Detailed account of studies related groundwater in al-Khalifa

This Report aims to list the problems related to ground water in the areas of al-Khalifa and Zeinhoum; whether they were problems of water overflow (appearing in basements/ground floors/open spaces), or problems that may be causes of water overflow (networks/potholes/tanks). As well as all the studies carried out through the groundwater research project or compiled from previous projects.

For relevant information refer to the following Annexes:

Annex 1: Map of all the places with water problems with pictures and locations
Annex 2: Sections showing the street, monuments, and water levels of these areas
Annex 3: Water Analyses
Annex 4: Boreholes from previous projects
Annex 5: Water flow rate from an existing dewatering project in the area

1. Groundwater problems in Khalifa

Ground Water overflows appear in several places along al-Khalifa Street (12 spotted). In addition, rising damp resulting from ground water poses a threat to a many other buildings. This is due to the streets altitude which is lower than surrounding areas. In most cases these are places lower than the street level (monuments/basements). Below are the most notable cases.

a. Al-Ashraf Khalil and Fatima Khatun Domes

- The two domes near al-Sayyida Nafisa square lie next to the site for Khalifa Heritage and Environment Park and suffer from rising damp, cracks as well as ground water overflow appearing in their surroundings.
- A pisometer is installed next to Fatima Khatun Dome shows a water level beneath the ground level by 2.5 to 2.9 m. and water samples taken from it were analysed. In addition, a pisometer was installed east of Fatima Khatun pisometer in the cemetery area to compare water levels.

b. Al-Sayyida Ruqayya Dome:

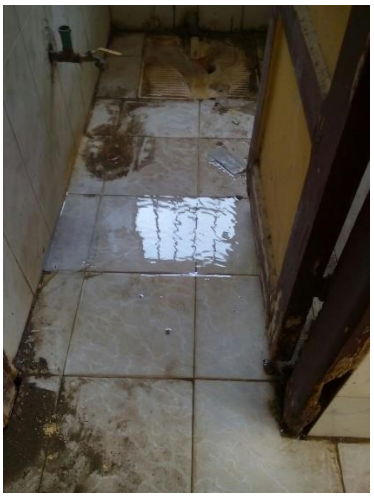
- Street level: +516 cm (zero = al-Saliba Street).
- Monument level: +426 cm.
- Ground water level (borehole): +316.
- Ground water overflow level (neighboring empty land): +616; the water level appearing above the ground in this area, which is neighboring to the Zaynhum area, is higher than the street level.
- Effects of rising damp appear on the monument's walls up to a height of 2 meters.

- According to local accounts, water overflows appeared several times in the S. Ruqayya Dome area, the earliest they can date is in 2012 at the time of the *mawlid* (festival), the last was in march 2017 (also the time of the *mawlid*), where the water company detected a pipe breakage and got it fixed, thereby stopping the overflow.
- Boreholes were made in this site in 2005 and 2016, and water samples from the overflowing water were analysed.



c. Shajar al-Durr school

- Water overflow appears periodically (almost yearly) in the southern and eastern sides of the school yard, and the ground floor classes.
- School sanitation is in a bad shape with water supply and sewage pipes seeping continuously
- The School is side to side to a wood factory (no. 4), whose basement is covered in water with a level higher than the water in the school by 20 cm


- Water levels in the school at the current moment decreased, the school is being rehabilitated for studying by cleaning the effects of water and removing undesired plants. While it is being planned to install pumps by the Cairo Governorate by the end of studying in summer to regulate the water level.



d. Wood factory (6 Darb el-Bazabiz)

- The Wood factory basement with an area of 1400 m2 is covered with water with a height of 2 meters. According to local accounts, a water pipe in the street next to the factory has been

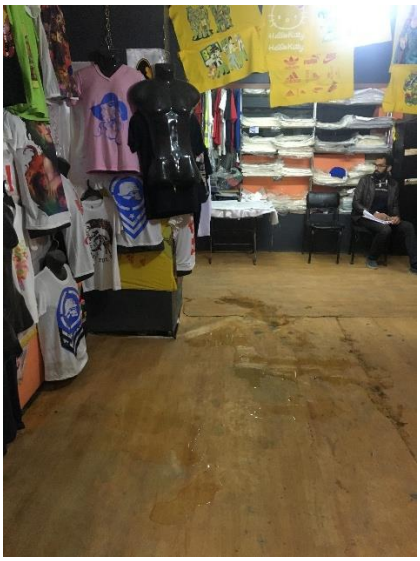
broken for years. The factory's water level is higher than that of the school by 20 cm, next to the factory is also an empty land plot where plants grow organically.


e. Ahmed Kohya mosque

- The mosque is the only structure in the area with a complete dewatering system, that decreases the water level by 3.7 meters, pumping 300 cubic meters daily


f. Residential buildings

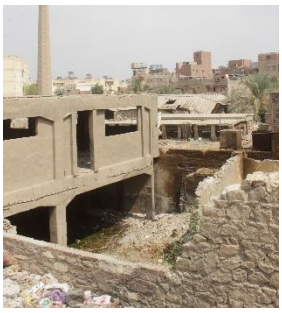
- 23 el-Rokbeyya Street; Residents increased the 500 m^2 basement floor level by 1m and applied insulation, water still appears in small areas on the ground
- 37 el-Rokbeyya Street; Residents pump water out of the 173 m^2 basement every 4-6 weeks. The water reaches a height of about 1m and stops increasing in level.
- 20 al-Khalifa Street; basement is covered in water to a level below street level by 156 cm



g. Other cases:

- Saffiy el din Gohar dome also suffer from overflowing water, a pisometer was installed there, and water samples from it were analyzed.
- A deserted Factory next to S. Ruqayya Dome and neighboring Zainhum has water appearing with **water level higher than street level**
- A basement in a wood workshop (69 Darb el-Masdud) next to zeinhom is covered in water
- A pisometer was installed east of Fatima Khatun pisometer in the cemetery area to compare water levels





h. Inspection chambers:

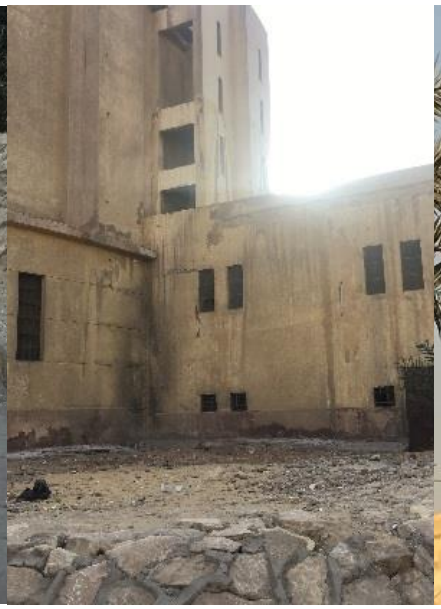
- Many inspection chambers, especially in alleyways and between houses, aren't isolated or covered with a cement layer, and suffer from continuous clogging, few of those were spotted; Atfet berto bek and next to Fatima Khatun dome.
- In The area of Arba'een shrine, sewage water overflows happen every month or two

2. Groundwater problems in Zaynhum

The public housing area, which was built on a hill higher than neighboring areas, was built on different phases through the 80s and the 90s. At least two buildings of the project were demolished due to structural problems caused by water resulting from bad sanitation. In the S. Ruqayya and S. Nafisa areas the water level is higher near the Zaynhum area. Below are problems in the network that were spotted in the area.

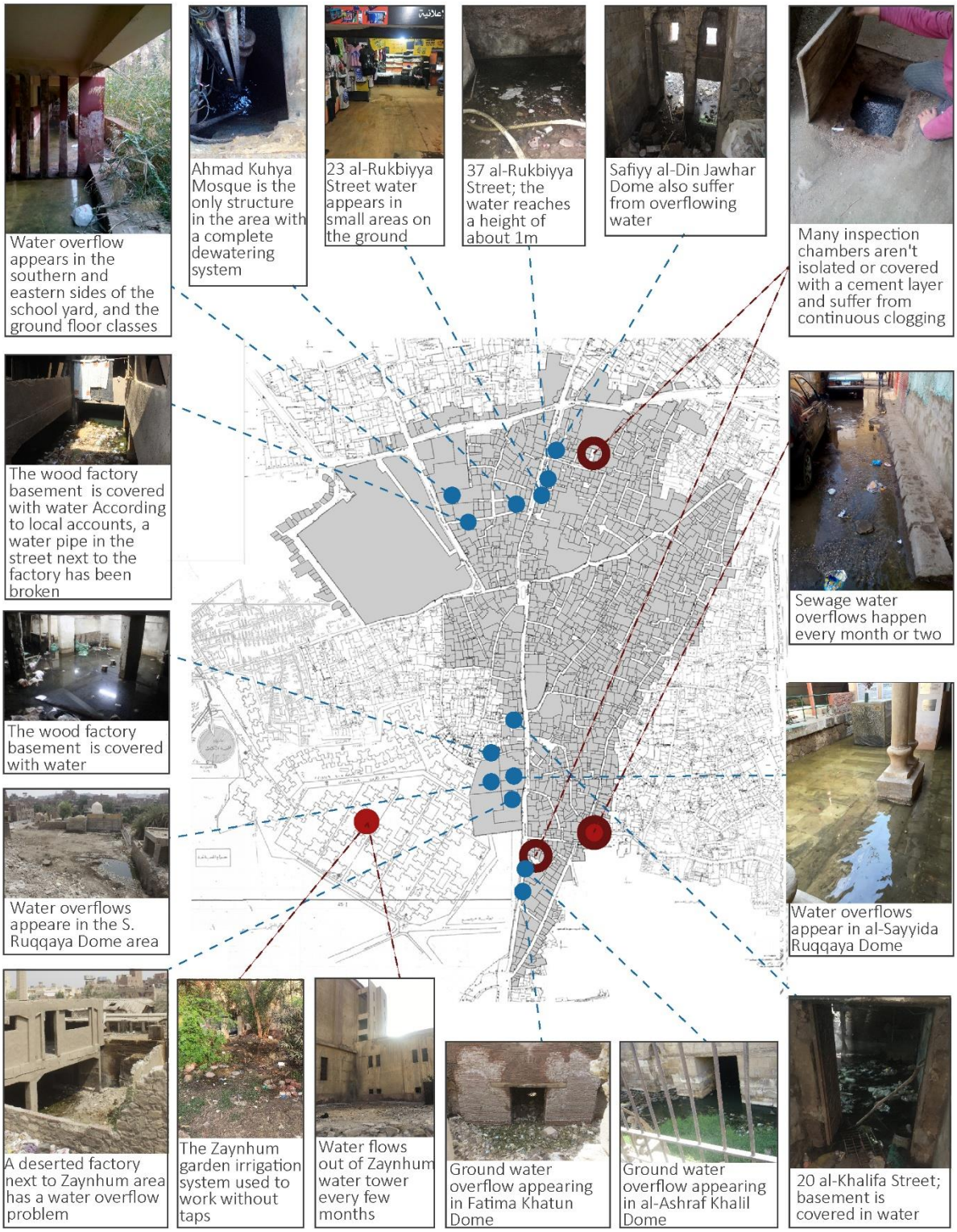
- According to local accounts the Zaynhum garden irrigation system used to work without taps. The overflow of water was suspected to cause structural problems, and the action taken by the water company was closing the openings of these irrigation pipes and burying it. Some of these pipes can now be spotted overflowing with water, while others are diverted by the residents to water their gardens.

- According to local accounts, water flows out of the neighborhood water tower every few months. This is due to a problem with the water level regulator. Traces of the water appear on the building and the surrounding areas contain water ponds, soil failures and plants growing organically.
- The poor state of sanitation in the Zaynhum area appears in the damp spots on the building facades.

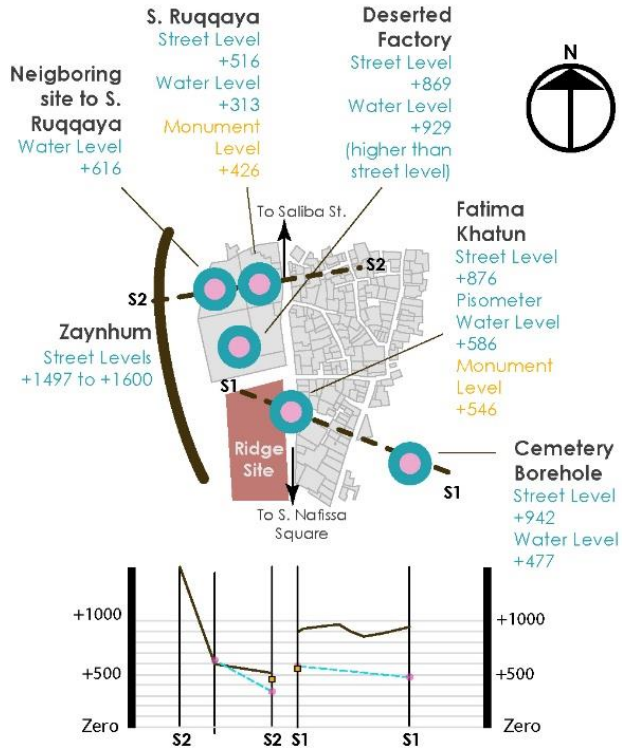

- The poor state of sanitation in the Zaynhum area appears in the damp spots on the building facades.

Annex 1: Map of all the places with water problems with pictures and locations

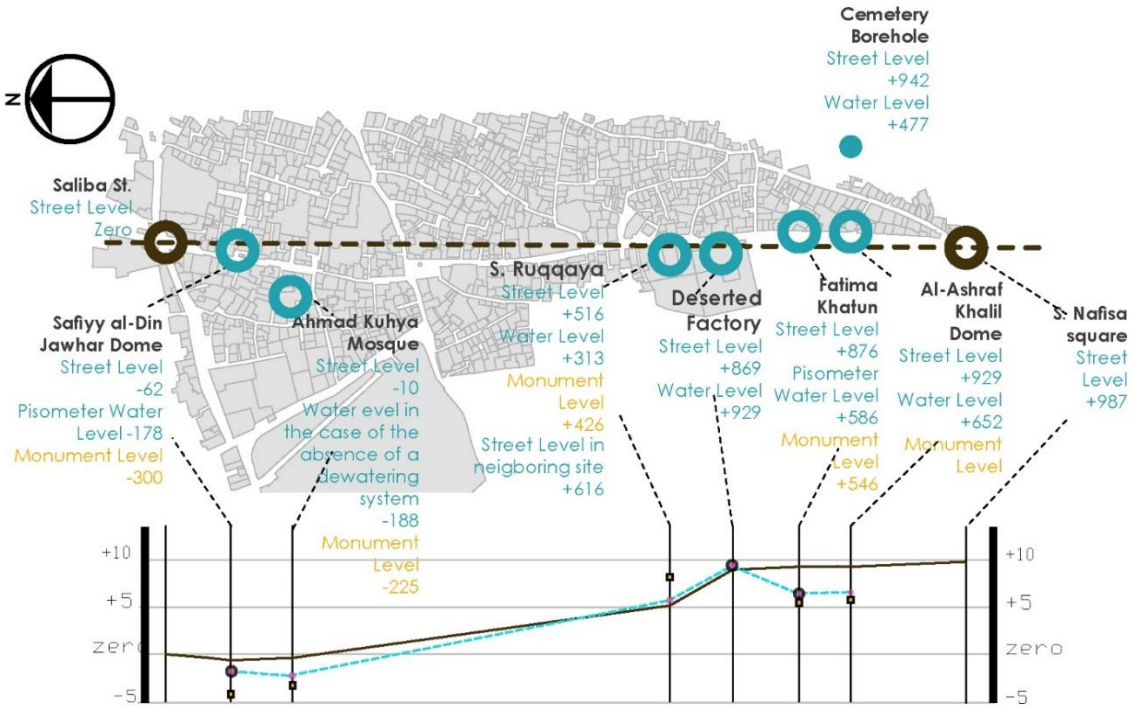


Annex 2: 3. Water levels

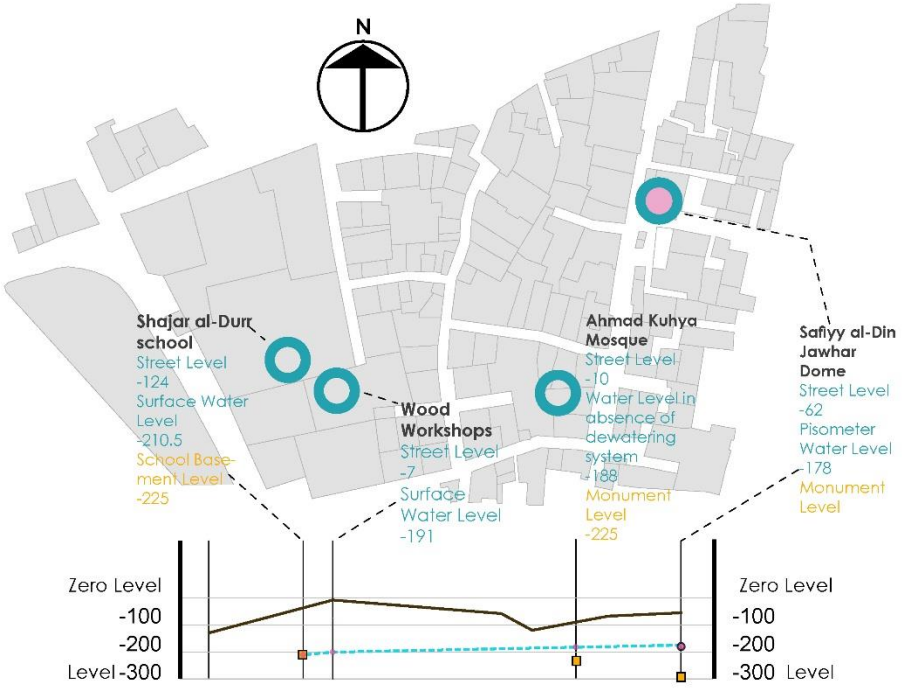
Water Levels in several sites next to the ridge are listed below, water levels along east-west axes appear to increase towards the west (hence Zaynhum) in a significant way.



Levels of water in sites arround Khalifa Heritage and Environment Park



Levels of water in sites along Khalifa Street



Sections in the northern part of the street

Annex 3: Water Analyses

Below is the water analysis report for a sample taken from the pisometer next to Fatima Khatun Dome, across the street from the site for the Khalifa Heritage and Environment Park. Compared to a sample taken from another site (Safiyy al-Din Jawhar Dome) in the northern section of the study area.

Chemical Test	WHO (ppm)	wastewater (mg/L-1)	Fatima Khatun		Safiyy al-Din Jawhar	
			results	unit	results	unit
PH	6.5-8.0	6.0-9.0	7.47		7.27	
TDS	100-600	300-900	2650	mg/l	1020	mg/l
TSS			2236	mg/l	280	mg/l
COD	<10	1000	987	mg/l	331	mg/l
BOD	<6	110-400	<0.5	mg/l	<0.5	mg/l
Turbidity			184	1/m	13.7	1/m
Cl^{-1} (chloride)	-	100	951.4	mg/l	142	mg/l
NH_4^+ (Ammonia)	1.5	12.0-80	1.2	mg/l	0.9	mg/l
NO_3^{-1} (Nitrate)	50	20-40	5	mg/l	1.8	mg/l
Oil and Grease		100	24	mg/l	12	mg/l
Bicarbonate			976	mg/l	732	mg/l

Conclusions

1. The water found is not underground water, for a number of reasons:

    a. Total dissolved solids (TDS) ratios in underground water should be between 1000 and 1500 mg/l, while results show TDS ratios of 2650 mg/l for the Fatima Khatun site and 1020 mg/l for the Safiyy al-Din Jawhar site.
    b. Total suspended solids (TSS) ratios vary from 6 to 30 gm/l in underground water. Which did not happen in either site (2 gm/l for the Fatima Khatun site and 0.2 gm/l for the Safiyy al-Din Jawhar site)
    c. Bicarbonates ratio in underground water varies from 300 to 640 mg/l which is much less than the amounts in the above table
    d. Turbidity should not exceed 12 gm/l which also did not happen in either site

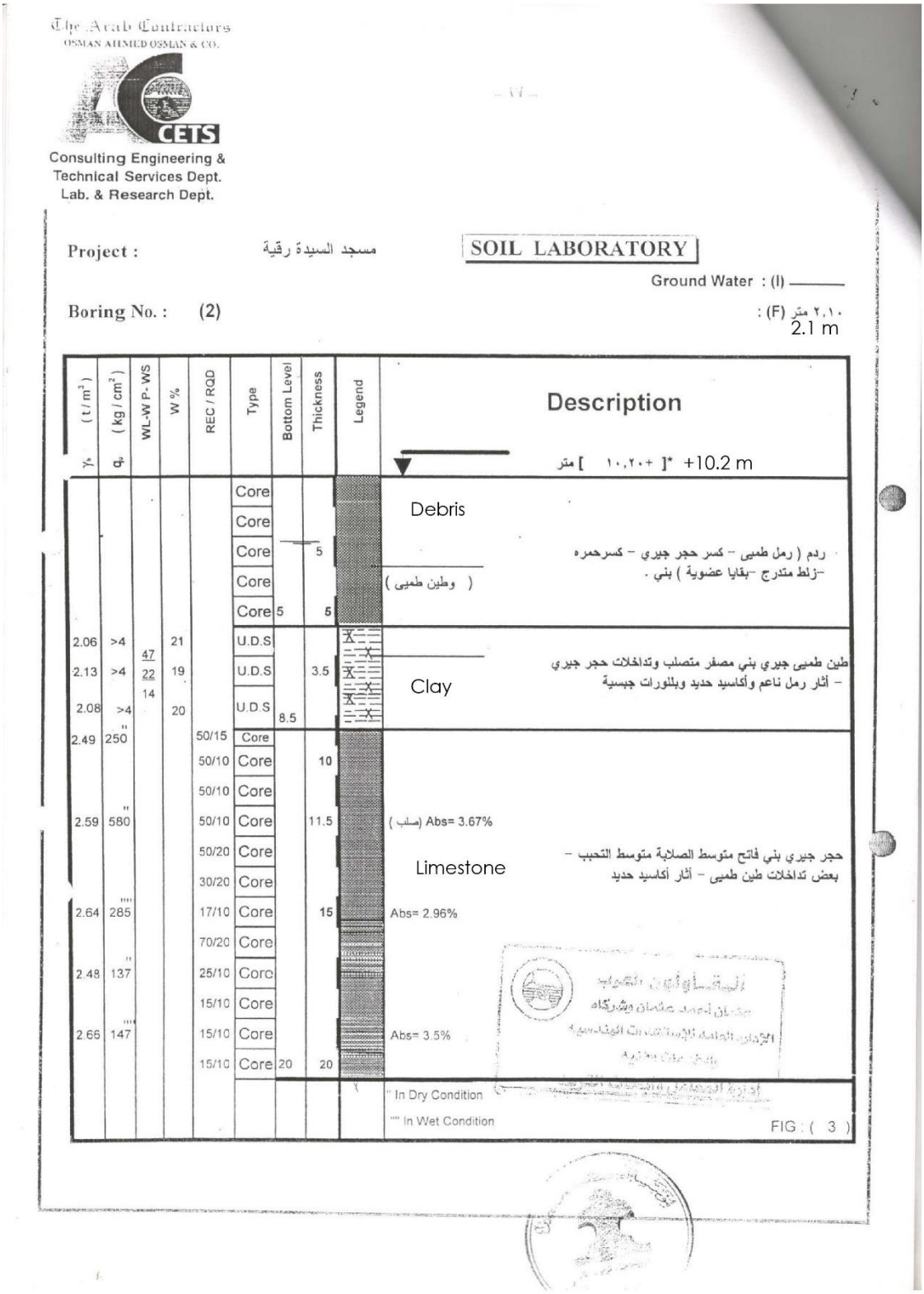
2. Water from the Safiyy al-Din Jawhar site is purer than the water from the Fatima Khatun site. However, analysis shows that water from both sites does not reach in their contamination levels the levels of waste water, for the following reasons:

    a. Wastewater has high levels of BOD (500 to 1000 gm/l), while both samples had a BOD of less than 0.5 mg/l. Wastewater also has high values of COD (reaching 1500 mg/l) while in both sites it didn't exceed 900 mg/l.
    b. Wastewater has high ratios of Ammonia reaching 80 mg/l. While this ratio didn't exceed 1 mg/l in both sites.
    c. Oil and grease ratios in wastewater reaches 100 mg/l. While it didn't exceed 24 mg/l in either site.

From the above we deduce that the extracted water is not underground, it is also not wastewater, but rather contaminated water that needs treatment to be used. It is most likely that this water is drinking water that got polluted. This appears from the pH value of 7 for the water. It is also noted that turbidity values ae directly proportional with chorine values, and chlorine is the most common method for water treatment for drinking purposes.

Annex 4: Boreholes from previous projects

Boreholes in the Sayyida Ruqayya site



The Arab Contractors
OSMAN AHMED OSMAN & CO.

CETS
Consulting Engineering & Technical Services Dept.
Lab. & Research Dept.

Project : مسجد السيدة رقية

SOIL LABORATORY

Ground Water : (I) ———

Boring No. : (2)

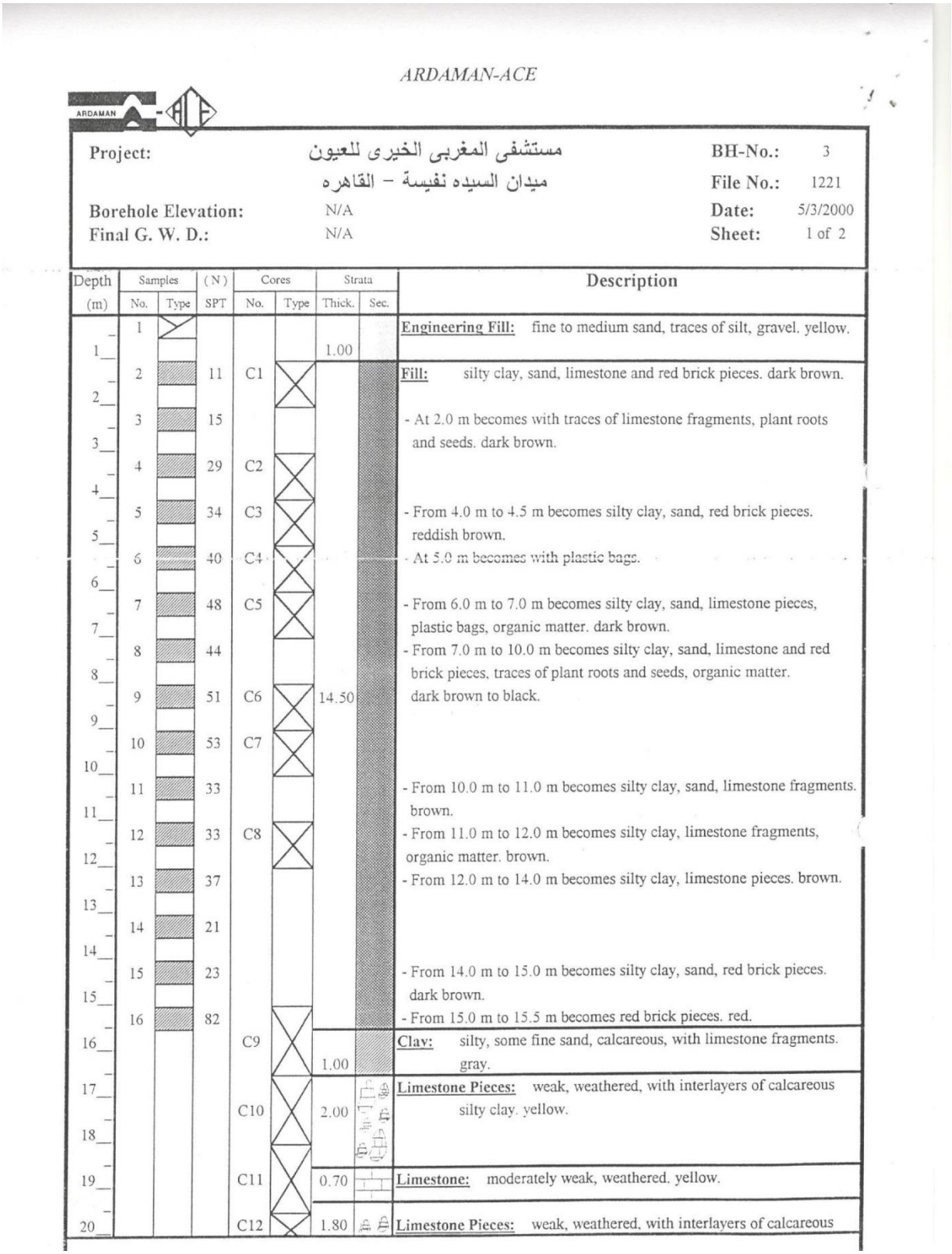
: (F) ٢,١٠ متر
2.1 m

γ_o (t/m³)	q_u (kg/cm²)	WL-W P- WS	W %	REC / RQD	Type	Bottom Level	Thickness	Legend	Description (متر [١٠,٢٠+]* +10.2 m)
					Core				Debris
					Core				
					Core		5		ردم (رمل طمي - كسر حجر جيري - كسرحمره -زلط متدرج -بقايا عضوية) بني .
					Core				(وطين طمي)
					Core	5	5		
2.06	>4	47	21		U.D.S				Clay
2.13	>4	22	19		U.D.S		3.5		طين طمي جيري بني مصفر متصلب وتداخلات حجر جيري - أثار رمل ناعم وأكاسيد حديد وبلنورات جبسية
2.08	>4	14	20		U.D.S	8.5			
2.49	250	"		50/15	Core				Limestone
				50/10	Core		10		حجر جيري بني فاتح متوسط الصلابة متوسط التحبب - بعض تداخلات طين طمي - أثار أكاسيد حديد
				50/10	Core				
2.59	580	"		50/10	Core		11.5		(صلب) Abs= 3.67%
				50/20	Core				
				30/20	Core				
2.64	285	""		17/10	Core		15		Abs= 2.96%
				70/20	Core				
2.48	137	"		25/10	Core				
				15/10	Core				
2.66	147	""		15/10	Core				Abs= 3.5%
				15/10	Core	20	20		

" In Dry Condition
"" In Wet Condition

FIG : (3)

Boreholes in the Maghrabi hospital bulding (near Sayyida Nafisa square and with ground level +1560 cm from Saliba street (zero for all levels in these studies)



ARDAMAN-ACE

ARDAMAN

Project:	مستشفى المغربى الخيرى للعيون ميدان السيده نفيسة – القاهره	BH-No.:	3
		File No.:	1221
Borehole Elevation:	N/A	Date:	5/3/2000
Final G. W. D.:	N/A	Sheet:	1 of 2

Depth (m)	Samples No.	Samples Type	(N) SPT	Cores No.	Cores Type	Strata Thick.	Strata Sec.	Description
1	1					1.00		**Engineering Fill:** fine to medium sand, traces of silt, gravel. yellow.
2	2		11	C1				**Fill:** silty clay, sand, limestone and red brick pieces. dark brown.
3	3		15					- At 2.0 m becomes with traces of limestone fragments, plant roots and seeds. dark brown.
4	4		29	C2				
5	5		34	C3				- From 4.0 m to 4.5 m becomes silty clay, sand, red brick pieces. reddish brown.
6	6		40	C4				- At 5.0 m becomes with plastic bags.
7	7		48	C5				- From 6.0 m to 7.0 m becomes silty clay, sand, limestone pieces, plastic bags, organic matter. dark brown.
8	8		44					- From 7.0 m to 10.0 m becomes silty clay, sand, limestone and red brick pieces, traces of plant roots and seeds, organic matter. dark brown to black.
9	9		51	C6		14.50		
10	10		53	C7				
11	11		33					- From 10.0 m to 11.0 m becomes silty clay, sand, limestone fragments. brown.
12	12		33	C8				- From 11.0 m to 12.0 m becomes silty clay, limestone fragments, organic matter. brown.
13	13		37					- From 12.0 m to 14.0 m becomes silty clay, limestone pieces. brown.
14	14		21					
15	15		23					- From 14.0 m to 15.0 m becomes silty clay, sand, red brick pieces. dark brown.
16	16		82					- From 15.0 m to 15.5 m becomes red brick pieces. red.
17				C9		1.00		**Clay:** silty, some fine sand, calcareous, with limestone fragments. gray.
18				C10		2.00		**Limestone Pieces:** weak, weathered, with interlayers of calcareous silty clay. yellow.
19				C11		0.70		**Limestone:** moderately weak, weathered. yellow.
20				C12		1.80		**Limestone Pieces:** weak, weathered, with interlayers of calcareous

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ARDAMAN

Project:	مستشفى المغربى الخيرى للعيون ميدان السيده نفيسة – القاهره	**BH-No.:**	3
		File No.:	1221
Borehole Elevation:	N/A	**Date:**	5/3/2000
Final G. W. D.:	N/A	**Sheet:**	2 of 2

Depth (m)	Samples No.	Samples Type	(N) SPT	Cores No.	Cores Type	Strata Thick.	Strata Sec.	Description
21					X			Continuation of the Same Layer
22								End of Boring 21.0 m.
23								**Notes:** - Attempts were made for core drilling at depths 2.0 - 3.0 m, 7.0 - 8.0 m, 10.0 - 11.0 m, and 12.0 - 15.0 m with no core recovery. - No return of drilling fluid from 1.0 m to end of drilling at 21.0 m.
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Project:	مستشفى المغربى الخيرى للعيون ميدان السيده نفيسة – القاهره	**BH-No.:**	4
		File No.:	1221
Borehole Elevation:	N/A	**Date:**	28/2/2000
Final G. W. D.:	N/A	**Sheet:**	1 of 2

Depth (m)	Samples No.	Samples Type	(N) SPT	Cores No.	Cores Type	Strata Thick.	Strata Sec.	Description
0	1			C1				**Fill:** fine silty sand, limestone pieces. gray.
1								
	2		41	C2				- From 1.0 m to 1.5 m becomes coarse to fine sand, some silt, calcareous. reddish brown. **(Engineering Fill??)**
2								
	3		25	C3				- From 1.5 m to 3.0 m becomes silty clay, sand, coarse gravel. dark brown to black.
3								
	4		9	C4				- From 3.0 m to 6.0 m becomes silty clay, sand, limestone and red brick pieces. dark brown to black.
4								
	US1	I						
5								
	US2	I		C5				
6								
	5		16	C6				- From 6.0 m to 7.0 m becomes fine silty sand, silty clay, limestone pieces, traces of plant roots. black.
7						15.80		
	6		21	C7				- From 7.0 m to 8.2 m becomes silty clay, sand, limestone fragments. brown.
8								
	7		23	C8				- From 8.2 m to 9.3 m becomes fine silty sand, silty clay, plant roots and seeds. brown.
9								
	8		41	C9				- From 9.3 m to 10.3 m becomes silty clay with limestone pieces. brown and white.
10								
	9		29	C10				- From 10.3 m to 13.0 m becomes silty clay, sand, limestone and red brick pieces. dark brown to black.
11								
12								
	US3	I						
13								
	10		16	C11				- From 13.0 m to 14.0 m becomes silty clay and limestone pieces. brown and white.
14								
15				C12				- From 14.0 m to 14.8 m becomes silty clay, sand, red brick pieces, traces of limestone fragments. dark brown.
								- From 14.8 to 15.8 m becomes red brick pieces. red.
16								
				C13		1.70		**Limestone Pieces:** in boulder size, with interlayers of sandy silty clay. yellow.
17								
18				C14		1.10		**Limestone:** slightly weathered, moderately weak. yellow.
19								
				C15		1.40		**Clay:** silty, some fine sand, traces of limestone fragments. yellowish brown.
20								End of Boring 20.0 m.

Field Eng. : M. Morsi Lab. Eng. : T. Fakhr Equip.: Mechanical

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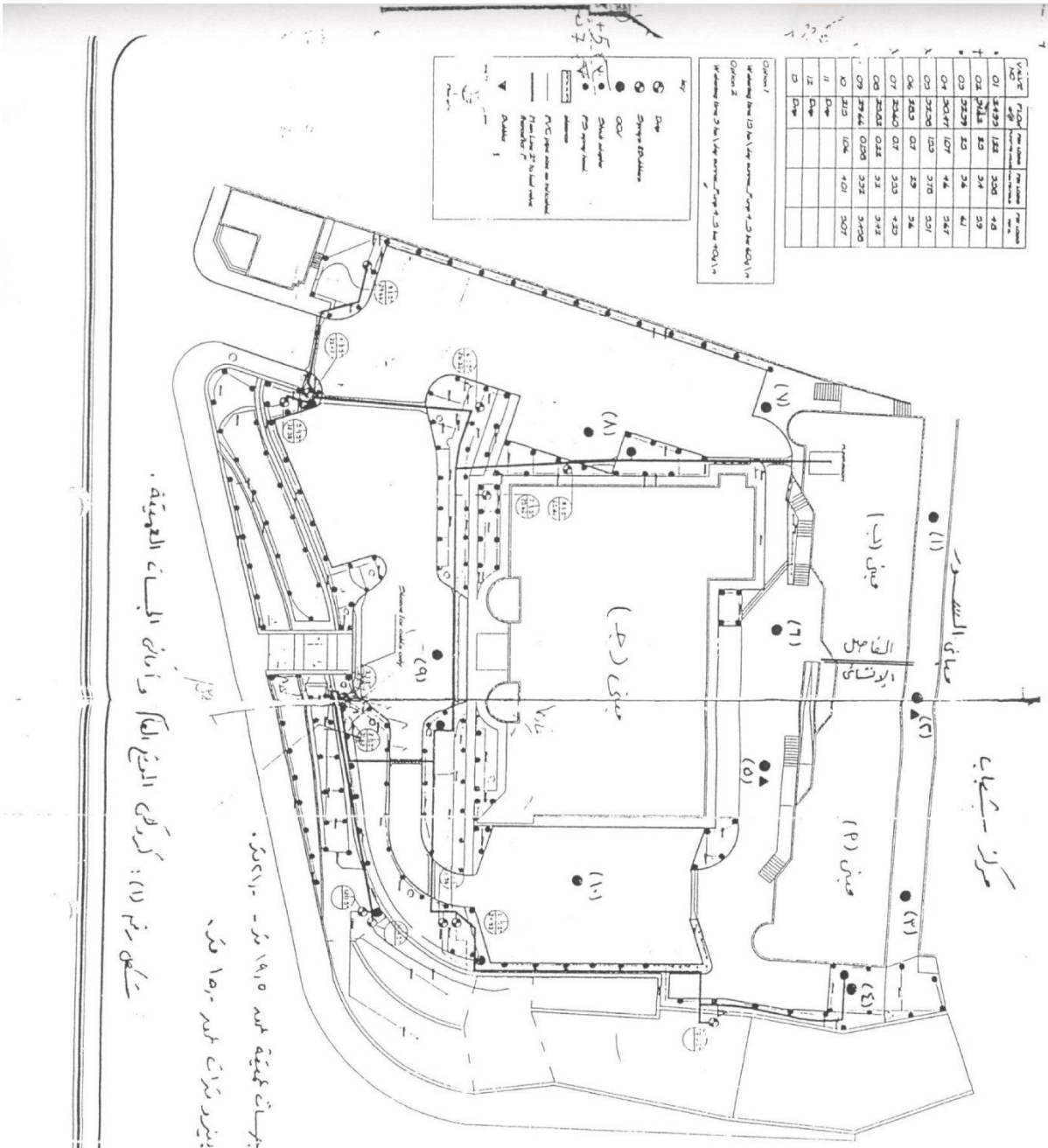
Project:	مستشفى المغربى الخيرى للعيون ميدان السيده نفيسة – القاهره	BH-No.:	4
		File No.:	1221
Borehole Elevation:	N/A	Date:	28/2/2000
Final G. W. D.:	N/A	Sheet:	2 of 2

Depth (m)	Samples No.	Samples Type	(N) SPT	Cores No.	Cores Type	Strata Thick.	Strata Sec.	Description
21								**Notes:**
22								- Attempts were made for core drilling at depths 4.0 - 5.0 m, 11.0 - 12.0 m and 12.0 - 13.0 m with no core recovery.
23								- High resistance for pushing Shelby tube from 4.0 m to 4.2 m.
24								- Shelby tube could not advance at depth 6.0 m to 7.0 m.
25								- No return of the drilling fluid from 8.0 m to end of boring at 20.0 m.
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Field Eng. : M. Morsi Lab. Eng. : T. Fakhr Equip.: Mechanical



● تجهيزات كهربية لمسه ١٩,٥ متر - ٢٧,٥ متر.

▲ تجهيز تركيبات لمسه ١٥,٠ متر.

شكل رقم (١): كروكى المشتل العام وأماكن الحبات العينية.

DRAWINGS ARE TO THE SCALE SPECIFIED BELOW UNLESS OTHERWISE STATED

Fiorito MODERN GARDENS

4 SALAH ELDIN St., HELIOPOLIS - CAIRO - EGYPT
TEL : (202) 418 2147 (202) 4176427
FAX : (202) 417 8428

PROJECT NAME : EL-MAGHRABI HOSPITAL
EL-SAYEDA NAFISA (CAIRO)

SHEET TITLE : AS-BUILT IRRIGATION LAYOUT

SHEET No.

DESIGN :

SCALE : 1/400

APPROVED :

DATE : 20 - 10 - 1998

NORTH :

REVISION :

NOTES :

ARDAMAN

PROJECT No. :

Annex 5: Water flow rate from an existing dewatering project in the area

Ahmad Kuhya Mosque is the only site in the study area with an installed dewatering system, the numbers below calculate the amount of water pumped per day from the site to be used as reference figures for the park.

Input Electrical Power (P)			
Voltage (V)	380	V	$W_{applied} = 3^{1/2}\ U\ I \cos \Phi$
Current (I)	15	A	$= 3^{1/2}\ U\ I\ PF$ (1)
Power Factor (PF)	0.73		
Real Input Power (P)	7207	W	where
Output Fluid Power (P)			$W_{applied}$ = real power (W, watts)
			U = voltage (V, volts)
System Effeciency (η)	0.7		I = current (A, amps)
Fluid Power (P)	5045	W	PF = cos Φ = power factor (0.7 - 0.95)
Density of Fluid (ρ)	1000	kg/m^3	$W_{out} = W_{in} \frac{\eta}{100\%}$
Acceleration due to Gravity (g)	9.81	m/s^2	
Fluid Column Height (h)	5	m	
			$P_{static\ fluid} = \rho g h$
Pressure (P)	49050	N/m^2	
			where
Flow Rate (Q_{peak})	0.103	m^3/s	
	103	l/s	ρ = m/V = fluid density
			g = acceleration of gravity
Up time after 15 minute (900 second) pause	35	s	h = depth of fluid
Up time per day (86,400 seconds)	3234	s/day	Power = P × Q
Flow per day ($Q_{average}$) for 113 m of exposed soil	332650	l/day	Flow per day = Flow per second × seconds per day
Flow per day ($Q_{average}$) for 1 m of exposed soil	2940	l/day/m	• Can be used for estimating flow rate of other systems employing different "lengths" of exposed soil

Amounts of water pumped daily = 332 m3/day.
Area of site = 250 m^2.
Length of pipes = 113 m.
Pipe Diameter = 6 inch.