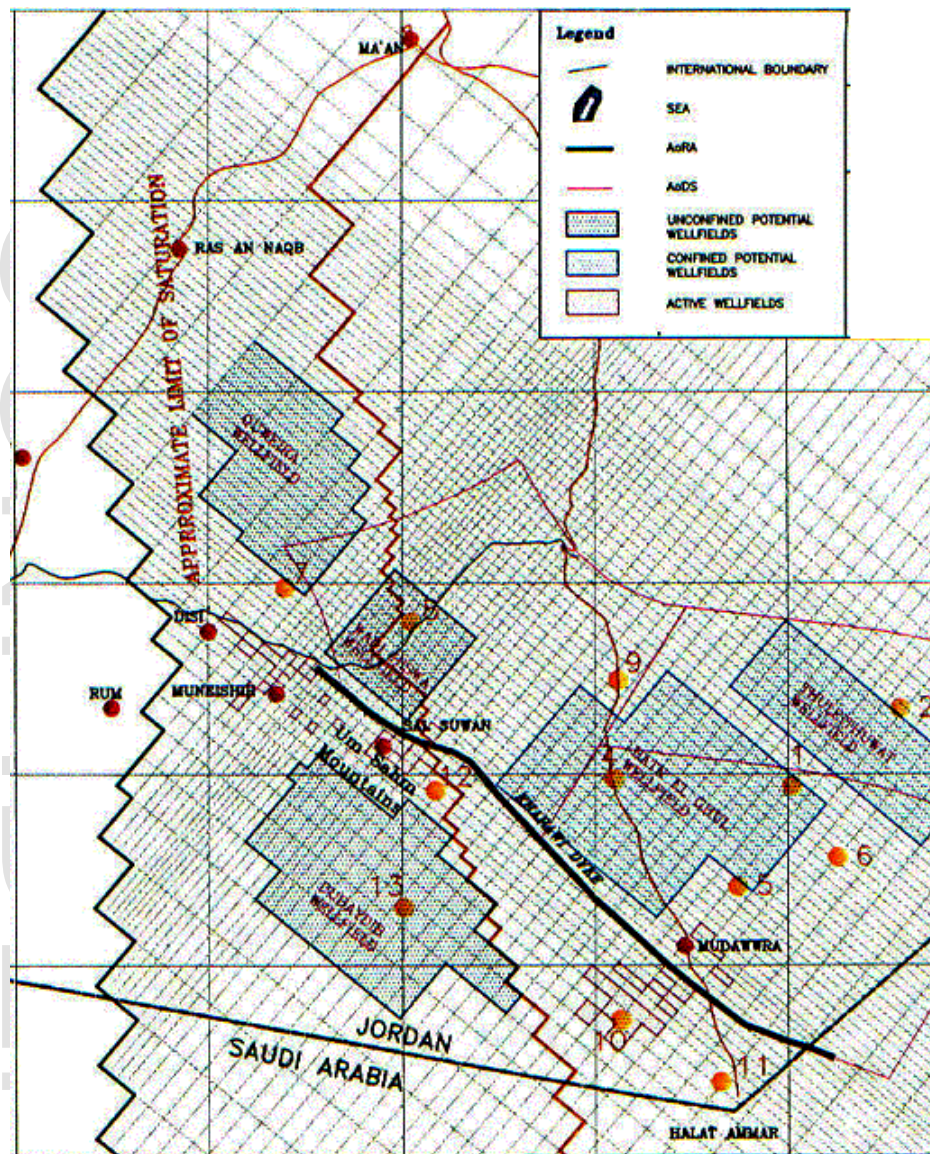


Figure 3: A generalized groundwater flow of the Rum Aquifer in Saudi Arabia, Southern and Central Jordan (Source: Haiste and Scott Wilson, 1995)

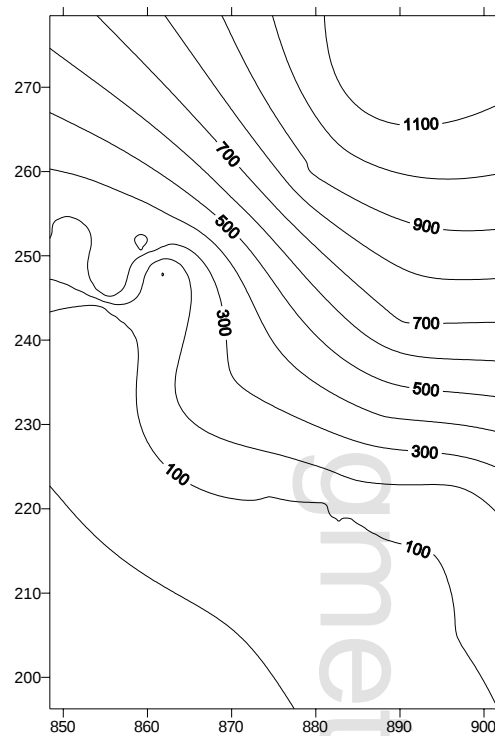


Figure 4: Penetrated depths to reach the Rum Aquifer (Depth in meters)

1.2 Aquifer System

In the area located between Disi-and Mudawarra, there are more than 80 wells drilled during the last five decades. Most of these wells were drilled during the last two decades. The abstracted water from these wells are used for domestic industrial purposes for Aqaba, domestic local communities distributed all over the area, and most of the abstracted amount is used for agricultural purposes utilized by many agricultural companies such as Rum Company, GRAMECO, Wafa and Arab Agriculture Company. **Table 1** presents the total amounts that were abstracted from the wells and distributed all over the area for different purposes during the last 6 years.

Table 1: Abstraction amounts from Disi-Mudawarra area

Year	Abstracted Amount MCM/year	No. of Wells
1996	69.8	71
1997	72.9	72
1998	65.2	71
1999	66.3	72
2000	61.6	71
2001	55.3	69

The abstracted amounts from the Disi-Mudawarra area were taken from both the unconfined aquifer in Disi-Sahel Suwaan area and the confined aquifer in the Mudawarra area.

1.2.1 Dubaydib Well Field

Due to the nature of the water quality that occurs in the confining layer of the Rum Aquifer, the study conducted by Brown and Root suggested locating the well field to produce the necessary amount of water in Dubaydib. As mentioned before, the water quality in this area is considered excellent water and there is no deposits of the Khreim Group present in the area where the water occurs in unconfined conditions.

For more emphasis on the nature of the aquifer and water type present in Dubaydib well field area, three wells were located and drilled under the supervision of Scott Wilson Company and a detailed report was submitted to the Ministry of Water and Irrigation (Scott Wilson, 2002). Two wells of these three wells were drilled and tested and the third one is drilled as an observation well in Dubaydib area. A summary of these wells is presented in **Table 2**.

Table 2: Hydrogeological summary of the recently drilled wells in Dubaydib area

Borehole	Aquifer System	Borehole Type	Depth (mbgl*)	Transmissivity (m ² /d)	Storage coefficient	Specific Capacity (m ³ /d/m)	Water Level (mbgl)	Water quality	
								EC (μS/cm)	pH
DBP-1	Rum	Test / production	500	1,100 – 2,400	0.02-0.06	360	123.6	350	6.9
DBO-1	Rum	Observation	400	2,900 – 4,000	0.005	-	121.7	310	8.0
DBP-2	Rum	Test / production	500	300 – 1,400	0.006	100	88.7	365	6.9

* mbgl: meters below ground level

The hydraulic characteristics of the aquifer encountered in the OBP-1, OBPO-1 and OBP-2 were calculated from the well testing supervised by Scott Wilson and Kirkpatrick & Co. Ltd. (Scott Wilson, 2002). The obtained results were found to be correspondent to the unconfined nature of the encountered aquifer in OBP-1 and OBPO-1 wells, and this is clearly indicated in the storage coefficient (specific yield) of this aquifer in these wells (OBP-1 and OBPO-1). Comparing the storage coefficients of these two wells (0.02-0.06 for OBP1 and 0.005 for OBPO-1) with the specific yields of the Disi unconfined aquifer from the previous studies UNDP (1972), Humphreys (1976) and Scott Wilson (1995) which were 0.07 – 0.1, 0.001 – 0.36 and 0.1 respectively, it is noted that the recent values (Scott Wilson, 2002) are smaller than the published values in previous studies. This is attributed to the lithological nature of the Disi aquifer in the area of Dubaydib where it contains traces of kaolinite and micaceous silt intercalated the medium to coarse clean sandstone.

The OBP-2 well is drilled in Dubaydib in the area where the aquifer is confined in nature. In the locality of OBP-2, the confining layer of the Khreim Group is the Haswa Formation, which is composed of shale, sandstone and claystone of about 100m in thickness. Due to this the calculated storage coefficient of the aquifer in OBP-2 (0.006) represents a confined aquifer.

A complete description of the well design is present in the Scott Wilson report (2002). The hydraulic characteristics of the Rum Aquifer obtained from the drilled wells are consistent with the known previous characteristics discussed before. The results on the water quality are also consistent with the water quality of the unconfined aquifer of Rum Group. The water quality changes of the two production wells (DBP1 and DBP2) during eight day pumping test duration are presented in **Table 3** and **Table 4**.

Table 3: Water quality changes of DBP1 during the pumping test

Parameter	Units	Results			
		Constant Rate Test		Airlift Development	
		Day 10 (05/06/2002)	Day 6 (01/06/2002)	Day 1 (26/05/2002)	Sample 1 (22/05/2002)
PH	(-)	7.01	6.80	7.53	7.93
Electrical Conductivity	μS/cm	347	347	349	400
Ca	meq/L	1.96	1.96	1.94	1.39
Mg	meq/L	0.54	0.54	0.56	0.71
Na	meq/L	0.75	0.75	0.88	1.92
K	meq/L	0.02	0.02	0.03	0.12
Cl	meq/L	0.76	0.77	0.75	0.93
SO ₄	meq/L	0.44	0.44	0.44	0.56
HCO ₃	meq/L as CaCO ₃	1.89	2.03	2.08	2.42
NO ₃	meq/L as NO ₃	0.22	0.22	0.22	0.21

Table 4: Water quality changes of DBP2 during the pumping test

Parameter	Units	Results				
		Day 5 (17/07/2002)	Day 6 (18/07/2002)	Day 7 (19/07/2002)	Day 8 (20/07/2002)	Day 15 (27/07/2002)
pH	(-)	6.92	6.81	6.81	6.30	6.82
Electrical Conductivity	μS/cm	383	383	380	383	351
Ca	meq/L	1.66	1.64	1.64	1.64	1.93
Mg	meq/L	0.68	0.70	0.68	0.58	0.47
Na	meq/L	1.25	1.24	1.25	1.20	1.02
K	meq/L	0.04	0.04	0.00	0.04	0.04
Cl	meq/L	1.11	1.12	1.13	1.07	1.13
SO ₄	meq/L	0.66	0.67	0.67	0.67	0.68
HCO ₃	meq/L as CaCO ₃	1.72	1.78	1.59	1.62	1.57
NO ₃	meq/L as NO ₃	0.16	0.16	0.16	0.20	0.16

These two tables (**Table 3** and **Table 4**) show that the water quality is excellent and acceptable for drinking purposes.

1.2.2 Disi Aquifer System

The Disi Aquifer System, which corresponds to Rum Aquifer System of the recent nomenclature of Natural Resources Authority of Jordan, was intensively explored since mid sixties. During the early stages of exploration, the unconfined aquifer was examined and exploited for local utilization and later for the different uses for Aqaba.

Throughout the pumping tests of drilled wells during the different periods, the hydraulic properties of this aquifer were determined while in the later stages specially the study carried out by Scott Wilson in 1995, beside the pumping tests, laboratory measurements and geophysical logs interpretation were determined. The different hydraulic characteristics of this aquifer either in the confined or in the unconfined area of the aquifer are presented in **Table 9. Annex C12** and

Table 9 present the well location, total depth, depth to water level, ground elevation, aquifer depth, discharge (m³/hr), permeability or transmissivity, etc..

A generalized hydrogeological summary of the drilled boreholes in Dubaydib area, which is one of the proposed areas to drill the new well field to supply Amman with 100-150 MCM/year, is presented in **Table 5**.

Table 5: Hydrogeological summary of the Dubaydib area

Borehole	Aquifer System	Borehole Type	Depth (m bgl)	Transmissivity (m ² /d)	Storage Coefficient	Specific capacity (m ³ /dlm)	Water level (m bgl)
DBP1	Rum	Test/Prod.	500	1,100-2,400	0.02-006	360	123.6
DBO1	Rum	Observ.	400	2,900-4,000	0.005	-	121.7
DBP2	Rum	Test/Prod.	500	300-1,400	0.006	100	88.7
S36	Rum	Observ.	380	1,300-2,000	0.005	-	88.34

The water level decline was very limited during the last decade as indicated in the observation wells distributed in the confined and unconfined areas of the Rum Aquifer System. The recorded water level fluctuations carried out in the observation wells are presented in **Table 6**.

Table 6: Water level, well location and aquifer type of the observation wells

Well Idn.	East	North	Depth to water	Aquifer Type
K 3008	241.965	881.020	165.70	Confined
K 3016	243.300	854.100	4.00	Confined
K 3007	241.970	880.980	165.00	Confined
K 1005	234.000	866.060	6.00	Confined
K 1000	258.300	869.100	70.50	Confined
ED 3071	213.130	885.517	66.86	Unconfined
ED 1202	206.050	895.540	-	Unconfined
ED 1203	214.400	887.340	87.40	Unconfined
ED 1204	196.270	897.400	75.67	Unconfined
ED 1303	217.440	884.220	-	Unconfined
ED 1328	223.500	878.400	95.00	Unconfined
ED 3070	209.000	893.370	73.00	Unconfined

The available water level fluctuations recorded in the observation wells presented in **Table 6** are shown in **Figure 5**, **Figure 6**, **Figure 7**, and **Figure 8** in relation with the average abstraction rates from the production wells that are shown in **Figure 9**.

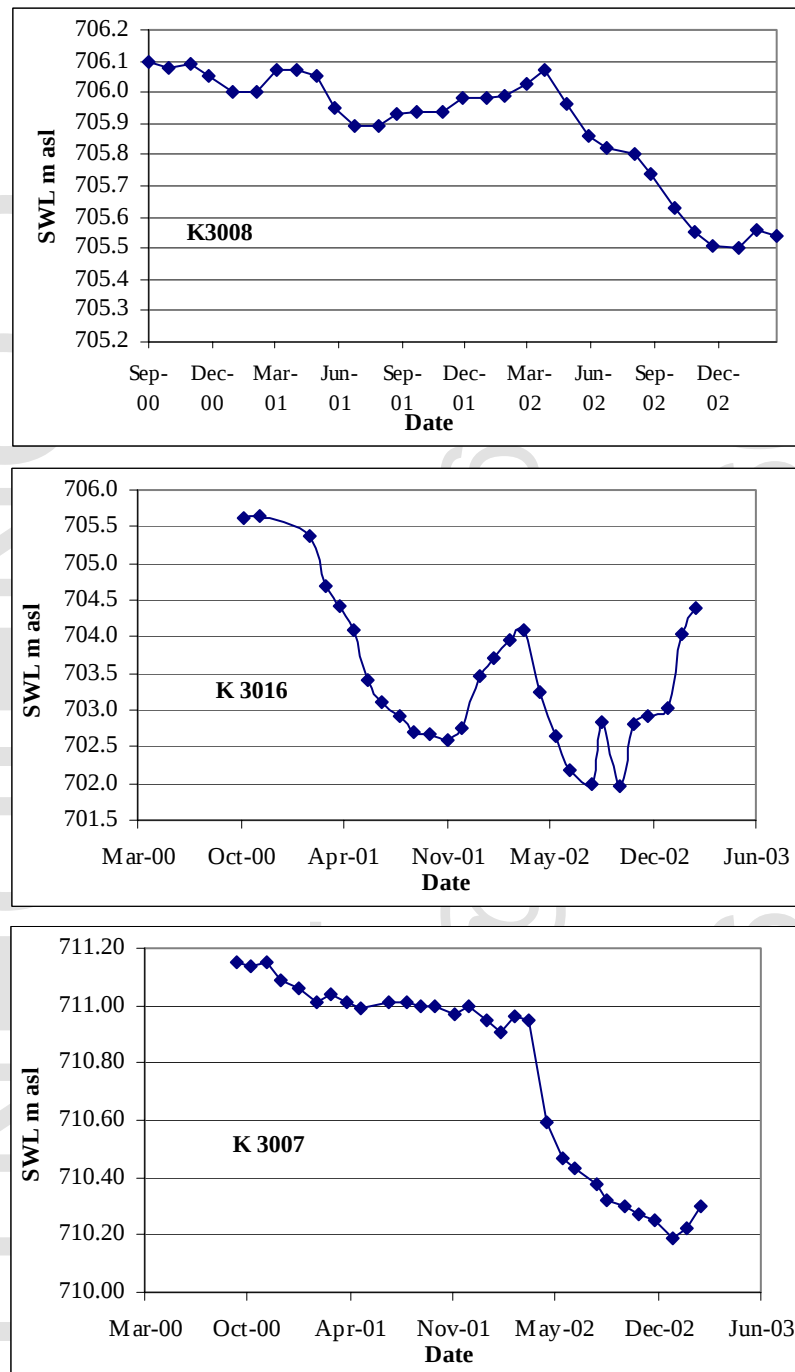


Figure 5: Water level fluctuation of the observation wells (K3008, K3016 and K 3007)

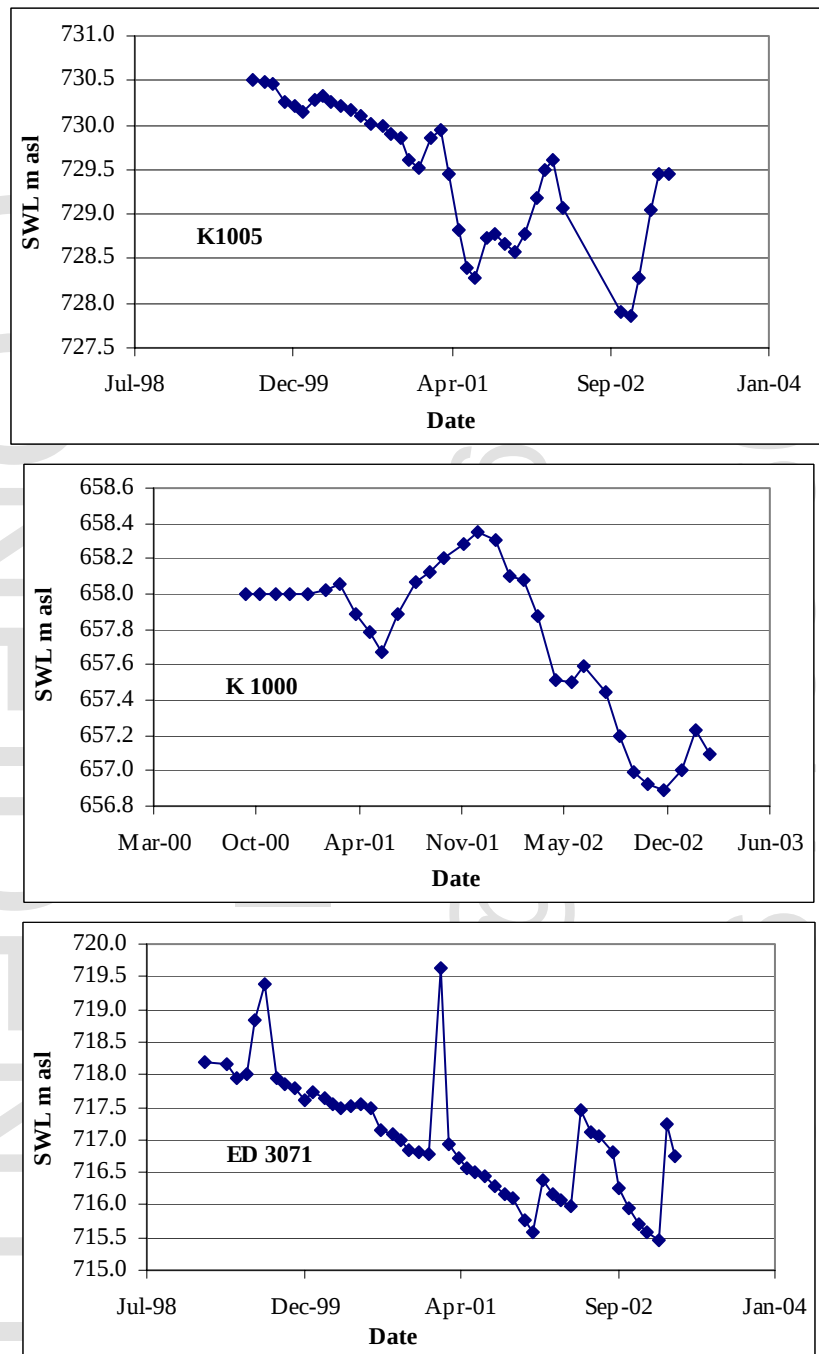


Figure 6: Water level fluctuation of the observation wells (K1005, ED1000 and ED 3071)

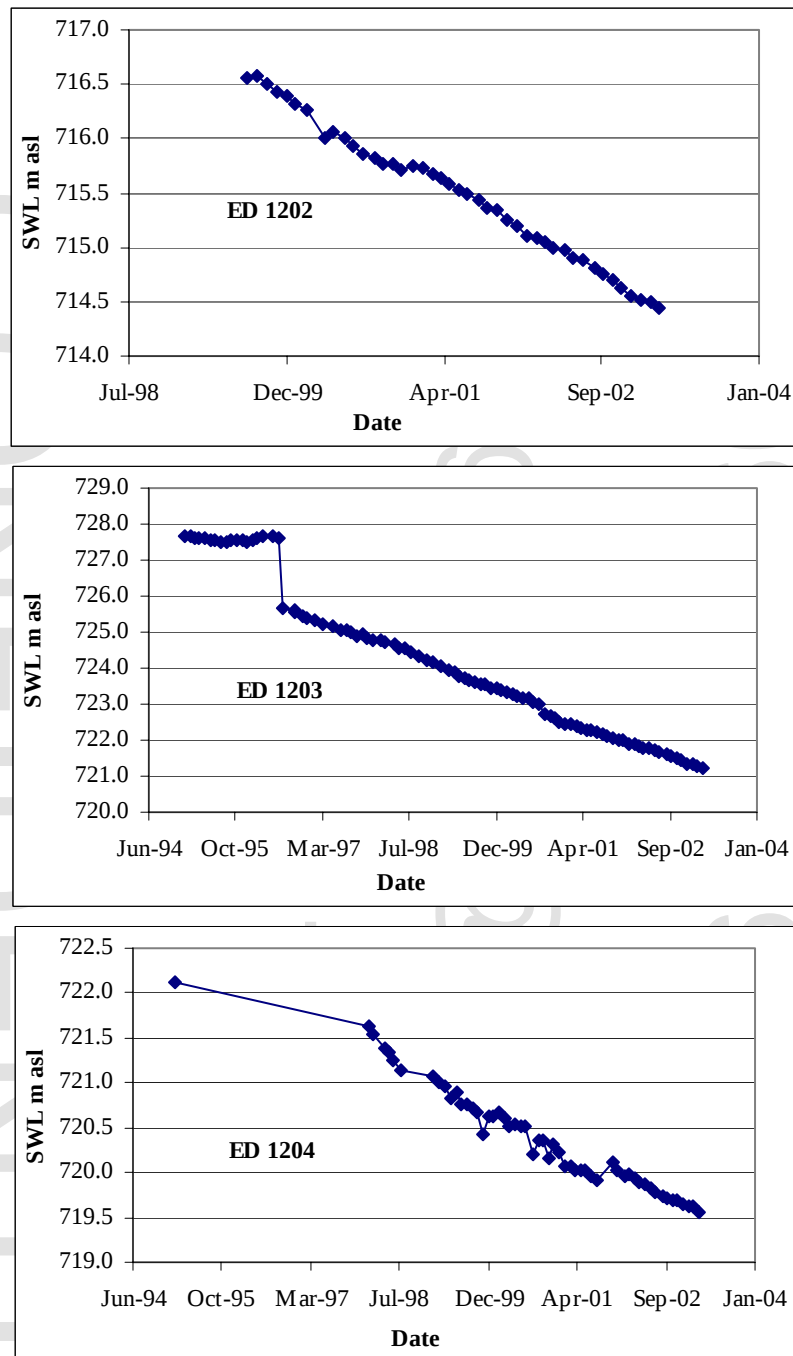


Figure 7: Water level fluctuation of the observation wells (ED1202, ED1203 and ED1204)

The jumps observed in the records of water level fluctuations of the observation wells ED1202 and ED1203 shown in **Figure 7** are attributed to the modifications carried out at the two wellheads when the automatic water level gauges were constructed and installed.

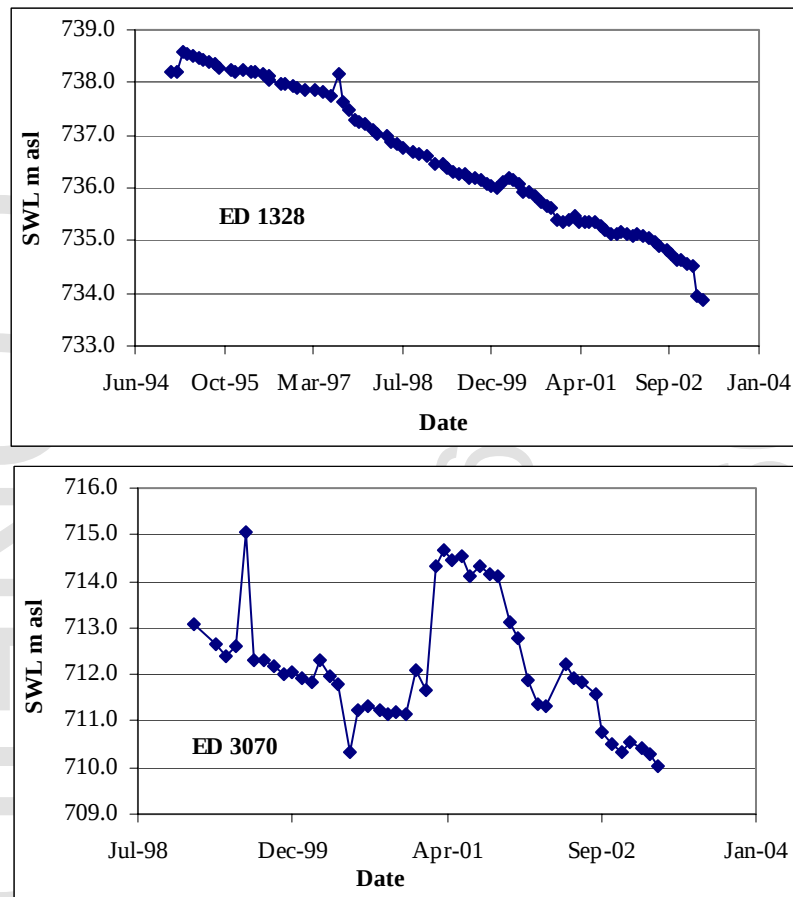


Figure 8: Water level fluctuation of the observation wells (ED1303, ED1328 and ED3070)

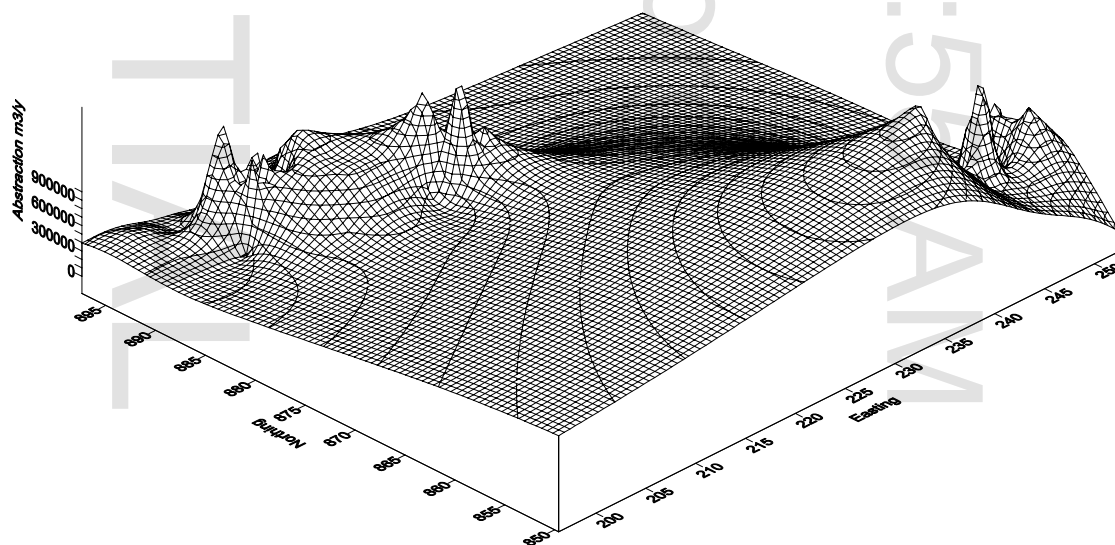


Figure 9: Abstraction aerial distribution from the Disi-Midawwara area

Generally the water level withdrawal during the last three years ranged between 1-4 m in the confined aquifer and between 1-2 m in the unconfined aquifer.

One of the most important characteristics of the water resources of the Rum aquifer is the limited water quality variation either in the aerial or vertical distribution of the aquifer. The examined total section of the Rum aquifer was found through geophysical logs to contain almost consistent water salinity. The water quality available at the Ministry of Water and Irrigation is presented in **Table 9**. Selected quality fluctuations of one groundwater well during the last decade are shown in **Figure 10**. The electrical conductivity ranged between 360 $\mu\text{S}/\text{cm}$ and 460 $\mu\text{S}/\text{cm}$. These values correspond to 230 and 295 mg/L of total dissolved solids. Generally, the EC-values of the groundwater resources of the Rum confined and unconfined aquifer range between 277 and 500 $\mu\text{S}/\text{cm}$. Exceptional values were recognized in Mneisheer wells where the EC values reached 950 $\mu\text{S}/\text{cm}$ (unconfined) and 2,550 $\mu\text{S}/\text{cm}$ in Mudawarra Wind mill well (Confined).

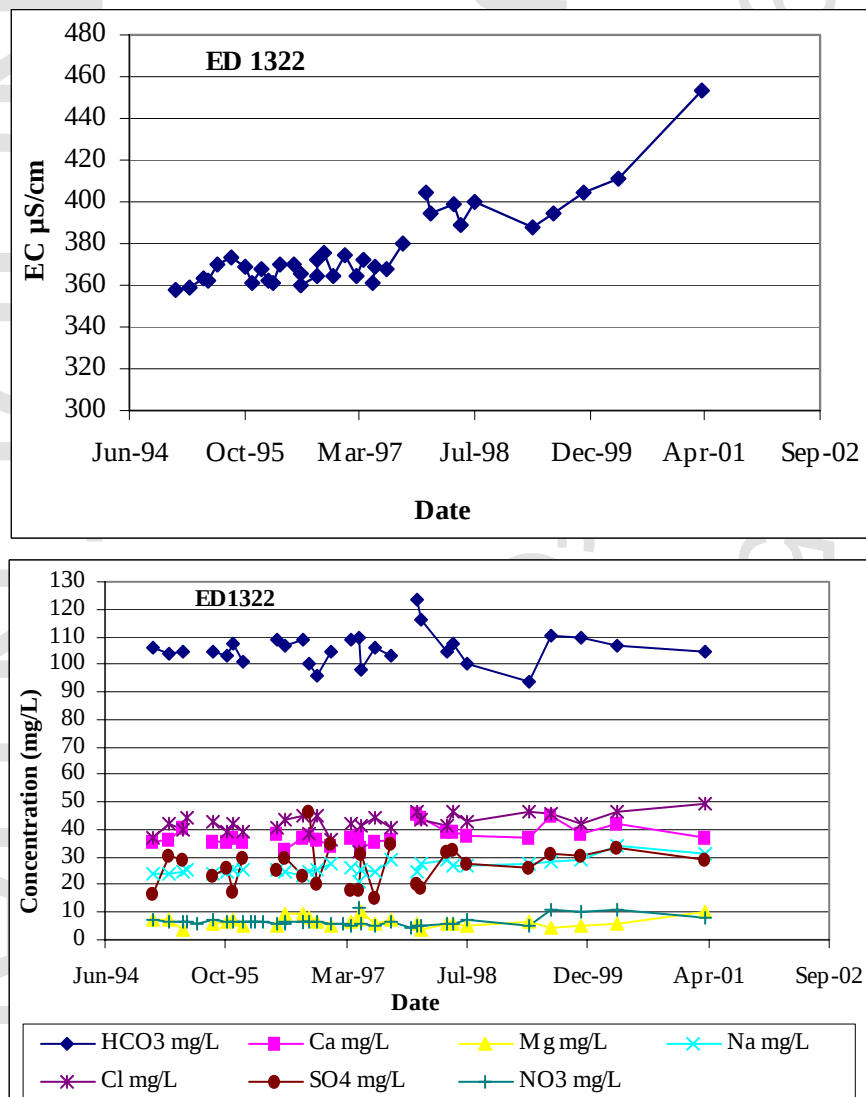


Figure 10: Water quality fluctuation of the observation wells (ED1322)

The water quality of the Dubaydib area, as indicated in the recently drilled well DBP1 (Scott Wilson, 2002), presented in **Table 7** reveals that the water is of calcium-bicarbonate type and of an electrical conductivity of 347 $\mu\text{S}/\text{cm}$ (220 mg/L).

Table 7: Water quality of DBP1 (Dubaydib area)

Date	DBP1 5/6/2002	DBP2 27/7/2002
pH	7.01	6.90
EC (µS/cm)	347.00	365.00
Ca (meq/L)	1.96	1.75
Mg (meq/L)	0.54	0.71
Na (meq/L)	0.75	1.06
K (meq/L)	0.02	0.05
Cl (meq/L)	0.76	1.16
SO ₄ (meq/L)	0.44	0.68
HCO ₃ (meq/L)	1.89	1.59
NO ₃ (meq/L)	0.22	0.16
Sulfate reducing bacteria < 1 CFU/200 ml		

1.2.3 Khreim Aquifer System

As mentioned before, the Khreim Group consists of two main parts; the lower most part overlying the Rum Group (Aquifer) consists of Sahl Suwaan Shale forming a confining layer of the Rum Aquifer, and the Upper part which consists of a heterogeneous sequence of interbedded fine grained sandstones, siltstones and silty shale where this part as a result of the constituents represent a leaky layer. The thickness of the second part (leaky layer) ranges between 400 m and 1,200 m.

Due to the heterogeneity in the constituents of the leaky part, the hydraulic characteristics vary in a wide range. For example, the transmissivity ranges between 112 and 4,143 m²/d, and the horizontal permeability ranges between 0.7 and 4.1 m/d.

The water quality of the Khreim leaky aquifer as documented in the Scott Wilson Report (1995) from boreholes that penetrated this aquifer is presented in **Table 8**.

Table 8: Water quality of the Khreim Group

Measured Parameter	Result	Normal Range
EC (µS/cm)	685 – 41,300	2,000-11,000
pH	6.65 - 11.5	7.1 - 8.0
Temperature (°C)	23 - 40	
Ca (mg/L)	20 - 40	
Mg (mg/L)	12 - 588	
Na (mg/L)	115 - 184	
K (mg/L)	8 - 39	
Cl (mg/L)	167 – 3,300	
SO ₄ (mg/L)	43 – 2,980	
HCO ₃ (mg/L)	92 - 530	

The water quality of the Khreim leaky aquifer varies vertically as indicated in **Figure 11**. The lowest recorded value of EC and consequently the contents of the other 10 constituents were found to occur just above the upper boundary of the Rum Group. This is attributed to the dilution effect from the underlying Rum Aquifer, which has a piezometric head much higher than the Khreim Leaky aquifer.

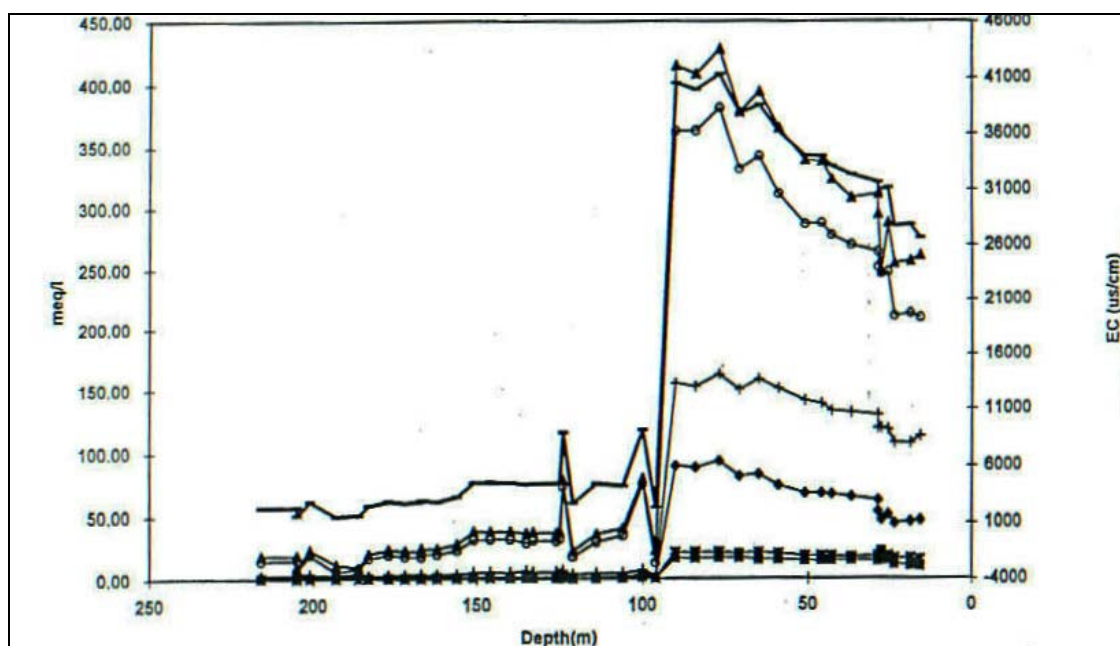


Figure 11: Water quality variations in the Khreim Aquifer with depth (Source: Haiste and Scott Wilson, 1995)

Table 9: Water quality of Disi-Mudawarra groundwater resources

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1007	MNEISHEER QD-7 /M11 (RUM CO.)	889.975	207.225	08/03/95	339	7.97	108.58	0.00	37.27	4.86	18.40	1.17	32.31	20.16	11.42
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1204	Q'A EL DISI MW-4 (OBS.)	897.400	196.270	06/04/99	392	7.78	99.43	0.00	40.48	3.89	23.46	1.96	43.67	9.60	15.53
				05/07/99	390	8.13	110.41	0.00	40.39	8.76	23.92	1.96	42.96	24.00	17.67
				08/11/99	397	7.60	109.80	0.00	39.78	9.12	25.07	1.96	40.12	22.08	16.26
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1302	MNEISHEER S-2	889.040	204.460	01/05/95	776	7.97	115.29	0.00	72.34	14.71	61.87	2.35	89.82	149.28	11.70
				23/05/95	764	8.02					1.15	103.22	85.56		11.10
				25/06/95	775	7.81	103.70	0.00	74.95	14.71	60.49	1.96	85.91	45.12	11.96
				03/07/95	810	7.95									11.74
				12/08/95											11.74
				27/09/95	892	7.89	106.14	0.00	80.36	14.84	68.77	2.35	88.04	184.32	11.92
				24/10/95	885	7.88	104.31	0.00	81.36	12.65	65.78	1.96	97.98	172.32	11.12
				30/10/95	894	7.80	107.36	0.00	81.36	14.11	67.62	2.35	102.60	170.40	11.78
				29/11/95	893	7.56									12.23
				04/01/96	794	7.84	111.02	0.00	75.95	14.47	57.96	1.96	94.08	131.04	11.87
				10/01/96	938	7.90	117.12	0.00	86.97	14.84	72.22	2.35	116.09	156.00	12.18
				06/02/96	912										12.18
				28/02/96	929	7.86									12.67
				27/03/96	944	7.43									12.58
				29/05/96	950	7.85	117.12	0.00	85.37	16.90	77.97	3.13	114.67	190.56	11.83
				26/06/96	939	8.03									11.60
				02/07/96	906	8.02	112.24	0.00	87.78	13.86	75.67	3.52	110.76	188.16	11.96
				30/07/96	950	7.90									12.67
				05/08/96											12.31
				12/09/96	931	7.81									12.40
				10/10/96	944	7.96	101.26	0.00	89.98	15.69	75.67	3.52	107.21	215.52	12.49
				12/11/96	918	7.80	103.09	0.00	84.57	15.81	75.67	3.52	107.21	194.88	12.31
				09/01/97	952	7.63	123.22	0.00	85.37	4.38	72.91	3.13	116.09	161.28	12.31
				26/02/97	938	8.21									12.35
				18/03/97	935	7.48	124.44	0.00	85.17	14.84	69.92	4.69	103.66	176.16	12.11
				27/03/97	940	7.85	111.02	0.00	87.37	15.20	74.06	3.13	107.92	192.00	12.30
				01/04/97				0.00							
				10/07/97	888	7.62	106.14	0.00	82.56	13.38	69.00	2.74	98.34	178.56	11.13
				11/09/97	896	7.86	109.19	0.00	83.97	16.17	73.37	3.13	103.66	178.56	11.96
				12/11/97	875	7.54									10.83

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1302	MNEISHEER S-2	889.040	204.460	06/12/97											10.31
				29/12/97	924	7.90	115.29	0.00	88.18	14.23	74.06	3.52	102.24	191.52	10.22
				18/01/98	901	8.03	121.39	0.00	85.37	18.12	74.29	3.52	99.05	202.56	10.75
				28/04/98	892	7.99	114.07	0.00	84.57	14.84	72.68	3.13	95.85	72.00	10.61
				28/05/98	869	8.03	109.80	0.00	84.57	14.84	67.16	3.13	95.85	180.00	9.98
				15/06/98	908	7.86									10.05
				29/07/98	899	7.90	105.53	0.00	75.75	19.94	71.76	3.52	97.63	199.20	10.99
				06/04/99	919	7.60	103.70	0.00	84.97	16.78	79.12	2.35	102.24	201.60	10.18
				08/11/99	947	7.60	116.51	0.00	81.40	19.94	80.27	2.35	96.21	199.68	14.12
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1307	Q'A EL GHAL S-7	882.440	208.000	08/03/95	451	7.83	115.90	0.00	49.70	6.08	26.91	1.17	49.70	40.80	14.53
				06/08/95	446	8.02	109.19	0.00	45.69	6.44	28.06	1.17	50.06	31.20	14.57
				30/10/95	444	7.77	123.83	0.00	47.90	6.32	30.59	0.78	48.64	36.48	14.04
				10/09/96	422	7.90	117.12	0.00	52.10	5.84	23.92	1.96	45.44	29.76	13.47
				18/03/97	422	7.50	123.22	0.00	46.29	8.76	25.07	1.96	50.41	24.00	13.07
				06/04/99	408	7.68	112.24	0.00	55.71	1.82	22.31	1.56	42.96	27.84	12.25
				05/07/99	413	7.65	122.61	0.00	51.00	5.84	22.31	1.56	40.12	30.24	14.66
				08/11/99	418	7.30	116.51	0.00	47.74	6.32	23.00	1.17	35.50	26.40	14.92
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1319	Q'A EL DISI S-19	895.400	198.980	01/02/95	470	7.77	117.73	0.00	47.90	9.73	29.44	1.56	54.67	31.68	17.20
				08/03/95	496	7.77	117.73	0.00	49.90	9.73	28.52	1.56	46.86	45.12	16.80
				03/05/95	467	7.95	111.63	0.00	49.50	7.42	29.44	1.56	49.35	36.48	16.60
				03/07/95	479	8.00									16.83
				03/09/95	472	8.00	114.07	0.00	44.69	8.63	31.05	1.17	58.22	34.08	17.28
				30/10/95	473	7.72	113.46	0.00	46.49	9.00	29.21	1.56	56.80	21.60	16.83
				06/02/96	476	7.48									17.06
				02/07/96	467	7.94	114.68	0.00	45.89	9.85	28.52	2.74	58.93	33.12	16.79
				10/09/96	462	7.90	116.51	0.00	49.30	8.03	27.37	2.35	54.32	33.12	16.61
				18/03/97	455	7.27	109.19	0.00	42.28	8.76	28.52	2.35	53.96	20.16	16.47
				28/07/98	456	7.75	112.24	0.00	42.48	6.93	27.37	2.35	48.64	30.24	14.86
				06/04/99	449	7.72	104.92	0.00	45.69	9.00	28.52	1.96	53.96	31.68	15.06
				08/11/99	462	7.40	113.46	0.00	43.45	6.93	29.67	2.35	48.28	28.80	17.35

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1322	Q'A EL DISI S-22 (TWEISEH)	895.400	201.720	02/01/95	358	7.75	106.14	0.00	35.27	7.30	24.15	1.17	36.92	16.80	6.99
				08/03/95	359	7.93	103.70	0.00	36.07	7.30	24.15	1.17	41.89	30.72	6.68
				01/05/95	363	8.11	104.31	0.00	40.68	3.89	24.84	1.17	39.76	28.80	6.42
				23/05/95	362	8.01					25.53	1.17	44.02		6.33
				03/07/95	370	8.14		0.00							6.16
				03/09/95	373	7.81	104.92	0.00	35.67	5.72	24.15	1.17	42.60	23.04	6.95
				30/10/95	369	7.85	103.09	0.00	35.27	6.57	24.84	1.17	39.41	26.40	6.73
				29/11/95	361	7.80	107.36	0.00	37.07	7.42	25.07	1.17	42.25	17.28	6.69
				10/01/96	368	7.89	100.65	0.00	35.87	5.23	25.30	1.17	39.41	29.76	6.60
				06/02/96	362	7.00									6.65
				28/02/96	361	7.74									6.82
				27/03/96	370	7.45									6.78
				29/05/96	370	7.95	109.19	0.00	38.68	5.23	25.76	1.96	40.83	25.44	6.16
				26/06/96	366	8.02									60.20
				02/07/96	360	8.25	106.75	0.00	32.67	9.24	24.61	2.35	43.31	29.76	6.79
				10/09/96	364	7.98	109.19	0.00	37.07	9.12	23.00	2.35	45.09	23.52	6.33
				12/09/96	372	7.70									6.78
				10/10/96	376	8.00	100.04	0.00	37.88	7.66	24.84	1.96	38.70	46.56	6.42
				12/11/96	365	7.90	95.77	0.00	36.07	6.20	25.30	1.96	44.73	20.64	6.64
				09/01/97	374	7.66	104.92	0.00	33.87	5.23	27.60	1.96	36.21	34.56	6.05
				26/02/97	364	8.50									6.02
				27/03/97	372	7.76	108.58	0.00	37.07	6.81	26.22	1.96	41.89	18.24	5.25
				01/04/97				0.00							
				06/05/97	361	7.82	109.80	0.00	37.68	7.42	21.16	1.96	31.95	18.24	11.62
				13/05/97	369	8.02	98.21	0.00	33.07	9.85	25.53	1.96	41.18	31.20	5.95
				10/07/97	368	7.31	106.14	0.00	35.67	5.84	24.61	1.96	44.02	15.36	5.39
				11/09/97	380	7.93	103.09	0.00	36.07	7.17	28.75	3.13	40.83	34.56	6.64
				06/12/97											4.69
				29/12/97	404	7.97	123.22	0.00	45.49	6.08	24.61	1.96	46.15	20.16	5.41
				18/01/98	394	8.02	115.90	0.00	44.49	3.28	27.83	2.35	43.67	18.72	5.19
				28/04/98	399	7.96	104.92	0.00	39.28	6.08	29.21	2.74	41.18	31.68	6.01
				28/05/98	389	8.13	107.36	0.00	39.28	6.08	26.68	2.74	46.51	32.64	5.49
				28/07/98	400	7.85	100.04	0.00	38.08	5.11	26.91	1.96	42.96	27.36	7.25
				06/04/99	388	7.67	93.33	0.00	37.27	6.20	27.60	1.96	46.51	25.92	5.06
				05/07/99	395	7.55	110.41	0.00	44.88	4.13	28.52	1.96	45.44	31.20	10.61
				08/11/99	405	7.40	109.80	0.00	38.35	5.23	29.21	1.96	41.89	30.24	10.50
				04/04/00	411	7.85	106.75	0.00	42.48	5.47	33.81	1.56	46.51	33.60	11.13
				09/04/01	453	7.36	104.92	0.00	37.13	9.85	31.28	1.17	49.35	28.80	7.68

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1402	MNEISHEER W-2 /M 8 (RUM CO.)	891.200	207.450	02/01/95	718	7.66	107.36	0.00	69.14	12.16	56.58	1.96	77.39	130.08	12.10
				07/03/95	810	7.95		0.00							11.74
				08/03/95	732	7.82	104.92	0.00	70.14	10.94	56.58	1.96	80.23	144.00	11.51
				01/05/95	383	7.96	124.44	0.00	41.08	8.51	24.38	3.52	38.70	26.88	10.50
				03/07/95	810	7.95									11.74
				04/12/95	394	7.97	116.51	0.00	40.88	8.63	24.38	1.17	40.47	37.92	9.39
				10/09/96	925	7.75	112.85	0.00	88.38	14.23	74.06	5.08	110.05	189.60	12.85
				08/10/96	416	8.00	119.56	0.00	40.68	9.24	25.76	1.96	40.12	29.76	11.03
				18/03/97	935	7.48	124.44	0.00	86.77	14.84	69.92	4.69	103.66	176.16	12.11
				06/05/97	397	7.54	209.82	0.00	77.84	13.38	51.53	3.92	81.71	53.74	10.29
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1403	MNEISHEER W-3	889.246	207.065	30/10/95	323	7.72	106.14	0.00	35.67	5.47	17.02	0.78	30.53	6.24	11.43
				29/12/97	334	8.03	111.63	0.00	42.69	4.86	16.56	1.96	30.18	24.96	10.05
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1406	MNEISHEER W-6	886.574	208.949	08/03/95	346	7.86	112.24	0.00	38.48	7.30	17.71	1.17	31.24	20.64	13.51
				30/10/95	344	7.76	109.80	0.00	36.87	6.57	17.94	0.78	31.60	20.64	12.98
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1408	MNEISHEER W-8	887.415	211.222	08/03/95	373	7.85	115.90	0.00	42.69	6.08	18.86	1.17	35.50	23.04	14.79
				02/10/95	306	7.91	114.68	0.00	33.67	10.34	15.18	0.39	32.66	18.24	7.53
				18/03/97	362	7.54	115.29	0.00	45.49	3.28	20.01	1.96	34.08	20.16	10.77
				29/12/97	410	8.02	123.83	0.00	46.69	6.08	23.46	1.96	44.73	18.72	8.97
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1409	MNEISHEER W-9	884.920	210.780	06/08/95	377	7.95	110.41	0.00	42.08	6.08	20.47	1.17	35.50	20.16	14.66
				30/10/95	372	7.56	115.90	0.00	42.08	6.57	19.09	0.78	34.44	24.00	14.35
				10/09/96	375	7.86	123.83	0.00	41.08	7.42	19.78	2.35	35.50	24.00	14.75
				18/03/97	338	7.60	109.19	0.00	44.69	4.01	18.63	1.56	33.02	20.16	11.17
				29/12/97	810	15.85	361.70	0.00	152.85	23.36	62.80	3.92	118.99	76.78	25.02
				29/07/98	805	15.68	229.36	0.00	82.56	12.65	42.09	3.52	69.23	49.92	25.60
				06/04/99	365	7.78	112.24	0.00	42.48	7.05	19.09	1.96	35.86	16.80	12.91
				05/07/99	373	8.51	118.00	0.00	19.55	1.96	32.31	23.52	32.31	23.52	15.77
				08/11/99	372	7.70	115.29	0.00	40.39	8.51	19.55	1.17	29.82	23.52	15.86
				04/04/00	374	8.00	120.17	0.00	42.48	8.39	23.23	1.56	33.02	24.96	16.89

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Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1411	MNEISHEER W-11	885.375	213.213	06/08/95	351	8.10	111.63	0.00	35.67	6.81	19.55	0.78	33.37	19.20	11.21
				30/10/95	347	7.83	116.51	0.00	39.08	8.15	18.17	0.78	33.02	25.44	10.94
				10/09/96	344	7.95	104.92	0.00	39.88	6.20	18.40	1.96	30.53	20.16	10.81
				29/12/97	356	7.95	112.85	0.00	42.69	7.30	18.40	1.96	32.31	33.12	9.88
				29/07/98	353	7.88	109.80	0.00	36.07	6.32	18.40	1.56	28.40	19.68	10.06
				06/04/99	338	7.97	106.14	0.00	39.48	6.81	18.40	1.56	32.31	19.20	9.21
				05/07/99	340	7.51	120.17	0.00	40.39	8.27	18.40	1.56	30.18	21.60	13.12
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1501	SAHL EL SUWAN SS-1	884.320	217.520	02/01/95	331	7.67	120.78	0.00	40.28	7.30	16.33	0.78	28.76	23.04	12.60
				01/05/95	351	7.90	122.00	0.00	40.28	7.30	16.10	1.17	33.02	11.52	13.00
				06/05/97	350	7.75	113.46	0.00	38.88	8.39	17.94	1.96	30.18	18.24	12.82
				06/04/99	343	7.71	116.51	0.00	41.28	7.30	16.79	1.96	29.47	16.32	11.19
				04/04/00	348	8.01	122.61	0.00	40.88	8.88	20.01	1.17	27.69	22.08	15.60
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1502	SAHL EL SUWAN SS-2	884.180	218.150	08/03/95	335	7.92	120.78	0.00	40.08	6.08	14.72	1.17	28.40	14.88	12.40
				24/04/96	344	7.93	124.44	0.00	38.48	7.78	16.79	1.96	31.95	6.24	12.53
				06/04/99	332	7.92	117.12	0.00	43.09	5.72	16.10	1.96	28.05	15.36	10.57
				09/04/01	359	7.48	115.90	0.00	38.76	7.54	16.33	1.17	24.50	20.64	13.77
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1504	SAHL EL SUWAN SS-4	881.850	218.650	02/01/95	341	7.71	122.00	0.00	43.09	4.86	16.10	1.17	29.47	22.08	13.20
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1505	SAHL EL SUWAN SS-5A	881.560	220.000	01/05/95	333	7.58	120.17	0.00	40.08	8.63	15.18	1.17	29.47	14.40	12.40
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1508	Q'A ABU SUWANA M3 (RUM CO.)	891.965	210.200	02/01/95	445	8.01	118.34	0.00	48.30	7.30	27.60	1.17	56.45	32.64	11.90
				01/05/95	444	7.98	153.11	0.00	48.30	7.54	27.37	1.17	49.70	12.48	11.60
				02/10/95	430	7.74	109.80	0.00	44.69	9.00	25.99	1.17	56.80	33.60	10.85
				04/12/95	438	7.85	119.56	0.00	47.29	7.42	29.67	1.17	53.25	37.92	11.78
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1535	MNEISHEER M9 (RUM CO.)	891.250	206.092	02/07/95	308	7.88	100.65	0.00	35.87	4.86	21.16	0.78	32.31	25.92	7.92
				03/09/95	313	7.82	97.60	0.00	33.67	3.53	17.25	0.78	22.37	15.36	7.15
				04/12/95	308	7.85	105.53	0.00	35.47	5.72	16.56	0.78	29.47	13.44	9.19
				08/10/96	319	8.01	100.04	0.00	37.07	5.35	17.48	1.56	28.05	24.00	8.37
				06/05/97	309	7.85	97.60	0.00	36.47	3.28	17.48	1.56	28.40	9.60	7.63
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1540	MNEISHEER M6 (RUM CO.)	891.550	208.020	03/09/95	346	7.73	111.63	0.00	35.67	4.38	21.16	0.78	32.31	19.20	8.15
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1545	MNEISHEER M12A (RUM CO.)	889.580	206.306	02/01/95	277	7.86	99.43	0.00	31.66	4.86	14.26	0.78	27.34	3.84	6.24
				08/11/99	287	7.70	97.60	0.00	16.12	15.69	15.87	2.74	23.43	19.68	11.16

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1606	SS22 (SAHL EL SUWWAN)	885.560	222.650	01/05/95	359	8.08	111.02	0.00	37.27	6.57	21.39	1.17	31.95	16.32	10.50
				03/09/95	368	7.84	107.97	0.00	37.88	5.11	21.85	1.17	35.15	23.04	9.66
				02/10/95	336	7.90	114.68	0.00	38.88	8.03	14.26	0.78	30.89	14.40	12.00
				04/12/95	378	7.77	115.29	0.00	38.68	8.03	22.77	1.17	36.92	24.48	10.72
				24/04/96	372	7.92	112.24	0.00	36.67	7.66	22.54	1.96	44.73	18.72	9.92
				02/07/96	358	8.00	117.12	0.00	37.07	6.32	22.08	2.35	35.50	10.56	9.39
				06/05/97	367	7.78	107.36	0.00	32.67	10.09	21.62	1.96	35.50	31.20	10.03
				29/07/98	373	7.71	109.80	0.00	38.48	7.05	21.62	2.35	30.89	26.88	9.89
				05/07/99	466	7.41	125.05	0.00	49.78	10.46	30.82	1.96	47.93	38.40	19.62
				08/11/99	362	7.20	110.41	0.00	37.54	8.76	21.16	1.17	28.76	26.40	14.03
				04/04/00	361	7.91	111.02	0.00	37.07	9.24	25.30	1.17	32.66	29.76	13.64
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1608	SS24 (SAHL EL SUWWAN)	884.300	220.050	06/05/97	361	7.82	109.80	0.00	37.07	7.42	21.16	1.96	31.95	18.24	11.62
				05/07/99	355	7.56	120.17	0.00	41.62	7.54	19.78	1.96	28.05	25.44	13.17
				08/11/99	357	6.90	115.29	0.00	38.76	8.03	20.01	1.17	27.34	24.00	13.12
				04/04/00	359	8.02	120.17	0.00	40.88	8.88	23.46	1.17	30.18	27.36	14.93
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1612	M 14 (RUM CO.)	893.100	207.300	02/01/95	333	7.80	106.14	0.00	35.27	24.32	21.16	0.78	31.24	9.60	8.06
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1613	SS21 (SAHL EL SUWWAN)	883.600	221.300	24/04/96	340	8.12	124.44	0.00	38.68	10.58	17.48	1.96	31.60	6.24	12.58
				02/07/96	333	8.05	126.27	0.00	40.48	5.96	15.18	2.35	29.47	9.12	11.43
				08/10/96	378	8.00	104.31	0.00	37.07	10.21	21.16	1.56	36.21	29.76	10.85
				06/05/97	340	7.83	114.68	0.00	37.27	7.66	17.25	1.96	28.40	11.52	12.03
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1614	SS20 (SAHL EL SUWWAN)	884.500	219.900	01/05/95	453	7.98	124.44	0.00	49.50	6.32	29.44	1.56	52.90	28.80	19.30
				03/09/95	476	7.84	112.85	0.00	47.09	5.59	31.05	1.17	52.90	28.32	20.64
				24/04/96	512	7.99	129.32	0.00	48.10	10.58	36.57	2.74	61.06	33.12	23.21
				30/07/97	661	8.07	231.19	0.00	52.91	29.31	35.19	2.74	78.10	18.72	15.57
				05/07/99	625	7.59	120.17	0.00	62.83	9.24	47.84	2.35	78.46	61.92	27.27
				04/04/00	654	7.81	121.39	0.00	57.31	13.74	54.51	1.96	82.01	69.12	31.23
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1621	M 13 (RUM CO.)	889.300	205.310	04/04/00	399	7.93	114.07	0.00	43.69	6.93	27.14	1.17	44.02	33.12	13.41
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED1623	M 4 (RUM CO.)	890.310	210.650	06/04/99	362	7.94	113.46	0.00	41.08	9.00	20.70	1.56	36.21	30.24	9.25
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED3029	W 14 (EL GHAL)	886.336	210.133	05/07/99	362	7.72	120.00	0.00	46.10	6.08	18.86	1.96	30.89	23.52	13.96
				08/11/99	366	7.70	115.29	0.00	40.39	8.51	18.86	1.17	29.82	21.60	14.87
				04/04/00	363	8.01	120.17	0.00	41.68	6.69	23.23	1.17	30.18	22.56	14.61

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED3034	BH8B	896.460	219.990	14/10/95	482	6.13	109.19	0.00	45.29	12.28	39.79	5.08	60.00	61.92	11.87
				11/12/95	370	8.01	78.69	0.00	31.46	9.00	1.15	143.89	53.96	39.36	7.84
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED3036	BH13	866.000	215.450	24/05/95	384	7.66	151.28	0.00	47.90	7.66	18.40	1.56	25.92	27.84	43.41
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
ED3056	SHAKRIYEH MW4A	897.400	196.260	16/03/96	412	7.90	115.90	0.00	41.28	9.12	29.21	1.56	49.35	23.52	18.29
				20/03/96	826	16.16	211.67	0.00	74.15	19.46	27.14	1.17	102.60	30.72	36.77
				04/04/00	394	7.93	111.63	0.00	38.48	9.12	27.83	1.56	41.18	24.48	18.31
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1016	ARAB AGRICULTURE CO. 1	855.250	246.030	02/05/95	350	7.56	87.84	0.00	35.47	4.86	22.54	1.17	42.60	27.84	5.31
				24/03/96	348	7.68	81.13	0.00	37.68	4.62	23.46	1.17	44.73	37.44	5.54
				23/06/98	352	8.18	81.13	0.00	33.67	6.20	22.31	1.96	39.05	27.84	5.08
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1018	ARAB AGRICULTURE CO. 2	857.100	246.350	07/02/95	354	8.13		0.00							4.87
				02/04/95	335	7.53	87.84	0.00	36.27	4.86	23.00	0.78	42.25	34.08	5.13
				02/07/95	354	8.13									4.87
				25/06/97	349	7.49	96.38	0.00	39.08	4.62	21.16	1.96	39.76	20.16	3.20
				05/07/99	337	7.32	88.45	0.00	35.90	7.05	21.62	1.56	37.99	28.32	9.23
				09/11/99	341	6.90	83.57	0.00	32.23	7.05	21.85	0.78	33.73	24.00	9.14
				10/04/01	360	7.31	91.50	0.00	32.23	7.54	22.08	0.78	40.12	25.92	6.23
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1020	ARAB AGRICULTURE CO. 3	856.200	243.500	02/04/95	347	7.82	92.72	0.00	39.08	4.86	22.54	0.78	40.83	25.92	5.36
				25/06/97	341	7.63	94.55	0.00	37.68	4.26	21.85	1.96	39.76	20.16	4.25
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1024	ARAB AGRICULTURE CO. 5	856.150	246.350	24/03/96	352	7.62	86.01	0.00	36.47	6.57	22.77	1.17	43.31	38.40	5.36
				23/06/98	350	7.95	83.57	0.00	34.07	5.96	22.08	1.96	37.99	27.36	4.87
				05/07/99	343	7.25	88.45	0.00	18.16	15.93	21.85	1.56	39.05	28.80	9.41
				09/11/99	341	7.00	93.33	0.00	34.27	6.93	22.31	0.78	33.73	26.40	9.44
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1025	ARAB AGRICULTURE CO. 7	855.050	244.900	07/02/95	361	8.10		0.00							4.78
				02/05/95	346	7.84	92.72	0.00	36.27	4.86	22.54	0.78	39.76	33.60	5.31
				02/07/95	361	8.10									4.78
				23/06/98	352	7.96	93.94	0.00	33.47	6.81	22.31	1.96	37.63	27.36	4.97
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1026	ARAB AGRICULTURE CO. 6	858.300	246.200	02/05/95	346	7.87	92.11	0.00	36.67	4.86	22.08	0.78	39.05	28.80	5.27
				09/11/99	340	6.90	96.38	0.00	33.86	9.12	21.85	0.78	35.15	27.36	9.60

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1027	WAFA 1	859.100	250.500	23/06/98	328	7.54	88.45	0.00	32.26	6.69	19.55	1.96	37.28	17.28	4.90
				09/11/99	322	7.10	87.23	0.00	31.42	8.27	20.24	0.78	31.24	24.00	9.26
				05/04/00	354	7.53	98.82	0.00	35.07	6.93	26.22	1.17	42.25	30.24	9.99
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1028	WAFA 2	860.300	251.300	23/06/98	373	8.26	84.79	0.00	41.68	2.07	25.30	2.74	45.44	21.60	8.81
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1029	GRAMCO G 10	853.950	243.600	24/03/96	369	7.63	89.67	0.00	36.07	6.08	25.07	1.17	45.80	34.56	5.36
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1031	GRAMCO G 3	859.750	241.450	02/05/95	346	8.02	81.74	0.00	36.67	4.86	22.31	1.17	38.70	26.88	5.18
				24/03/96	342	7.53	81.13	0.00	34.47	5.35	22.08	1.17	38.70	36.48	5.40
				25/06/97	353	7.62	98.82	0.00	37.68	6.32	21.85	1.96	43.31	20.16	3.83
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1032	GRAMCO G 5	861.500	240.400	23/06/98	349	8.17	83.57	0.00	31.26	6.93	24.61	2.35	37.63	27.84	5.26
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1033	GRAMCO G 9	855.050	243.250	07/02/95	352	8.11		0.00							4.87
				02/04/95	333	7.84	89.06	0.00	36.67	3.65	21.39	0.78	39.05	27.84	5.31
				02/07/95	352	8.11									4.80
				25/06/97	334	7.00	91.50	0.00	37.68	5.47	21.16	1.96	40.83	20.16	3.35
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1034	GRAMCO G 6	856.600	242.100	07/02/95	350	7.90		0.00							4.56
				02/04/95	338	7.66	84.18	0.00	36.67	3.65	22.54	0.78	42.96	28.32	5.13
				02/05/95	328	7.86	90.28	0.00	36.27	3.65	21.62	0.78	36.57	16.80	5.36
				02/07/95	350	7.90									4.56
				24/03/96	338	7.58	86.01	0.00	34.07	5.59	21.85	0.78	38.34	35.52	5.45
				25/06/97	335	7.66	91.50	0.00	37.68	6.20	20.93	1.96	42.60	18.72	4.14
				05/07/99	327	7.24	85.40	0.00	34.68	6.32	21.16	1.56	35.50	26.88	9.31
				09/11/99	326	7.00	83.57	0.00	32.64	5.84	21.39	0.78	33.02	26.40	9.79
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1035	GRAMCO G 1	859.200	243.200	02/07/95	351	7.80	87.84	0.00	35.07	4.62	22.54	0.78	40.12	31.68	4.87
				05/07/99	330	7.28	85.40	0.00	35.09	6.57	21.62	1.56	36.57	27.36	9.23
				05/04/00	333	7.88	82.96	0.00	33.27	6.32	25.99	1.17	36.92	28.80	9.80
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1037	GRAMCO G 7	857.450	240.400	09/11/99	349	7.00	86.01	0.00	32.64	7.54	23.46	1.17	34.08	28.80	10.02
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1038	GRAMCO G 2	857.900	242.950	05/04/95	339	7.77	91.50	0.00	38.28	3.65	24.15	1.17	40.83	24.00	5.40
				02/05/95	344	7.97	89.06	0.00	34.27	6.08	23.00	1.17	39.05	27.84	5.27
				05/04/00	329	7.90	99.43	0.00	34.07	5.96	22.77	1.17	36.21	28.32	9.75

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1039	GRAMCO G 4	858.950	241.500	05/07/99	363	7.25	94.55	0.00	37.54	6.08	25.76	1.96	41.18	33.12	9.35
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1041	ARAB AGRICULTURE CO. 9	856.400	245.500	07/02/95	365	7.92		0.00							4.92
				02/04/95	351	7.80	86.62	0.00	36.67	6.08	23.69	1.17	42.96	27.84	5.40
				02/07/95	365	7.92									4.91
				24/03/96	357	7.60	88.45	0.00	36.87	4.86	23.00	1.17	44.73	26.88	5.54
				25/06/97	353	7.61	92.72	0.00	40.28	4.01	22.08	1.17	45.09	23.52	4.36
				23/06/98	355	8.17	87.84	0.00	33.87	5.84	23.00	1.96	39.41	27.84	5.27
				05/07/99	342	7.49	88.45	0.00	34.27	7.05	22.08	1.56	40.47	29.28	9.45
				05/04/00	347	7.71	84.18	0.00	34.07	7.05	26.91	1.17	40.47	30.24	9.88
				10/04/01	370	7.31	82.96	0.00	33.86	7.78	22.54	1.17	41.54	27.84	6.01
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1043	WAFA 3	859.800	251.500	07/02/95	384	7.83		0.00							5.00
				02/04/95	370	7.66	98.21	0.00	40.48	4.86	26.22	1.17	48.99	24.00	5.40
				02/07/95	384	7.83									5.00
				23/06/98	381	7.96	99.43	0.00	39.28	4.74	23.23	2.35	44.73	17.28	5.32
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1044	WAFA 4	860.800	250.700	02/05/95	376	7.97	106.14	0.00	40.08	6.08	23.69	1.17	39.05	36.48	5.67
				24/03/96	367	7.53	101.87	0.00	37.68	8.76	24.61	1.17	46.86	31.68	5.80
				25/06/97	365	7.75	100.04	0.00	37.68	6.57	23.23	2.35	44.38	22.56	3.53
				09/11/99	356	6.80	76.25	0.00	30.60	7.78	25.76	1.17	40.47	29.76	10.09
				05/04/00	352	7.70	86.01	0.00	34.47	6.81	27.37	1.17	41.54	29.76	10.06
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 1045	WAFA 5	861.000	250.900	07/02/95	351	8.00		0.00							4.43
				02/04/95	322	7.63	99.43	0.00	38.28	4.86	18.63	0.78	37.99	11.52	4.91
				02/07/95	351	8.00									4.43
				11/03/96	320										
				24/03/96	317	7.43	79.30	0.00	34.87	6.08	18.86	0.78	38.70	28.80	5.09
				09/11/99	384	7.30	86.01	0.00	30.19	7.05	19.78	12.12	31.60	32.64	22.70
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 3000	HALET A'MMAR 2 (HA2)/W16	849.600	252.500	24/03/96	806	7.87	176.90	0.00	19.24	4.86	138.69	7.82	117.51	65.28	0.35
				25/06/97	740	7.99	181.17	0.00	17.64	7.66	133.40	7.82	111.83	60.96	0.00
				23/06/98	820	8.18	182.39	0.00	16.43	9.12	136.62	8.21	123.90	58.56	0.73
				05/07/99	796	7.85	178.12	0.00	12.24	9.61	134.55	5.87	115.73	62.88	5.97

Table 9: Water quality of Disi-Mudawarra groundwater resources (contd.)

STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 3001	MUDAWWARA OLD (WIND MILL)	859.000	248.100	05/07/99	2550	7.96	326.96	0.00	28.56	25.05	494.27	16.81	402.22	394.08	41.15
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 3009	BH5	869.100	256.300	31/03/96	419	7.43	220.82	0.00	39.88	5.59	28.98	1.56	53.25	37.92	4.29
STATION_ID	STATION_NAME	NORTHING	EASTING	DATE	EC μ S/cm	pH	HCO ₃ mg/L	CO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO ₄ mg/L	NO ₃ mg/L
K 3023	SULEIMAN MAR'I EL A'TANEH	856.350	250.200	05/04/00	365	7.95	84.18	0.00	34.07	4.50	30.59	1.56	43.67	32.16	9.93

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