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1.9 Reuse of Effluent in Fuhis

1.9.1 Existing System of Wastewater Collection, Treatment and Disposal (Fuhis)

Fuhis Wastewater Treatment Plant receives sewage from the towns of Fuhis and Mahis. The sewerage system and the plant were completed recently (in 1996). Wastewater collection relies on two pumping stations. Construction of house connections was not completed in 1999. Therefore, the wastewater quantity discharged to the plant is still increasing.

Physical treatment facilities of the treatment plant consist of screens and non-aerated grit chambers. Biological treatment is based on an activated sludge process (extended aeration) comprising activated sludge tanks and secondary settling tanks. Additional treatment is provided by maturation ponds (see Figure 1.9.1-1). Treated wastewater may be chlorinated, if required.

Excess sludge is treated by sludge thickeners. During summer time the thickened sludge is dried by the sludge drying beds of the treatment plant, while during winter time the thickened sludge is transported by tankers to Ain Ghazal pretreatment plant and conveyed together with the raw wastewater of Amman to the As Samra treatment plant.

The design capacity of the treatment plant (put in operation in 1996) is 2,400 m³/d, of which presently one third is used only.

Wastewater at the outlet of the plant is pumped over a ridge to maturation ponds, which are located southeast of the plant (see Figure 1.9.4-1). Main receiving water is Wadi Shua'ab discharging finally into the Shua'ab Reservoir. The effluent of the plant (< 10 mg BOD₅/l) does meet the requirements according to the related Jordanian Standard 893/1995 for discharge into wadis and catchment areas. Due to the additional treatment of wastewater by the maturation ponds and chlorination of the effluents, the fecal coliform count could be reduced to less than 1,000 in 100 ml. However, at present the fecal coliform count is still higher than 10,000.

At present, treated wastewater is not reused for irrigation purposes downstream of the treatment plant, even required standards could be met by the applied/possible treatment process. It is reused only downstream of the Shua'ab Reservoir after dilution with surface water.

The design criteria for Fuhis Wastewater Treatment Plant are as follows:

Influent		Effluent
Inflow (m ³ /d)	BOD ₅ (mg/l)	BOD ₅ (mg/l)
2,400	990	30

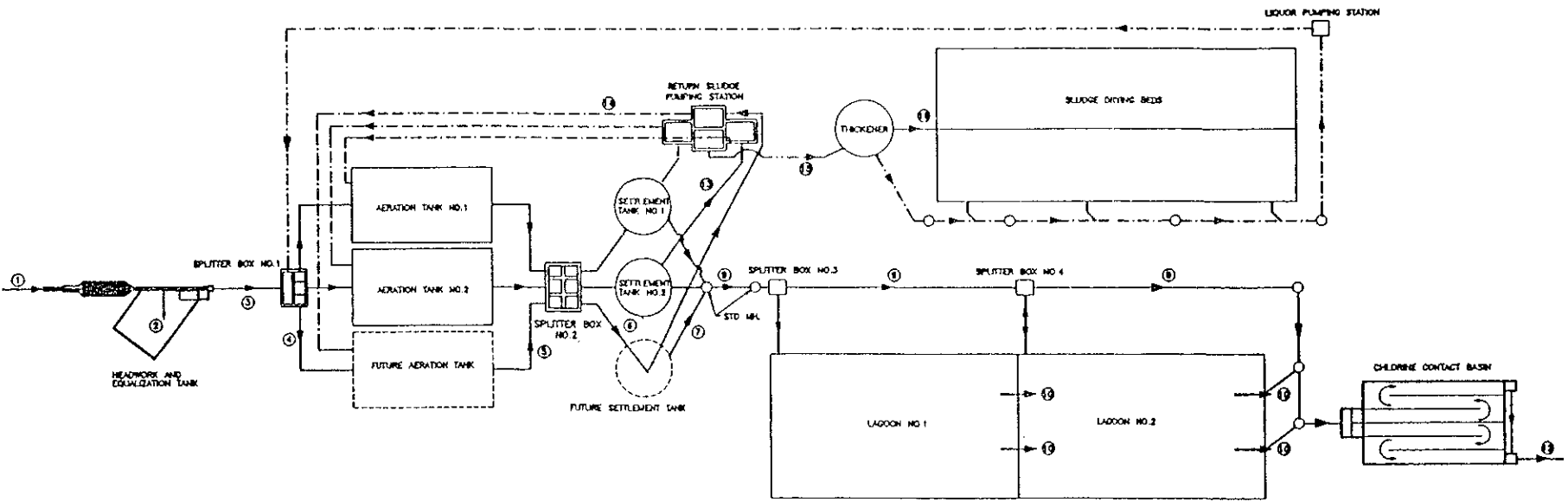


Figure 1.9.1-1 Schematic Layout of Fuhis Wastewater Treatment Plant

1.9.2 Wastewater Quantity and Quality (Fuhis)

The inflow quantity to the treatment plant has increased since 1997 from 410 m³/day to 1,218 m³/day in 2000. In spite of that the level of influent to the plant is still far below the design capacity of the treatment plant, which is 2,400 m³/day (see Table 1.9.2-1).

Table 1.9.2-1 Development in the Influent Quantity of Fuhis Wastewater Treatment Plant

Year	Influent (m ³ /day)
1997	410
1998	847
1999	1,019
2000	1,218

The coverage percentages for Fuhis WWTP is around 70 %, it is expected for this figure to increase to 90 % till the year 2010. Increasing coverage percentages will be accompanied by an increase in the per capita consumption. Therefore, after the year 2010 the treatment plant needs an expansion. Projected influent to the treatment plant will reach around 3,300 m³/day in 2020 (see Table 1.9.2-2).

Table 1.9.2-2 Projection of the Influent to Fuhis Wastewater Treatment Plant

Basic data:		Unit	1994	2000	2005	2010	2015	2020
Growth rate (previous period)	%		-	3.415	3.3	3.3	3.3	3.3
Spec.water demand	l/c/d		94	105	106	112	116	119
Coverage	%		0	70	85	90	90	90
Return factor	-		0.8	0.8	0.8	0.8	0.8	0.8
Specific polluttional load	gBOD ₅ /c/d		65	65	65	65	65	65
Projection		Unit	1994	2000	2005	2010	2015	2020
Population	c		16,723	20,456	23,901	28,114	33,069	38,898
Connected (sewerage)	c		0	14,319	20,316	25,302	29,762	35,008
Not connected (sewerage)	c		16,723	6,137	3,585	2,811	3,307	3,890
Water demand								
Domestic demand	l/c/d		94	105	106	112	116	119
	m ³ /d		1,572	2,148	2,534	3,149	3,836	4,629
Total	m ³ /d		1,572	2,148	2,534	3,149	3,836	4,629
Wastewater production								
Return flow (w.demand)	m ³ /d		0	1,203	1,723	2,267	2,762	3,333
Losses/inflow	m ³ /d		0	0	0	0	0	0
Total	m ³ /d		0	1,203	1,723	2,267	2,762	3,333
	M ³ /month		0	36,084	51,684	68,013	82,858	99,982
	M ³ /a		0	439,021	628,819	827,490	1,008,102	1,216,452
Polluttional load								
Poll. load (dom.demand)	kgBOD ₅ /d		0	931	1,321	1,645	1,935	2,276
Reuse of wastewater								
Inflow to the treatment plant	m ³ /a		0	439,021	628,819	827,490	1,008,102	1,216,452
Losses in treatment plant	%		0	10	10	10	10	10
(due to infiltr./evap.)	m ³ /a		0	43,902	62,882	82,749	100,810	121,645
Effluent of treatment plant	m ³ /a		0	395,119	565,937	744,741	907,291	1,094,807

Although there is an increase in the organic load in the influent to Fuhis WWTP, the plant is still within its capacity for organic load, which is 990 mg/l. An efficiency of about 97 % can be concluded from Table 1.9.2-3, which shows the quality of the influent and the effluent of Fuhis WWTP.

Table 1.9.2-3 Quality of Influent and Effluent of Fuhis WWTP for the Period (1997-2000).

Year	Influent (mg/L)			Effluent (mg/L)			
	BOD ₅	COD	TSS	BOD ₅	COD	TSS	TDS
1997	775	1,325	674	5	37	23	1,013
1998	533	1,425	565	8	56	19	1,037
1999	677	1,552	720	11	72	21	669
2000	745	1,134	583	22	76	35	237

1.9.3 Reuse of Effluent (Fuhis)

1.9.3.1 Present Reuse Practice

There is no planned reuse of treated effluent in the vicinity of the treatment plant. The treated wastewater from Fuhis WWTP is discharged to the Wadi Shua'ab, where the water is mixed with the discharged wastewater from Salt WWTP and end up in Wadi Shua'ab dam. The only unplanned reuse is the irrigation of some citrus trees (lemon) along the wadi downstream of Fuhis WWTP. Also downstream of the confluence point of Fuhis and Salt WWTPs, there is another unplanned reuse of irrigating some citrus, pomegranate, figs, and vegetables along Wadi Shua'ab.

1.9.3.2 Proposed Cropping Pattern

Fuhis area is classified as middleland, which lies between the highland and the Jordan Valley. So, it is influenced by climatic conditions of both the highland and the Jordan Valley. That is the reason why citrus and pomegranate is somehow predominate in the area.

Selection of adequate cropping pattern calls for crops, which match the existing water quality and which are tolerant to slightly increased salinity.

According to the water quality of the effluent for Fuhis WWTP (see Table 1.9.2-3), and the JS 893/1995, the above mentioned crops are still an option together with the introduction of eucalyptus, where most of them are strongly tolerant to salinity except citrus. The situation of citrus is acceptable to a certain extend because treated effluent is mixed with the base flow in Wadi Shua'ab in a reuse area located downstream of the proposed one (see section 1.9.1.4).

However, we selected a common cropping pattern for all reuse projects, which comprises fodder (alfalfa), olive trees, date palms and some field crops (wheat and barley).

1.9.3.3 Water Demand for Irrigation

Water demand and treated effluent were determined on the basis of net irrigation demand figures of the MWI (agro-zone 6). Results are summarized in Table 1.9.3-1 and Table 1.9.3-2 for the target years 2010 and 2020. Figure 1.9.3-1 illustrates seasonal variation of available treated effluent and demand for irrigation of proposed irrigation areas of Fuhis. During the period between March and November it is possible reuse the entire effluent quantity. From December to February precipitation is so high that there is no requirement for additional irrigation. Therefore about 140,000 m³/a is expected as excess water in 2010. This quantity will flow in Wadi Shua’ab and contribute finally to the stored volume in Shua’ab Reservoir.

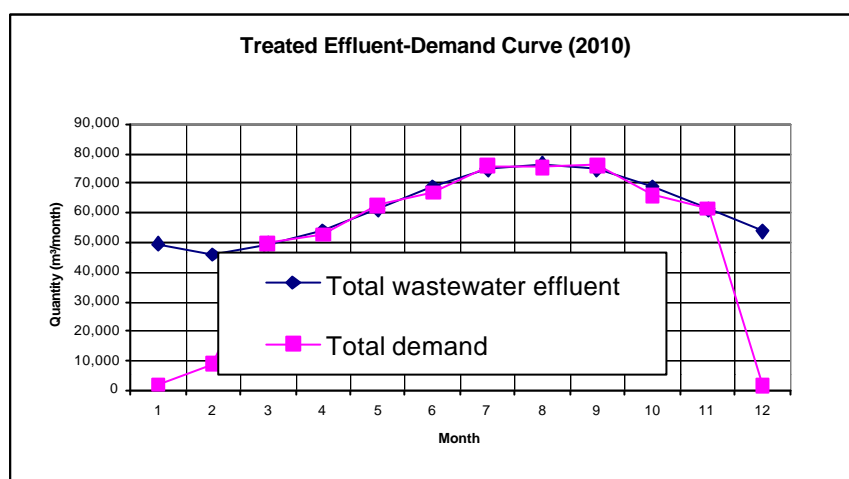


Figure 1.9.3-1 Seasonal Treated Effluent and Demand for Irrigation (Fuhis)

1.9.3.4 Area Proposed for Irrigation

There are considerable land areas available for irrigation downstream of Fuhis WWTP. These lands are distributed particularly in the Southern sides of the treatment plant. Figure 1.9.4-1 depicts the proposed reuse area that might be used for future irrigation by treated effluent of Fuhis WWTP. The land areas that could be exploited till the year 2010 and 2020 depend on the quantity of effluent that might be available in the future (see Tables 1.9.3-1 and 1.9.3-2). Following the irrigation strategy as applied for water demand projection (agro-zone 4) an area of up to 770 donums may be irrigated.

Effluent of the existing maturation ponds will be discharged by gravity to the reuse areas. They are located in an area below the contour line of 620 m a.s.l..

1.9.4 Preliminary Design of Facilities (Fuhis)

Only transmission lines are required to discharge treated effluent of the maturation ponds to the proposed reuse areas (see Figure 1.9.4-1). One pipeline will be laid in Southeastern direction and another one in Southwestern direction. Effluent can reach all reuse areas by gravity. Proposed transmission line (DN 200, 2,000 m) conveys the effluent from the existing maturation ponds to the reuse areas located south of the Fuhis WWTP.

A reservoir is in the specific case of Fuhis not necessary, because the existing maturation ponds may undertake the function of a storage.

Table 1.9.3-1 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Fuhis Wastewater Treatment Plant (2010)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Available wastewater													
Seasonal factor of treated effluent (wastewater)	0,81	0,75	0,81	0,88	1,00	1,12	1,22	1,25	1,22	1,12	1,00	0,88	-
Total wastewater effluent (m ³ /month) 2)	49.572	45.900	49.572	53.856	61.200	68.544	74.664	76.500	74.664	68.544	61.200	53.856	738.072
1 OLIVES													
Net irrigation demand (m ³ /donum/ month)	32	18	54	112	127	126	131	116	103	19	-	-	838
Irrigation efficiency	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	
Gross irrigation demand (m ³ / donum/ month)	38	22	64	133	151	150	156	139	123	22	0	0	998
Chosen area (donum)	55	55	55	55	55	55	55	55	55	55	55	55	
Demand (m ³ /month) 1)	2.083	1.189	3.541	7.307	8.318	8.263	8.565	7.627	6.747	1.236	0	0	54.877
2 WHEAT & BARLEY													
Net irrigation demand (m ³ /donum/ month)	-	19	65	144	11	-	-	-	-	-	100	3	342
Irrigation efficiency	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	
Gross irrigation demand (m ³ / donum/ month)	0	32	108	240	19	0	0	0	0	0	167	5	571
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m ³ /month) 1)	0	2.550	8.648	19.227	1.511	0	0	0	0	0	13.333	387	45.656
3 DATE PALM													
Net irrigation demand (m ³ /donum/ month)	-	15	54	128	167	174	178	158	140	94	49	14	1.171
Irrigation efficiency	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	0,84	
Gross irrigation demand (m ³ / donum/ month)	0	18	64	153	199	207	211	188	166	112	59	16	1.394
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m ³ /month) 1)	0	1.438	5.154	12.224	15.886	16.559	16.908	15.056	13.318	8.950	4.686	1.301	111.481
Total demand for crops no. 1 - 3 (m³/ month)	2.083	5.177	17.344	38.758	25.716	24.821	25.473	22.683	20.064	10.187	18.019	1.688	212.015
Remaining effluent (m ³ /month)	47.489	40.723	32.228	15.098	35.484	43.723	49.191	53.817	54.600	58.357	43.181	52.168	
4 ALFALFA													
Net irrigation demand (m ³ /donum/ month)	-	4	35	104	147	168	178	158	140	93	47	-	1.074
Irrigation efficiency	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	
Gross irrigation demand (m ³ / donum/ month)	0	7	59	173	245	280	296	263	233	155	79	0	1.791
Required area of alfalfa (donum)	0	5.867	546	87	145	156	166	204	234	377	546	0	
Selected area of alfalfa (donum)	550	550	550	80	150	150	170	200	240	360	550	550	
Demand for selected area of alfalfa (m ³ /month)	0	3.818	32.440	13.850	36.795	41.988	50.302	52.695	55.935	55.747	43.498	0	387.067
Water Balance													
Total demand (m ³ /month)	2.083	8.995	49.784	52.609	62.511	66.809	75.775	75.378	76.000	65.934	61.517	1.688	599.081
Total wastewater effluent (m ³ /month) 2)	49.572	45.900	49.572	53.856	61.200	68.544	74.664	76.500	74.664	68.544	61.200	53.856	738.072
Excess+/deficit- (m ³ /month)	47.489	36.905	-212	1.247	-1.311	1.735	-1.111	1.122	-1.336	2.610	-317	52.168	138.991

Remarks:

1) Based on irrigation time:24 hours/day

2) Wastewater effluents of treatment plan: **2.040** m³/day in 2010 and 744.600 m³/annum

3) Irrigation surface (donums):

	OLIVES	WHEAT & BARLEY	DATE PALM	ALFALFA
Total (min.):	55	80	80	80
Total (max.):	55	80	80	550

Table 1.9.3-2 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Fuhis Wastewater Treatment Plant (2020)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Available wastewater													
Seasonal factor of treated effluent (wastewater)	0.81	0.75	0.81	0.88	1.00	1.12	1.22	1.25	1.22	1.12	1.00	0.88	-
Total wastewater effluent (m ³ /month) 2)	72,900	67,500	72,900	79,200	90,000	100,800	109,800	112,500	109,800	100,800	90,000	79,200	1,085,400
1 OLIVES													
Net irrigation demand (m ³ /donum/ month)	32	18	54	112	127	126	131	116	103	19	-	-	838
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m ³ /donum/ month)	38	22	64	133	151	150	156	139	123	22	0	0	998
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m ³ /month) 1)	3,029	1,730	5,151	10,629	12,100	12,018	12,459	11,094	9,813	1,798	0	0	79,821
2 WHEAT & BARLEY													
Net irrigation demand (m ³ /donum/ month)	-	19	65	144	11	-	-	-	-	-	100	3	342
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m ³ /donum/ month)	0	32	108	240	19	0	0	0	0	0	167	5	571
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m ³ /month) 1)	0	2,550	8,648	19,227	1,511	0	0	0	0	0	13,333	387	45,656
3 DATE PALM													
Net irrigation demand (m ³ /donum/ month)	-	15	54	128	167	174	178	158	140	94	49	14	1,171
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m ³ /donum/ month)	0	18	64	153	199	207	211	188	166	112	59	16	1,394
Chosen area (donum)	120	120	120	120	120	120	120	120	120	120	120	120	
Demand (m ³ /month) 1)	0	2,157	7,732	18,336	23,830	24,838	25,362	22,584	19,977	13,426	7,029	1,952	167,222
Total demand for crops no. 1 - 3 (m³/ month)	3,029	6,437	21,531	48,192	37,440	36,856	37,821	33,678	29,790	15,224	20,362	2,339	292,699
Remaining effluent (m ³ /month)	69,871	61,063	51,369	31,008	52,560	63,944	71,979	78,822	80,010	85,576	69,638	76,861	
4 ALFALFA													
Net irrigation demand (m ³ /donum/ month)	-	4	35	104	147	168	178	158	140	93	47	-	1,074
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m ³ /donum/ month)	0	7	59	173	245	280	296	263	233	155	79	0	1,791
Required area of alfalfa (donum)	0	8,797	871	179	214	228	243	299	343	553	881	0	
Selected area of alfalfa (donum)	900	900	900	200	200	250	250	300	350	550	900	900	
Demand for selected area of alfalfa (m ³ /month)	0	6,247	53,083	34,626	49,059	69,979	73,973	79,043	81,572	85,169	71,178	0	603,930
Water Balance													
Total demand (m ³ /month)	3,029	12,684	74,614	82,818	86,500	106,836	111,794	112,721	111,362	100,393	91,540	2,339	896,630
Total wastewater effluent (m ³ /month) 2)	72,900	67,500	72,900	79,200	90,000	100,800	109,800	112,500	109,800	100,800	90,000	79,200	1,085,400
Excess+/deficit- (m ³ /month)	69,871	54,816	-1,714	-3,618	3,500	-6,036	-1,994	-221	-1,562	407	-1,540	76,861	188,770

Remarks:

- 1) Based on irrigation time:24 hours/day
- 2) Wastewater effluents of treatment plant **3,000** m³/day in 2020 and 1,095,000 m³/annum
- 3) Irrigation surface (donums):

	OLIVES	WHEAT & BARLEY	DATE PALM	ALFALFA
Total (min.):	520	80	120	200
Total (max.):	1,220	80	120	900

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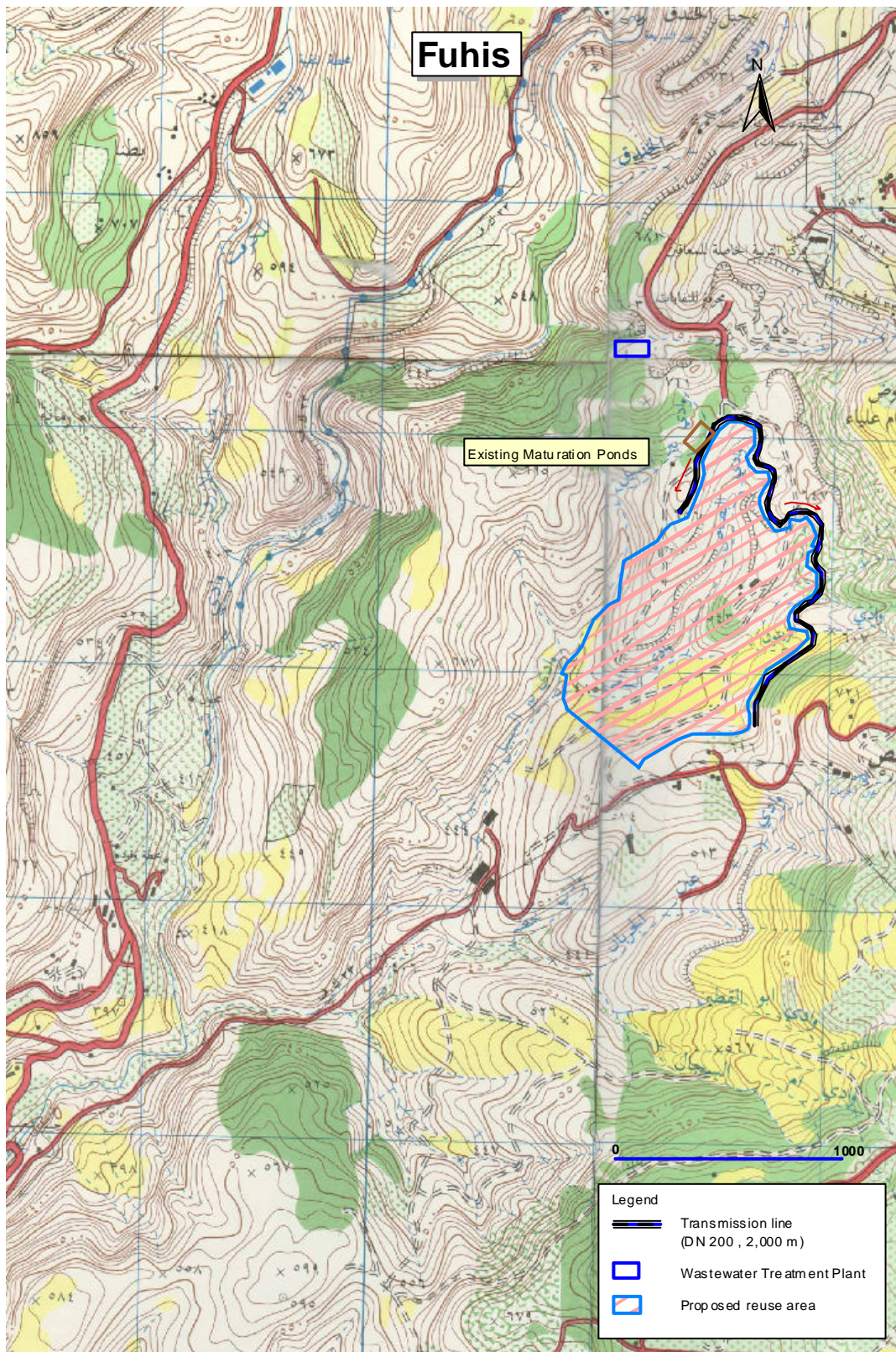


Figure 1.9.4-1 Location of Fuhis Wastewater Treatment Plant and Proposed Site for Effluent Reuse