Chapter 2 Wadi Zarqa Treatment Plant Construction

1.11 Reuse of Effluent in Wadi Essir

1.11.1 Existing System of Wastewater Collection, Treatment and Disposal (Wadi Essir)

Wadi Essir Wastewater Treatment Plant serves part of Wadi Essir town. About 90 % of the population of Wadi Essir town are served and connected to As Samra wastewater treatment plant, while the other 10 % are connected to Wadi Essir Plant. Figure 1.11.1-1 depicts the general layout of the sewerage system for Wadi Essir town.

The treatment plant is located some 16 km downstream of the town in the steep valley of Wadi Essir. The plant started operation in 1997. Basic design criteria according to the Consultant designing the plant are shown in the following table:

Influent			Effluent	
Inflow (m^3/d)	BOD_5 (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	TSS (mg/L)
4,000	700	850	30	30

The inflow to Wadi Essir WWTP is still below the design capacity of the treatment plant. The reason is that connection rate has not reached yet assumed values and furthermore the per capita consumption is low. Primary treatment of the existing system at Wadi Essir WWTP (see Figure 1.11.1-2) consists of screens without grit chambers. Biological treatment is done in two trains of parallel anaerobic ponds (2 ponds), two aerated parallel ponds, and four maturation ponds (two of them are in parallel, and the other two are in series). Only one anaerobic pond is currently in operation, because the other one is damaged by a landslide (see section 1.11.2). Submersible pumps lifting water and jetting it back to the water surface do aeration of the aerobic ponds. Treated wastewater may be chlorinated when required.

The design capacity of the treatment plant is 4,000 m^3/d, of which presently a quarter is used only.

Up to now the ponds did not need desludging because of the operation time of four years only and because of the low present load (25 % of installed capacity). For future sludge emptying of the operated anaerobic pond it is proposed to use the second anaerobic pond (presently out of operation) as sludge drying bed. Separate drying beds do not exist. Dried sludge shall be used within the treatment area as fertilizer and soil conditioner or supplied to the farmers for the same purposes, if possible.

Natural receiving water for the plant is the Wadi Essir downstream of its confluent with the Wadi El Bahhath discharging finally into the Kafrein Reservoir. The effluent of the plant (<50 mg BOD_5/l) does meet the requirements according to the relevant Jordanian Standard 893/1995 for discharge into wadis and catchment areas. Without chlorination of the effluents of the plant the fecal coliform count was found as 1,600 in 100 ml in 1999. Following the Jordanian Standard the effluent could be reused for irrigation of vegetables eaten uncooked (restricted irrigation), if safety chlorination would be provided.

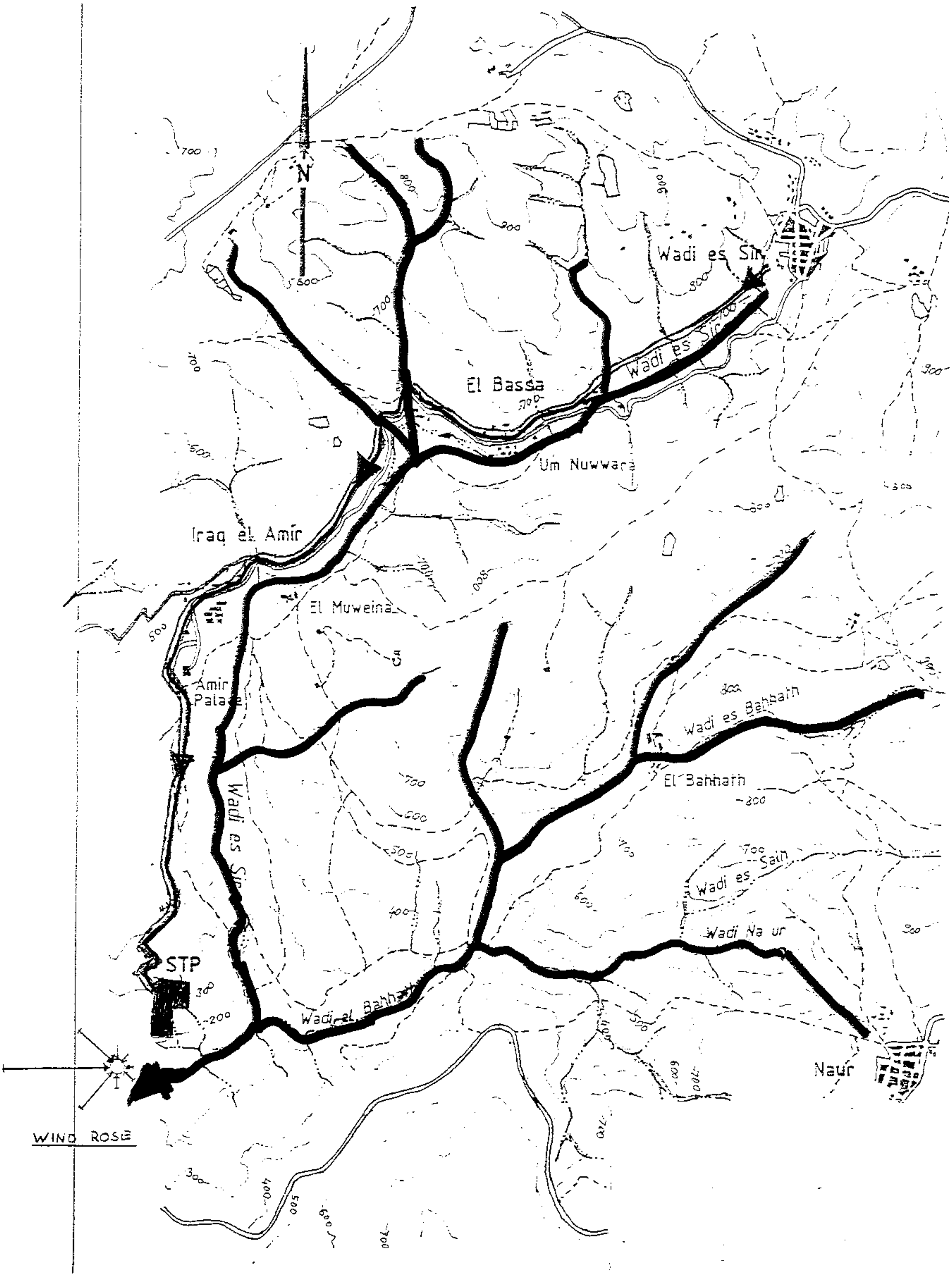

Figure 1.11.1-1 General Layout of Wadi Essir Sewerage System

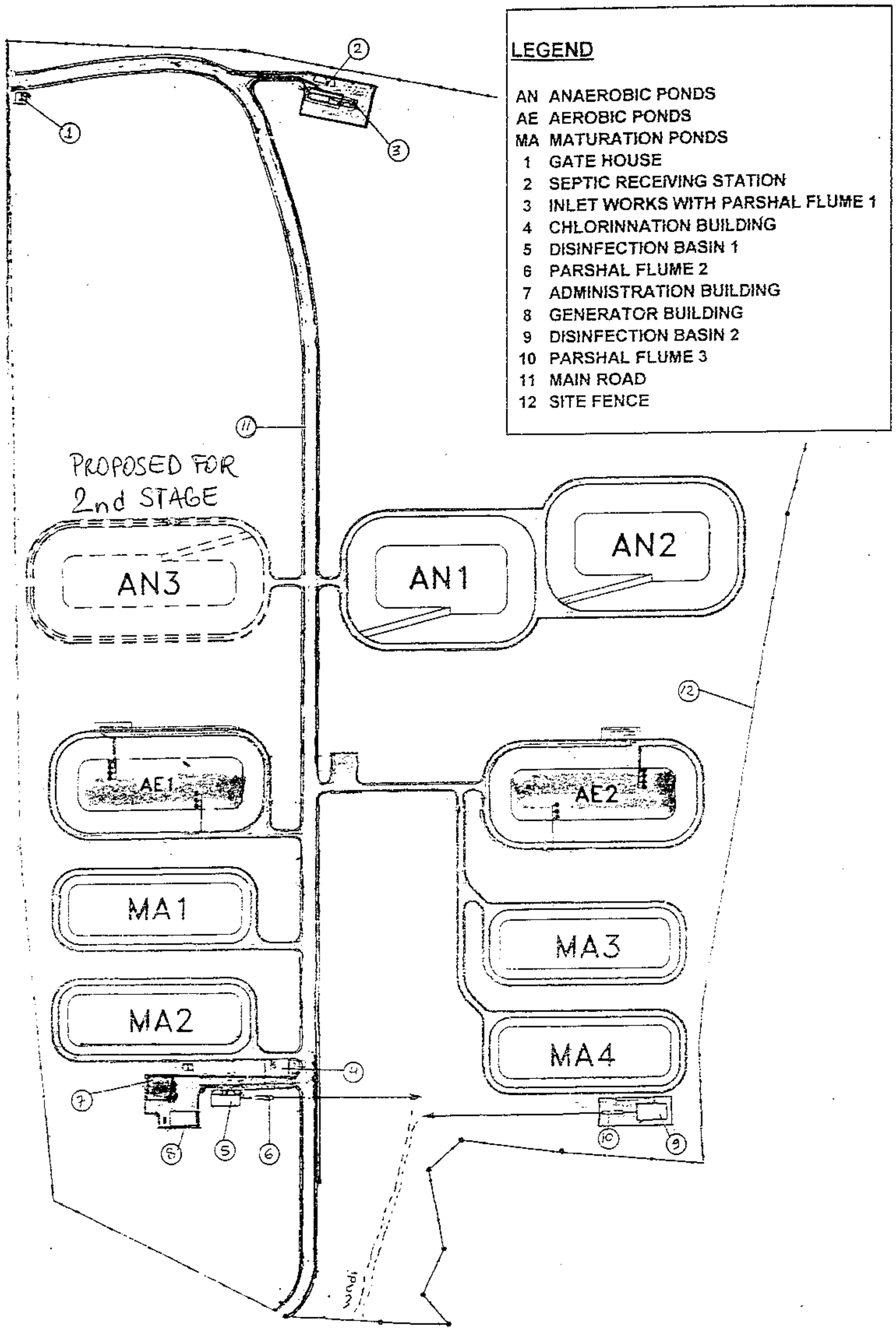

Figure 1.11.1-2 Layout of Wadi Essir Treatment Plant

The consortium of Suez Lyonnaise des Eaux - Montgomery Watson Arabtech Jardaneh operates the treatment plant of Wadi Essir. Related contract comprises wastewater collection for the Greater Amman area and operation of wastewater treatment plant Wadi Essir. The consortium has started work in 1999. The treatment plant disposes of a small laboratory for routine wastewater analysis. The efficiency of the treatment process is controlled by the central laboratory of WAJ taking samples and analyzing the effluent water of the treatment plant monthly (pH, BOD_5, COD, TSS, TDS, total coliforms, fecal coliforms) and each forth month (heavy metals).

1.11.2 Proposed Modifications Due to Geotechnical Conditions at the Treatment Site

In February 1997 a landslide occurred at Northeast of the plant at the uphill side of one of the anaerobic pond and, consequently, the affected pond was put out of operation. WAJ decided to stabilize the slope by construction of several series of gabions. However, the slide could not be stopped by these measures. The National Committee for Dams has inspected the site in June 1999 to prepare a technical report.

More land sliding is expected in future. Meanwhile it was decided to implement special modifications at the Wadi Essir Treatment Plant to cope with the new situation and alleviate the consequences of such further landslides.

The Consultants Mott-MacDonald (in association with CEC) proposed in accordance with WAJ some modifications to be carried out to the existing Wadi Essir treatment plant. The first modification includes collection and diversion of the treated effluent throughout a pipeline downstream beyond Kafrein Reservoir to prevent pollution of the water springs located along the wadi (see Figure 1.11.2-2). The second modification includes possible diversion of raw wastewater of the main trunk sewer, feeding Wadi Essir Plant, in order to divert the raw sewage collected from the town of Wadi Essir to the proposed new Naur Wastewater Treatment Plant for common treatment in case of land sliding or any other failure of the existing Wadi Essir Plant. Figure 1.11.2-1 shows schematically the proposed modified system for the year 2020, while Figure 1.11.2-2 gives an overview on the planned systems according to the Consultants Mott-MacDonald.

1.11.3 Reuse Scheme Proposed by the Consultants Mott-MacDonald

The reuse site proposed by the Consultants Mott-MacDonald is located upstream of Kafrein Reservoir west of the planned Naur Wastewater Treatment Plant. The elevation of the site ranges from 85 m to 105 below sea level. Figure 1.11.3-1 presents the location of the five proposed effluent reuse sites. The area of the available land is slightly in excess of 80 donums. The site is a moderately sloping plane, with an average gradient of 5 percent. It is dissected by two gullies – roughly at right angels to each other. The main gully runs from east to west, along the southern limits of the reuse area, into the Kafrein Reservoir. The terrain is suitable for a wide range of climatically adapted crops. However, if the cropped area is to be extended into the surrounding hills, only certain tree crops will be suitable.

The surplus effluent flows downstream passed the Kafrein Reservoir to offer e.g. the banana grower (were some 2,000 donums for this crop exist) a chance to use it in total or part of it – in the supplemental irrigation of their banana crop.

Capital cost for the modification of the Wadi Essir diversion sewers were estimated as 597,380 JD, while the effluent reuse system (irrigation network) was estimated as 12,200 JD (all costs of 2000 excluding cost for contingencies and supervision).

1.11.4 Final Conclusion for the Reuse System of Wadi Essir

The new proposal made by the Consultants Mott-MacDonald for a common reuse of treated effluent of both Wastewater Treatment Plants of Wadi Essir and Naur seems a logical and practical concept to reduce capital and operation costs. In addition it includes a sound solution for the case, if future landslides will exclude the operation of the Wadi Essir Treatment Plant. Available final design and cost estimates of the project "Wastewater collection, treatment and reuse systems for the Municipality of Naur and the adjacent areas" comprise all construction measures to implement the plans as presented. Due to the fact that the reuse facilities are only a minor part of the Naur Project and a separate implementation under two separate contract would lead to enormous difficulties of coordination, it is recommended to keep the reuse facilities of Wadi Essir as part of the Naur Project.

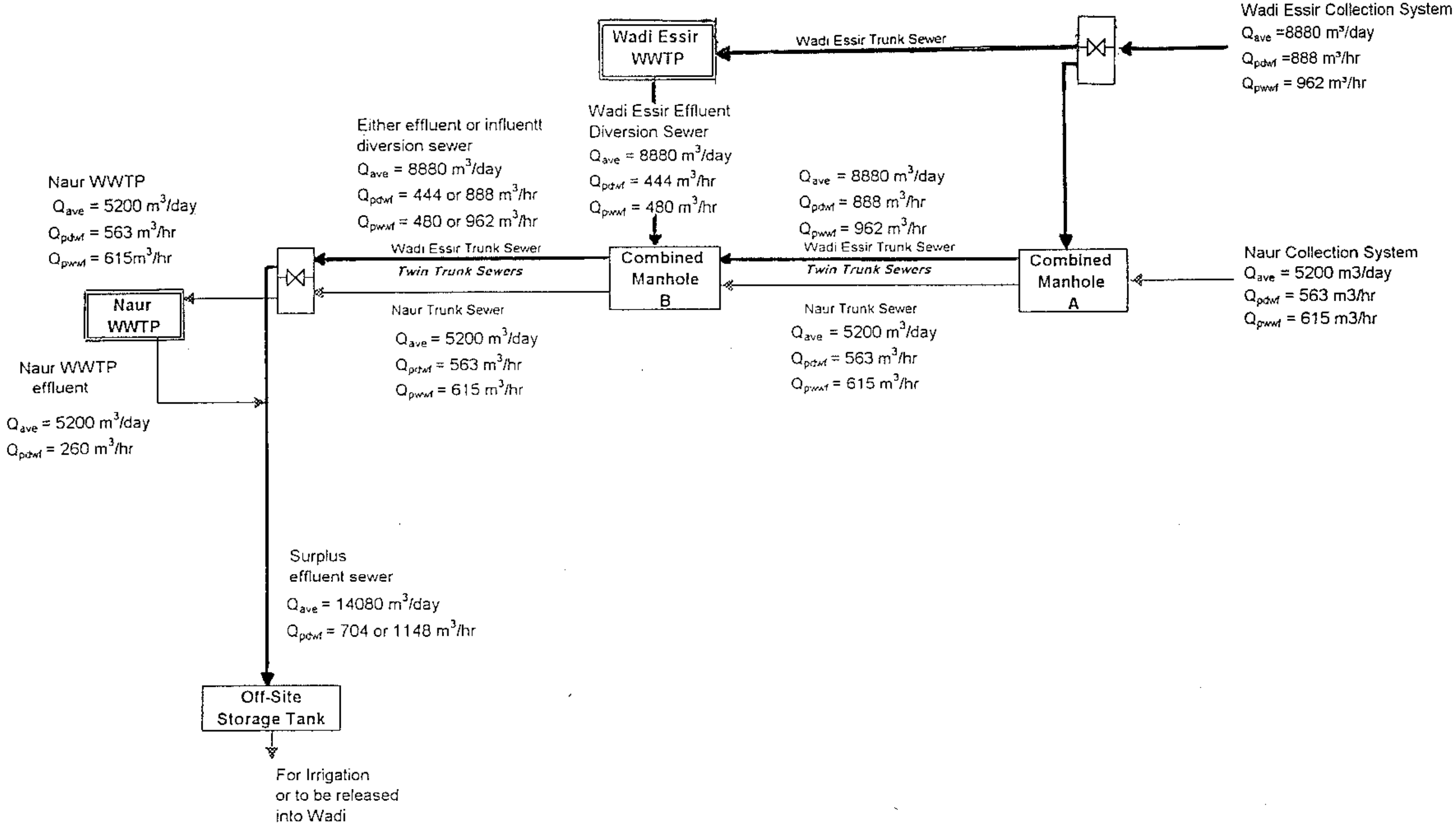

Figure 1.11.2-1 Proposed Combined Scheme of Wadi Essir and Naur Treatment Plant (in 2020)

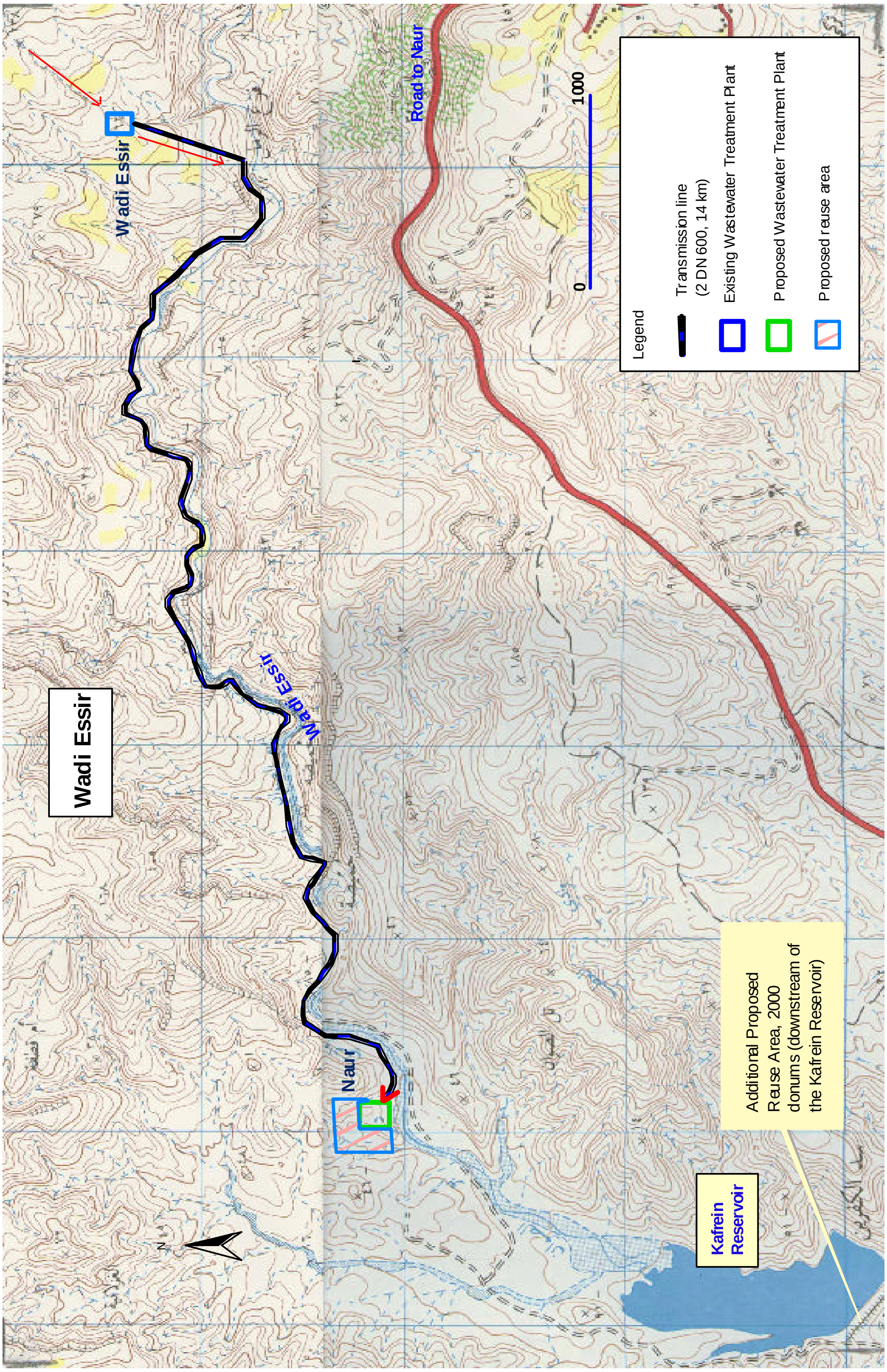

Figure 1.11.2-2 Location of Wadi Essir and Naur Wastewater Treatment Plants and Proposed Sites for Combined Effluent Reuse

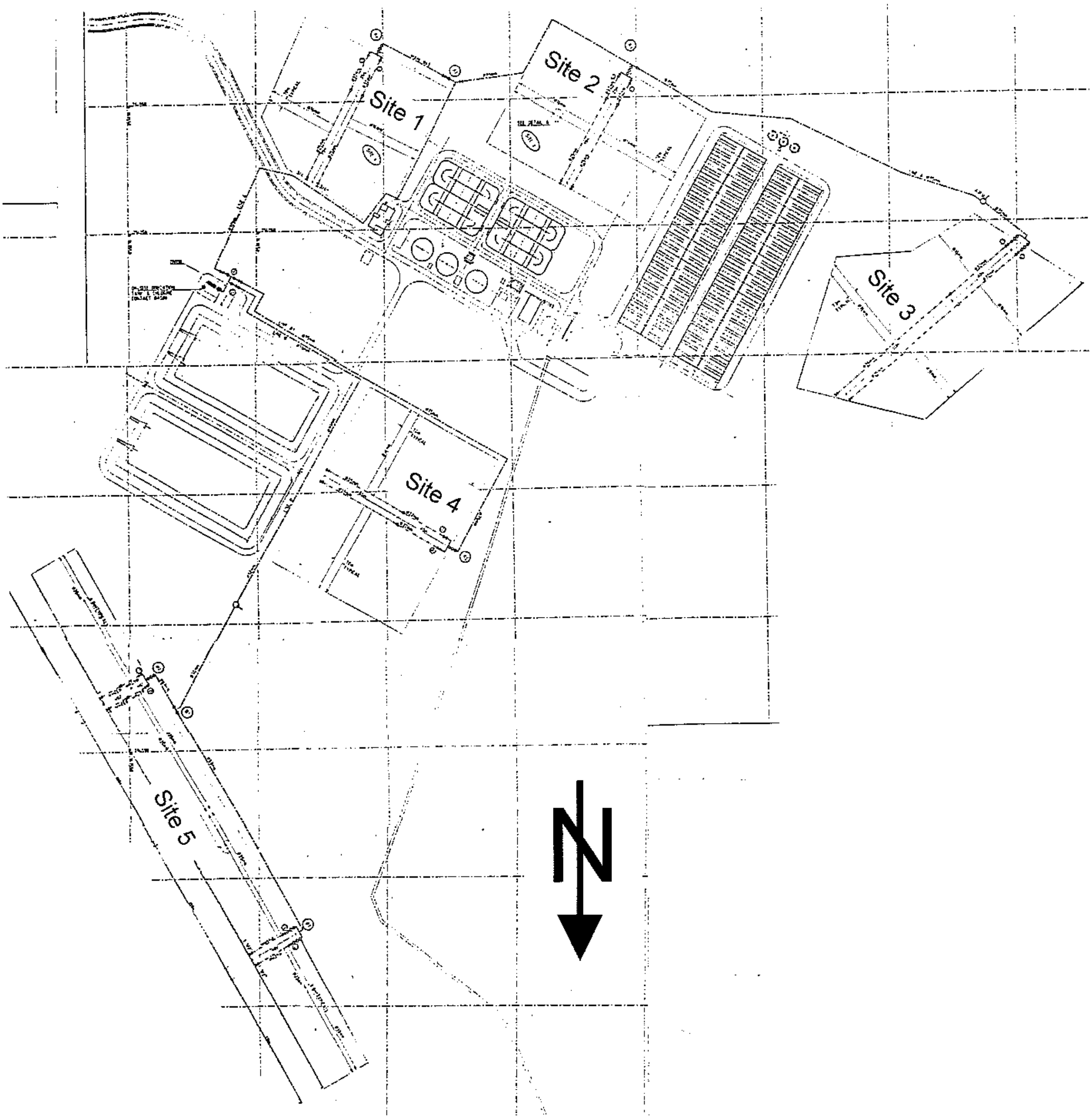

Figure 1.11.3-1 Location of the Effluent Reuse Sites (Wadi Essir and Naur)

1.12 Preliminary Cost Estimates

1.12.1 Basic Assumptions and Unit Costs

The adopted unit construction costs are established based on the following information and documents:

- Several previous Study Reports of MOWI
- Latest price list of the Ministry of Public Works and Housing, version 1999 (The Government Tenders Directorate Annual Report
- Quotation and consultation with local contractors and manufacturers
- Experience of the Consultant

Unit prices include all the costs for construction works including belongings and all indirect prices except owner’s engineering cost and contingencies. The prices given in the previous study reports of MOWI mentioned above are converted to year 2001 prices considering the annual escalation ratio of 3 % per annum.

(1) Land Acquisition

Additional land is needed for the sewage treatment plant, however, WAJ possesses already the land required for the new ponds as far as the WWTP of Ma’an is concerned.

In addition land has to be acquired for the transmission mains between the treatment plants and the reuse areas as well as for the proposed reservoir for effluent storage. It was estimated that a 2 m large strip along the main would be enough. According to information got from various sources actual land unit price is estimated to 30,000 JD per ha.

(2) Sewerage System and Reuse Facilities

Table 1.12.1-1 summarizes unit prices for the estimates of investment cost for sewerage and reuse facilities. Both tables are based on prices of the year 2001.

Unit construction cost for pump stations is given in JD per m^3/h of installed capacity as cost curves (see Table 1.12.1-1). Unit prices decrease with increasing total capacity of pumping station. Investment cost for pumping facilities was calculated accordingly, whereby the portion of cost for each - electromechanical equipment and civil works - was estimated to 45 and 55 % of the total price.

For the sewerage network as well as for the transmission pipes of treated effluent from the treatment plants to potential reuse areas concrete or reinforced concrete pipes in case of gravity flow were proposed and ductile iron pipes in case of pressure mains. Reinforced concrete are selected for diameters DN 300 mm and bigger, while concrete will be used for diameters 250 mm and lower.

In general the reservoirs of treated effluent shall have a volume of about two days effluent quantity of the treatment plant. However, such an additional storage reservoir was not proposed in cases, where the treatment plant comprises maturation ponds and the treated effluent is discharged by gravity to the irrigation areas. It is assumed that the maturation ponds provide sufficient storage volume (e.g. Fuhis) in these cases.

HDPE lined reservoirs are adopted as they satisfy the required function and have an enormous economical advantage. This type of reservoir is applied already in many irrigation systems of Jordan. It is assumed that the water depth will be about 3.5 m with an additional freeboard of 0.5 m. The irrigation areas will be supplied by gravity flow from the reservoirs.

Base construction costs are calculated applying unit prices as outlined in Table 1.12.1-1 and preliminary estimated quantities of works.

Table 1.12.1-1 Unit Prices for Sewerage and Reuse Facilities

Component	Unit	Unit cost (JD/unit)
Pump station		
Portion civil works (H<40m)	55%	
Portion electromechan.equipment (H<40m)	45%	
Capacity 50 m^3/h	JD/(m^3/h)	8.5H+500
Capacity 200 m^3/h	JD/(m^3/h)	10.5H+600
Transmission main in ductile iron (DI)		
DN 100	m	48
DN 150	m	61
DN 200	m	75
DN 250	m	88
DN 300	m	102
DN 350	m	123
DN 400	m	151
DN 500	m	199
DN 600	m	276
Transmission main in concrete		
DN 150	m	41
DN 200	m	50
DN 250	m	
Transmission main in reinforced concrete		
DN 300	m	69
DN 350	m	83
DN 400	m	90
DN 500	m	108
DN 600	m	141
DN 700	m	166
DN 800	M	191
DN 900	M	221
Reservoir 3,000 m^3	1	81,000
Reservoir 4,000 m^3	1	103,000
Reservoir 5,000 m^3	1	126,000
Reservoir 7,000 m^3	1	171,000
Reservoir 8,000 m^3	1	193,000

(3) Treatment Plant

Screens

Screen including by-pass is estimated to 8,000 JD per unit for a discharge of about 40 l/s. This price comprises 4,000 JD for electromechanical equipment and 4,000 JD for civil works.

Ponds

The investment cost of the ponds were estimated on the basis of the surface. Unit prices are as follows:

Component	Price in JD per ha
Anaerobic ponds	87,000
Facultative ponds	67,000
Maturation ponds	73,000

All unit prices include earthworks, construction of surrounding dike and connection works between the various basins.

Drying beds

Unit price for the construction of on m^2 of the drying beds is estimated to 20 JD.

Additional works

Costs for additional works are estimate as 10 % of the total investment cost of the treatment plant. These works comprise

- operation building,
- internal roads of the plant area,
- connection of water, electricity, telephone,
- fencing,
- etc.

(4) Additional Costs

As additional costs the following items were taken into account

- Indirect costs:
  - Administration cost
  - Engineering cost
- Physical contingencies

Administration cost were assumed as 5 % of the base investment cost. Engineering costs include the cost for the engineering services such as surveys, planning, designs, site supervision etc.. The amount of these services is estimated as 10 % of the base construction cost according to the experience of the consultant.

Physical contingencies are taken into account for unpredictable variation in construction conditions and other unforeseen difficulties that may increase the final construction cost. The amount of these contingencies is estimated as 10 % of the base construction including indirect cost.

1.12.2 Capital Costs

Base construction cost of infrastructure are calculated applying unit prices as outlined in section 1.12.1.1 and preliminary estimated quantities of works.

1.12.2.1 Investment Cost for Sewerage System and Treatment Plant (Ma'an)

Investment cost for the sewerage system up to 2015 was estimated on the basis of the increase of connected population between 2001 and 2015. At present (in 2001) the number of persons connected to the sewerage system is about 21,000. This number will increase until 2015 to about 39,400. Taking into account a unit price of 50 JD per meter for the sewer pipes (for DN 200) gives an investment cost of 1,840,000 JD.

Net investment costs of the treatment plant are shown in Table 1.12.2-1. Total investment costs of the sewerage system and the treatment plant of Ma'an are shown in Table 1.12.2-2.

Table 1.12.2-1 Cost of Treatment Plant of Ma'an

(Price basis: JD 2001)

COMPONENT	UNIT	QUANTITY	Civil Works JD	Equipment JD	Total JD	Percentage of total cost
TREATMENT PLANT						
Screening facilities	U	1	4,000	4,000	8,000	1.2%
Anaerobic basins	ha	0.37	32,231		32,231	4.8%
Facultative basins	ha	6.05	405,169		405,169	60.4%
Maturation basins	ha	0.73	53,499		53,499	8.0%
Drying beds	m²	5,250	99,750	5,250	105,000	15.6%
SUB-TOTAL TREATMENT PLANT	-		594,649	9,250	603,899	90.0%
Additional works (10 %)	-		66,072	1,028	67,100	10.0%
TOTAL COST TREATMENT PLANT			**660,721**	**10,278**	**670,999**	100.0%

Phase I (Planning Horizon 2015)

Table 1.12.2-2 Total Cost of Sewerage System and the Treatment Plant of Ma'an

(Price basis: JD 2001)

Component	UNIT	QUANTITY	FOREIGN AMOUNT	LOCAL AMOUNT	TOTAL AMOUNT	PERC.OF TOTAL
SEWERAGE NETWORK						
Civil works						
Extension of existing sewerage system (2001-2015)	lump sum	1	184.000	1.656.000	1.840.000	73,3%
SUB-TOTAL CIVIL WORKS			184.000	1.656.000	1.840.000	73,3%
Equipment E&M						
Pumping stations	l. sum	0	0	0	0	0,0%
Cars, machines	l. sum	0	0	0	0	0,0%
SUB-TOTAL EQUIPMENT NETWORK			0	0	0	0,0%
WASTEWATER TREATM. PLANT						
Civil works	l.sum	1	66,072	594,649	660,721	26.3%
Equipment E&M	l.sum	1	9,250	1,028	10,278	0.4%
Land acquisition (WAJ possesses requir.land already)	ha	0.0	0	0	0	0,0%
SUB-TOTAL WASTEWATER TREATMENT PLANT (WWTP)			75,322	595,677	670,999	26.7%
SUB-TOTAL (Sewerage and WWTP)			**259,322**	**2,251,677**	**2,510,.999**	
PART Civil Works			250,072	2,250,649	2,500,721	99.6%
PART Equipment E&M			9,250	1,028	10,278	0.4%
SUB-TOTAL (BASE COST FOR INFRASTRUCTURE)			**259,322**	**2,251,677**	**2,510,999**	**100.0%**
Administration costs (5 % of net investment cost)		5	0	125,550	125,550	5.0%
Engineering costs (10 % of net investment cost)		10	200,880	50,220	251,100	10.0%
SUB-TOTAL (INDIRECT COST)			200,880	175,770	376,650	15.0%
Physical contingencies (10 % of base cost for infrastructure and indirect cost)		10	46,020	242,745	288,765	11.5%
TOTAL			**506,222**	**2,670,191**	**3,176,413**	126.5%

Phase I (Planning Horizon 2015)

1.12.2.2 Investment Cost for Reuse Systems

Investment cost are presented in detail in Annex 1.12.3.2 for each of the reuse system. Table 1.12.2-3 summarizes cost estimates and, in addition, shows the specific investment cost of the reuse schemes. Specific costs for investment of proposed reuse systems differ considerably depending on the manner of effluent transfer to the irrigation areas, whether this is a gravity system or a pumped one (Ma'an), and on the length of the transmission main (Tafielah).

Table 1.12.2-3 Investment Cost for Reuse Systems

	Base cost for infrastructure JD	Indirect Cost JD	Physical conting. JD	Investment Cost JD	Specific investment JD/1,000m³
Abu Nuseir	179,500	26,925	20,643	227,068	214
Fuhis	112,000	16,800	12,880	141,680	190
Ma'an	295,200	44,280	33,948	373,428	429
Tafielah	343,300	51,495	39,480	434,275	826
Total	930,000	139,500	106,950	1,176,450	

1.12.3 Operation and Maintenance Costs

1.12.3.1 Operation and Maintenance Cost for Sewerage System and Treatment Plant (Ma'an)

(1) Staff Cost

Estimates of personnel costs are based on current salaries paid by WAJ including allowances, contributions to pension fund etc.. Staff requirements and the costs in each category are shown in the following table.

Position	Required staff Treatment plant No.		Required staff Sewerage system No.		Annual Cost JD/pers/a
	2005	2015	2005	2015	
Chief Engineer	1	1	0	0	6,000
Engineer of system	0	0	0	0	
Chief of crew	1	1	0	0	3,500
Technician laboratory	0	0	0	0	
Skilled worker	2	3	1	2	3,000
Driver	0	0	1	1	2,500
Unskilled worker Guard	2	3	2	2	2,000
Technician (pumping)	2	2	0	0	1,000
	0	0	0	0	

Additional cost for administration staff was estimated to 30 % of the technical staff cost. Details of staff cost estimation are given in Annex 1.12.3.1.

(2) Maintenance Cost

Operation and maintenance requirements are calculated as a percentage of the investment costs. This item includes the equipment (including all materials and small tools) required but does not include personnel cost, which is considered separately (see previous paragraph). The following percentages of the capital cost were considered for the annual maintenance cost:

0.5 % p.a.	for civil works
2.0 % p.a.	for mechanical and electrical equipment
0.5 % p.a.	for sewerage network
5.0 % p.a.	for rolling stock (cars, trucks etc.)

These percentages are based on experience and are widely accepted as representative of typical conditions. Details of maintenance cost estimation are given in Annex 1.12.3.1.

(3) Power Cost

Electrical energy is consumed in sewage pumping and water treatment e.g. sludge pumping in case of desludging, lighting, work shop etc.. Total electric power requirements is estimated to 140 (in 2005) and 180 kWh/d (in 2015). According to WAJ the average compound rate per kWh is equivalent to 0.023 JD.

Annual maintenance cost estimation is shown in Annex 1.12.3.1.

(4) Cost for Consumables

These costs comprise particularly following types of consumables

- fuel/diesel for the rolling stock
- lubricants required for the rolling stock and other equipment

The consumption of fuel (0.3 JD/l) is estimated as follows:

- 2005: 30 l/d
- 2015: 40 l/d

Working days per year is assumed to 200 d/a. Cost for lubricants is estimated as 10 % of the cost for fuel and diesel. Annual cost for consumables is shown in Annex 1.12.3.1.

(5) Total Operation Cost for Sewage Collection and Treatment of Ma'an

Operation costs are calculated on the basis of the criteria and assumptions as explained in the previous paragraphs. Total operation cost for sewerage system and treatment plant are presented in Table 1.12.3-1.

Table 1.12.3-1 Total Operation Cost for Sewage Collection and Treatment of Ma'an

Component	Unit	Costs 2005	Costs 2015
Staff cost	JD/a	42,900	53,300
Maintenance cost	JD/a	25,298	29,898
Cost for consumables	JD/a	2,000	2,700
Energy cost	JD/a	1,175	1,511
Desludging of ponds	JD/a	5,596	7,875
Total cost:	**JD/a**	**76,970**	**95,284**

1.12.3.2 Operation and Maintenance Cost for Reuse System

(1) Staff Cost

The effluent quantities of Abu Nuseir, Fuhis, Ma'an and Tafielah reused for agricultural irrigation are all less than 3,000 m³/d. Therefore, in general one employee per system seems enough. However, an additional technician was foreseen for the pumping station for effluent in Ma'an. Annual costs are estimated to be 3,500 JD/a including all additional cost for administration.

(2) Maintenance Cost

Operation and maintenance requirements are calculated as a percentage of the investment costs (see paragraph 1.12.3.1.2). The following percentages of the capital cost were considered for the annual maintenance cost:

0.5 % p.a. for civil works
2.0 % p.a. for mechanical and electrical equipment
0.5 % p.a. for transmission mains including distribution network (if any)

Details of maintenance cost estimation are given in Annex 1.12.3.2.

(3) Power Cost

Electrical energy is consumed for pumping of treated effluent to the reuse areas, if required. Power consumption is calculated by:

$$E = \frac{gamma * Q_a * H_{av}}{k * eta_{glob}} = \frac{Q_a * H_{av}}{eta_{glob}} \mathbf{x}\ 2.725*10^{-3}\ [kWh/a]$$

where:	H_{av}	= pumping head at average flow	[m]
	Q_a	= annual discharge	[m³/a]
	eta_{glob}	= global efficiency factor	[-]
	gamma	= gravity acceleration	[9.81 N/m³]

k = conversion factor [3,600 Nm/Wh]

Global efficiency factor is assumed as 70 %. Present average compound rate per kWh for agricultural sector is 0.023 JD.

(4) Total Operation Cost for Reuse Systems
Annual maintenance cost estimation is shown in Annex 1.12.3.2 and summarized in Table 1.12.3-2.

Table 1.12.3-2 Total Operation Cost for Reuse Systems (2010)

	Maintenance cost JD/a	Staff cost JD/a	Energy cost JD/a	Operation cost JD/a	Specific operat. cost JD/m³
Abu Nuseir	826	3,500	0	4,326	0.0041
Fuhis	500	3,500	0	4,000	0.0054
Ma'an	2,138	7,000	781	9,918	0.0114
Tafielah	1,580	3,500	0	5,080	0.0097
Total	5,043	17,500	781	23,324	

1.13 Consideration for Economic and Financial Analysis

1.13.1 Socio-Economic Conditions

(1) Ma’an

1) Population

<u>Population and its Growth in the Past</u>

Item	1979 Census	1994 Census	Inter-Censual Growth Rate/a
Jordan	2,149,177	4,139,458	4.5%
Ma’an Governorate	39,433	79,670	4.8%
Ma’an City	11,284	22,989	4.9%

Source: Department of Statistics

The 1994 population of Ma’an City was 22,989. It accounted for 29% of the governorate population. It grew during the inter-censual 15 years 1979 to 1994 at the average annual rate of 4.9%, which was slightly higher than the governorate average, and also considerably higher than the national average as shown in the above table.

2) Agriculture

<u>Agricultural Area</u>

(Unit: Cropped Area in Dunum)

Item	Vegetables	Field Crops	Tree Crops	Total
Jordan	284,030 (11%)	1,580,443 (59%)	794,138 (30%)	2,658,611 (100%)
Ma'an Governorate	22,245 (12%)	142,039 (74%)	27,479 (14%)	191,763 (100%)
Ma'an District	21,731 (16%)	101,266 (74%)	13,342 (10%)	136,339 (100%)

Source: General Results of the Agricultural Census 1997, Department of Statistics

(Unit: Cropped Area in Dunum/1,000 Population)

Item	1997
Jordan	642
Ma'an Governorate	2,407
Ma'an District	2,628

One characteristic of the agriculture in the Ma'an District is that the cropped area per 1,000 population is 2,628 dunum, which is by 9% greater than the governorate average, and more than 5 times greater than the national average. It means that the district is a predominantly agricultural one. Another characteristic is that the share of the field crops is 74%, which is markedly greater than the Jordanian average of 59%. It shows that the rain-fed agriculture is widely practiced in the district.

(2) Abu Nuseir

1) Population

<u>Population and its Growth in the Past</u>

Item	1979 Census	1994 Census	Inter-Censual Growth Rate/a
Jordan	2,149,177	4,139,458	4.5%
Amman Governorate	795,675	1,576,238	4.7%
Abu Nuseir	-	18,879	-

Source: Department of Statistics

The 1994 population of Abu Nuseir was 18,879. The town, which belongs to the Amman Governorate is a new town created through the 1st phase construction of a housing complex. The population is currently estimated at around 30,000, and it is expected to double after the completion of the upcoming 2nd phase construction.

During the inter-censual 15 years 1979 to 1994, the governorate population grew at the average annual rate of 4.7%, which was a little higher than the national growth rate of 4.5%.

2) Agriculture

Agricultural Area

(Unit: Cropped Area in Dunum)

Item	Vegetables	Field Crops	Tree Crops	Total
Jordan	284,030 (11%)	1,580,443 (59%)	794,138 (30%)	2,658,611 (100%)
Amman Governorate	19,560 (4%)	355,224 (78%)	82,861 (18%)	457,645 (100%)

Source: General Results of the Agricultural Census 1997, Department of Statistics

(Unit: Cropped Area in Dunum/1,000 Population)

Item	1997
Jordan	642
Amman Governorate	290

The characteristics of the agriculture in the Amman Governorate to which Abu Nuseir belongs are that the cropped area per 1,000 population is around 300 dunum, which is less than a half of the national average, and that the share of the field crops area is around 80%, which is greater than the Jordanian average of about 60%. All of this means that the agriculture of the governorate is less active than the rest of the kingdom.

(3) Fuhis

1) Population

Population and its Growth in the Past

Item	1979 Census	1994 Census	Inter-Censual Growth Rate/a
Jordan	2,149,177	4,139,458	4.5%
Balqa Governorate	151,544	276,082	4.1%
Fuhis	5,425	10,098	4.2%

Source: Department of Statistics

The 1994 population of Fuhis was 10,098. It grew during the inter-censual 15 years 1979 to 1994 at the average annual rate of 4.2%, which was slightly higher than the governorate average, but a little lower than the national average as shown in the above table.

2) Agriculture

Agricultural Area

(Unit: Cropped Area in Dunum)

Item	Vegetables	Field Crops	Tree Crops	Total
Jordan	284,030 (11%)	1,580,443 (59%)	794,138 (30%)	2,658,611 (100%)
Balqa Governorate	80,472 (37%)	59,278 (27%)	79,258 (36%)	219,008 (100%)

Source: General Results of the Agricultural Census 1997, Department of Statistics

(Unit: Cropped Area in Dunum/1,000 Population)

Item	1997
Jordan	642
Balqa Governorate	793

The characteristics of the agriculture in the Balqa Governorate to which Fuhis belongs are that the cropped area per 1,000 population is 793 dunum, which is by 24% greater than the national average of 642 dunum, and that the combined share of the vegetables and tree crops area reaches 73% compared with the Jordanian average of 41%. All of this means that the agriculture of the governorate is much more active than the rest of the kingdom.

(4) Tafielah

1) Population

Population and its Growth in the Past

Item	1979 Census	1994 Census	Inter-Censual Growth Rate/a
Jordan	2,149,177	4,139,458	4.5%
Tafielah Governorate	35,545	62,783	3.9%
Tafielah City	12,493	20,881	3.5%

Source: Department of Statistics

The 1994 population of Tafielah City was 20,881. It accounted for 33% of the governorate population. It grew during the inter-censual 15 years 1979 to 1994 at the average annual rate of 3.5%, which was considerably lower than the governorate average of 3.9%, and also markedly lower than the national average of 4.5% as shown in the above table.

2) Agriculture

Agricultural Area

(Unit: Cropped Area in Dunum)

Item	Vegetables	Field Crops	Tree Crops	Total
Jordan	284,030 (11%)	1,580,443 (59%)	794,138 (30%)	2,658,611 (100%)
Tafielah Governorate	1,375 (2%)	49,376 (73%)	16,913 (25%)	67,664 (100%)

Source: General Results of the Agricultural Census 1997, Department of Statistics

(Unit: Cropped Area in Dunum/1,000 Population)

Item	1997
Jordan	642
Tafielah Governorate	1,078

One characteristic of the agriculture in the Tafielah Governorate is that the cropped area per 1,000 population is 1,078 dunum, which is by 68% greater than the national average. It means that the district is an agricultural one. Another characteristic is that the share of the field crops is 73%, which is markedly greater than the Jordanian average of 59%. It shows that the rain-fed agriculture is mainly practiced in the district.

1.13.2 Economic and Financial Analysis

(1) Methodology

Economic and financial analysis was performed for the wastewater reuse projects at the four wastewater treatment stations, namely Ma'an, Abu Nuseir, Fuhis and Tafielah as well as for the wastewater treatment capacity expansion project at the Ma'an station.

The analysis was done separately for each project, and at the same time for a compound project combining the 4 wastewater reuse projects together.

The following description fits into each of the above-mentioned 5 single projects.

1) Financial Analysis

(a) Preparation of cost benefits streams

a) Project life for financial analysis was set at 30 years.

b) Preparation of cost streams
The estimated initial cost of the project was spread over the implementation period. Also, the annual recurrent cost for the operation and maintenance (O & M) of the facilities was entered annually after the implementation up to the end of the project life.

c) Preparation of effluent/influent stream
(Treated Wastewater Reuse Project)
The quantity of effluent to be transported from the wastewater treatment plant to the irrigation site was annually entered after the implementation of the project up to the end of the project life.
Then, the estimated administrative loss of water was annually subtracted from the quantity of water to be transported. This way, the quantity of water to be transported and billed was annually determined up to the end of the project life.
(Wastewater Treatment Project)
The quantity of influent to be transported from the users to the wastewater treatment plant was annually entered after the implementation of the project up to the end of the project life.
Then, the estimated administrative loss of water was annually subtracted from the quantity of water to be transported. This way, the quantity of water to be transported and billed was annually determined up to the end of the project life.

d) Estimation of the unit value of effluent/influent
(Treated Wastewater Reuse Project)
The financial value of the unit quantity of effluent was estimated based on the existing treated wastewater tariff and the future needs for raising it.
(Wastewater Treatment Project)

The financial value of the unit quantity of influent was estimated based on the existing sewerage tariff and the future needs for raising it.

e) Preparation of benefits stream
From items c) and d) the benefits stream was worked out up to the end of the project life.

(b) Calculation of Financial Criteria and Financial Evaluation

a) The discount rate was assumed as 5%.
b) Using the cost benefits streams, FIRR, NPV and the unit wastewater price were calculated.
c) Based on the values of financial criteria, taking into consideration qualitative factors as well, the judgment on the financial feasibility of the project was passed.

2) Economic Analysis

(a) Preparation of cost benefits streams

a) Project life
(Same as in financial analysis)

b) Preparation of cost streams
The estimated initial cost was divided into foreign and local components. The standard conversion factor was applied to the local components, except land acquisition cost, which was annualized based on land rent. The initial cost of the project was spread over the implementation period. Also, the annual recurrent cost for the operation and maintenance (O & M) of the facilities was entered annually after the implementation up to the end of the project life.

c) Preparation of effluent/influent stream
(Treated Wastewater Reuse Project)
The quantity of effluent to be transported from the wastewater treatment plant to the irrigation site was annually entered after the implementation of the project up to the end of the project life.
(Wastewater Treatment Project)
The quantity of influent to be transported from the users to the wastewater treatment plant was annually entered after the implementation of the project up to the end of the project life.

d) Estimation of unit value of effluent/influent
(Treated Wastewater Reuse Project)
The annual profit to the farmers per unit area for each of the crops proposed to be grown on the farmland to be irrigated by the effluent was estimated based on the farm budget. Then, the total irrigated farmland area and the share of the area for each crop were determined. This way, the annual profit expected from the irrigation was calculated. Finally, it was divided by the estimated annual quantity of the effluent.
(Wastewater Treatment Project)
The economic value of the unit quantity of wastewater to be transported by the sewerage was estimated based on the affordability of a household

to pay for the sewerage service and the wastewater discharge per household.

e) Preparation of benefits stream
From items c) and d) the benefits stream was worked out up to the end of the project life.

(b) Calculation of Economic Criteria and Economic Evaluation
a) The opportunity cost of capital was assumed as 10%.
b) Using the cost benefit streams, EIRR, NPV and the wastewater price were calculated.
c) Based on the values of economic criteria, taking into consideration qualitative factors as well, the judgment on the economic feasibility of the project was passed.

(2) Common Preconditions

Section Nos. 1) and 2) are applied commonly to all the wastewater reuse projects, and section Nos. 3) to 5) are applicable to both wastewater reuse projects and the Ma'an wastewater treatment plant extension project.

1) Wastewater Tariff (Unit: Fils/m^3)

2003	2004	2005	2006	2007	2008	2009	2010
10	13	16	20	24	31	38	48

Starting in 2004, the average wastewater tariff per m^3 was assumed to be increased at the annual rate of 25% up to 2010.

2) Farm Budget for Proposed Crops

Table 1.13.2-1 Farm Budget for Proposed Crops

1. Barley

Item	Unit	Value
Productivity	kg/du	300
Farm gate price	JD/kg	0.180
Return	JD/du	54.0
Plowing	JD/du	4.0
Seeds & seedlings	JD/du	2.5
Organic fertilizers	JD/du	0.0
Chemical fertilizers	JD/du	0.0
Pesticides	JD/du	0.0
Water	JD/du	4.0
Labor	JD/du	3.0
Fuel	JD/du	1.0
Transportation	JD/du	1.0
Interest	JD/du	1.0
Others	JD/du	1.0
Variable cost total	JD/du	17.5
Gross margin	JD/du	36.5

2. Wheat

Item	Unit	Value
Productivity	kg/du	350
Farm gate price	JD/kg	0.200
Return	JD/du	70.0
Plowing	JD/du	4.0
Seeds & seedlings	JD/du	3.0
Organic fertilizers	JD/du	0.0
Chemical fertilizers	JD/du	0.0
Pesticides	JD/du	0.0
Water	JD/du	5.0
Labor	JD/du	3.0
Fuel	JD/du	1.0
Transportation	JD/du	1.0
Interest	JD/du	1.0
Others	JD/du	1.0
Variable cost total	JD/du	19.0
Gross margin	JD/du	51.0

3. Olive

Item	Unit	Value
Productivity	kg/du	4,000
Farm gate price	JD/kg	0.050
Return	JD/du	200.0
Plowing	JD/du	6.0
Seeds & seedlings	JD/du	0.0
Organic fertilizers	JD/du	6.0
Chemical fertilizers	JD/du	4.0
Pesticides	JD/du	4.0
Water	JD/du	5.0
Labor	JD/du	7.0
Fuel	JD/du	2.0
Transportation	JD/du	2.0
Interest	JD/du	4.0
Others	JD/du	3.0
Variable cost total	JD/du	43.0
Gross margin	JD/du	157.0

4. Date-Palm

Item	Unit	Value
Productivity	kg/du	780
Farm gate price	JD/kg	0.300
Return	JD/du	234.0
Plowing	JD/du	15.0
Seeds & seedlings	JD/du	0.0
Organic fertilizers	JD/du	15.0
Chemical fertilizers	JD/du	10.0
Pesticides	JD/du	5.0
Water	JD/du	5.0
Labor	JD/du	9.0
Fuel	JD/du	3.0
Transportation	JD/du	4.0
Interest	JD/du	4.0
Others	JD/du	5.0
Variable cost total	JD/du	75.0
Gross margin	JD/du	159.0

5. Alfalfa

Item	Unit	Value
Productivity	kg/du	2,076
Farm gate price	JD/kg	0.035
Return	JD/du	72.65
Cost of water	JD/du	7.22
Cost of mineral fertilizers	JD/du	1.67
Cost of seeds	JD/du	10.67
Cost of hired machinery	JD/du	4.43
Cost of labor	JD/du	2.30
Variable cost total	JD/du	26.28
Gross margin	JD/du	46.37

Source: MOWI

3) Depreciation Period: 30 years

4) Standard Conversion Factor: 0.9664

5) Land Rent: 35 fils/dunum

(3) Ma’an Wastewater Reuse Project

1) Preconditions

(a) Wastewater to be Reused (Unit: m^3/year)

Year	2005	2010
Wastewater to be Reused	727,884	870,677

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
377,428	56%	207,497	44%	165,931

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006
		■			

(d) O & M Costs (Unit: JD)

Year	2005	2010
O & M Costs	9,790	9,918

(e) Use of Effluent for Crops

Municipal Water	Effluent (m^3/a)	Irrigation Area (dunum)
Wheat/Barley	147,003	150
Olive	67,938	55
Date-Palm	139,929	80
Alfalfa	505,796	400
Total	860,665	685

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
4.1%	-40,923	44

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
7.4%	-75,607	58

Note: Discount Rate=10%

4) Evaluation

This project is financially not feasible with the FIRR of 4.1%, NPV of –40,923 JD and the unit wastewater price of 44 fils per m^3. It is also economically not feasible with the EIRR of 7.4%, NPV of –75,607 JD and the unit wastewater price of 58 fils per m^3.
The project is placed 3rd and 4th in terms of financial and economic feasibility respectively out of the 4 projects concerned. However, the values of both FIRR and EIRR are not too low for a social project like this, and also both financial and economic wastewater prices are reasonably low compared with other water sources. Because of all these reasons, the project can be judged to be sufficiently worthwhile for implementation.

(4) Abu Nuseir Wastewater Reuse Project

1) Preconditions

(a) Wastewater to be Reused (Unit: m^3/year)

Year	2005	2010
Wastewater to be Reused	797,647	1,060,250

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
227,068	77%	173,883	23%	53,185

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006
		■			

(d) O & M Costs (Unit: JD)

Year	2005	2010
O & M Costs	4,326	4,326

(e) Use of Effluent for Crops

Municipal Water	Effluent (m^3/a)	Irrigation Area (dunum)
Wheat/Barley	112,227	200
Olive	194,074	200
Date-Palm	139,446	100
Alfalfa	321,768	250
Total	767,517	750

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
12.0%	273,031	21

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
19.1%	226,283	28

Note: Discount Rate=10%

4) Evaluation

This project is financially highly feasible with the FIRR of 12.0%, NPV of 273,031 JD and the unit wastewater price of 21 fils per m^3. It is also economically highly feasible with the EIRR of 19.1%, NPV of 226,283 JD and the unit wastewater price of 28 fils per m^3.
The project is placed 2nd and 1st in terms of financial and economic feasibility respectively out of the 4 projects concerned. And the financial wastewater price is very low compared with 38 fils per m^3, which is the average financial wastewater price of all the future wastewater reuse projects. Because of all these reasons, the project is judged to be in the forefront in the priority for implementation.

(5) Fuhis Wastewater Reuse Project

1) Preconditions

(a) Wastewater to be Reused (Unit: m^3/year)

Year	2005	2010
Wastewater to be Reused	565,937	744,741

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
141,680	93%	131,824	7%	9,856

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006
		■			

(d) O & M Costs (Unit: JD)

Year	2005	2010
O & M Costs	4,000	4,000

(e) Use of Effluent for Crops

Municipal Water	Effluent (m^3/a)	Irrigation Area (dunum)
Wheat/Barley	45,656	80
Olive	54,877	55
Date-Palm	111,481	80
Alfalfa	387,067	315
Total	599,081	530

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
12.6%	194,618	20

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
18.7%	120,651	26

Note: Discount Rate=10%

4) Evaluation

This project is financially highly feasible with the FIRR of 12.6%, NPV of 194,618 JD and the unit wastewater price of 20 fils per m^3. It is also economically highly feasible with the EIRR of 18.7%, NPV of 120,651 JD and the unit wastewater price of 26 fils per m^3.

The project is placed 1st and 2nd in terms of financial and economic feasibility respectively out of the 4 projects concerned. And the financial wastewater price is very low compared with 38 fils per m^3, which is the average financial wastewater price of all the future wastewater reuse projects. Because of all these reasons, the project is judged to be in the forefront in the priority for implementation.

(6) Tafielah Wastewater Reuse Project

1) Preconditions

(a) Wastewater to be Reused (Unit: m^3/year)

Year	2005	2010
Wastewater to be Reused	516,867	525,600

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
434,275	83%	358,326	17%	75,948

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006

(d) O & M Costs (Unit: JD)

Year	2005	2010
O & M Costs	5,080	5,080

(e) Use of Effluent for Crops

Municipal Water	Effluent (m^3/a)	Irrigation Area (dunum)
Wheat/Barley	13,877	20
Olive	202,675	180
Date-Palm	63,677	40
Alfalfa	213,908	350
Total	494,136	590

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
0.4%	-206,568	69

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
8.9%	-38,843	92

Note: Discount Rate=10%

4) Evaluation

This project is financially not feasible with the FIRR of 0.4%, NPV of –206,568 JD and the unit wastewater price of 69 fils per m^3. It is also economically not feasible with the EIRR of 8.9%, NPV of –38,843 JD and the unit wastewater price of 92 fils per m^3.

The project is placed 4^{th} and 3^{rd} in terms of financial and economic feasibility respectively out of the 4 projects concerned. However, the value of FIRR is positive and also the value of EIRR is at a reasonable level for a social project like this. Moreover, both financial and economic wastewater prices are reasonably low compared with other water sources. Because of all these reasons, the project can be judged to be sufficiently worthwhile for implementation.

(7) Four Wastewater Reuse Projects Combined

1) Preconditions

(a) Wastewater to be Reused (Unit: m^3/year)

Year	2005	2010
Wastewater to be Reused	2,608,371	3,201,268

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
1,176,451	74%	871,530	26%	304,920

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006

(d) O & M Costs (Unit: JD)

Year	2005	2010
O & M Costs	23,196	23,324

(e) Use of Effluent for Crops

Municipal Water	Effluent (m^3/a)	Irrigation Area (dunum)
Wheat/Barley	318,763	450
Olive	519,564	490
Date-Palm	454,533	300
Alfalfa	1,428,539	1,315
Total	2,721,399	2,555

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
6.4%	235,992	35

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
12.2%	225,284	47

Note: Discount Rate=10%

4) Evaluation

The results of financial and economic analysis of the four wastewater reuse projects combined are that they are financially feasible with the FIRR of 6.4%, NPV of 235,992 JD and the unit wastewater price of 35 fils per m^3. It is also economically feasible with the EIRR of 12.2%, NPV of 225,284 JD and the unit wastewater price of 47 fils per m^3.

The FIRR of 6.4% is better than the assumed discount rate of 5%, the EIRR of 12.2% is better than the OCC of 10%, and the financial wastewater price of 35 fils per m^3 is lower than 38 fils, which is the average financial wastewater price of all the future wastewater reuse projects.
Because of all these reasons, the four wastewater reuse projects combined are judged to be sufficiently worthwhile and suitable for implementation.

(8) Ma'an Wastewater Treatment Plant Extension Project

1) Preconditions

(a) Incremental Wastewater Inflow (Unit: m^3/year)

Year	2005	2010	2015
Incremental Wastewater Inflow	349,000	532,000	790,000

(b) Investment Costs (Unit: JD)

Investment Costs	Local Components		Foreign Components	
3,176,413	84%	2,670,191	16%	506,222

(c) Implementation Schedule

2001	2002	2003	2004	2005	2006
		(shaded)	(shaded)		

(d) O & M Costs (Unit: JD)

Year	2005	2010	2015
O & M Costs	24,000	33,000	42,000

(e) Sewerage Tariff (Unit: Fils/m^3)

2003	2004	2005	2006	2007	2008	2009	2010
147	173	205	242	285	336	397	468

Starting in 2004, the average sewerage tariff per m^3 of wastewater was assumed to be increased at the annual rate of 18% up to 2010.

(f) Unit Benefits of Sewage : 368 Fils/m^3

2) Results of Financial Analysis

FIRR	NPV (JD)	Unit Wastewater Price (Fils)
5.3%	137,948	420

Note: Discount Rate=5%

3) Results of Economic Analysis

EIRR	NPV (JD)	Unit Wastewater Price (Fils)
4.5%	-1,271,569	647

Note: Discount Rate=10%

4) Evaluation

This project is financially feasible with the FIRR of 5.3%, NPV of 137,948 JD and the unit wastewater price of 420 fils per m^3. However, it is economically not feasible with the EIRR of 4.5%, NPV of –1,271,569 JD and the unit wastewater price of 647 fils per m^3.

The project is financially feasible on conditions that the sewerage tariff be raised at the annual rate of 18% since 2004 up to 2010. As a result, the sewerage tariff will be 468 fils per m^3 in 2010. This value is beyond the assumed affordable limit of 368 fils per m^3. However, as the sewerage charge is paid together with the water charge, which is still substantially low compared with the affordability limit, the combined water and sewerage charges are calculated to be sufficiently affordable by the households. The EIRR of 4.5% is by far low measured by the OCC of 10%. However, the value can be said to be passable as a socially oriented project.

As a conclusion, the project is judged to be financially as well as economically worthwhile and suitable for implementation.

1.13.3 Preparation of Projected Financial Statements

(1) Preconditions

The projected financial statements, namely the income statement, the funds statement and the balance sheet were prepared.

In preparing projected financial statements, the following preconditions were set:

Item	Values, etc.
Financing resources	80% : External; 20%: Local
Financing terms	Repayment period: 30 years
	Grace period: 5 years
	Annual interest rate: 4%
Inflation rate	2%/a
Executing Entity	Public
Corporate Tax	0%

(2) Evaluation of Projected Financial Statements

The financial statements for the four wastewater reuse projects combined and the Ma'an wastewater treatment plant extension project shown in Tables 1.13.3-1 and 1.13.3-2 respectively are summarized by the representative managerial indices as follows:

(Unit: %)

Projects	Profit/ Revenues	Working Capital/ Revenues	Profit/ Liabilities and Capital
	Up to 2020	Up to 2020	Up to 2020
Wastewater Reuse	21.9	21.4	2.9
Wastewater Treatment	14.1	11.4	1.7

For the sake of comparison analysis, it can be stated that the standard level would be 10% for the profit to revenues ratio, 10% for the working capital to revenues ratio, and 5% for the profit to liabilities and capital ratio.

1) Four Wastewater Reuse Projects Combined

Regarding the profit to revenues ratio, the wastewater reuse projects have been found to be perfectly OK with the calculated value more than two times the standard level. With regard to the working capital to revenues ratio also, the projects are solidly sustainable with the value more than twice the desired level.

With respect to the profit to liabilities and capital ratio, the projects would not be up to the standard level. However, this point should not be overemphasized because these undertakings of social nature are essentially not profit-oriented and, therefore, the estimated values should be regarded as acceptable.

2) Ma'an Wastewater Treatment Plant Extension Project

Regarding the profit to revenues ratio, the project has been found to be OK with a better value than the standard level. With regard to the working capital to revenues ratio also, the project has a higher value than the desired level.

With respect to the profit to liabilities and capital ratio, the project would not be up to the standard level. However, this point should not be overemphasized because this undertaking of social nature is essentially not profit-oriented and, therefore, the estimated values should be regarded as acceptable.

In conclusion, it can be stated that the projects concerned would be financially sustainable under the afore-mentioned preconditions, although it should be noted that they might face liquidity problem in the initial years, which must be overcome by either the fund on hand or by borrowings.

Table 1.13.3-1 Financial Statements of 4 Wastewater Reuse Projects Combined

(Unit: JD at Current Prices)

Item	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(1) Income Statement																		
Revenues	0	26,937	38,162	51,324	68,966	92,598	124,238	166,578	166,578	166,578	166,578	166,578	166,578	166,578	166,578	166,578	166,578	166,578
O & M Cost	0	23,634	24,133	24,643	25,163	25,695	26,238	26,792	26,792	26,792	26,792	26,792	26,792	26,792	26,792	26,792	26,792	26,792
Depreciation	0	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294
Interest Payment	47,058	47,058	47,058	47,058	47,058	47,058	45,176	43,293	41,411	39,529	37,646	35,764	33,882	31,999	30,117	28,235	26,353	24,470
Expenditures	47,058	105,986	106,485	106,994	107,515	108,046	106,707	105,379	103,497	101,614	99,732	97,850	95,967	94,085	92,203	90,320	88,438	86,556
Profit Before Tax	-47,058	-79,048	-68,323	-55,671	-38,549	-15,448	17,531	61,199	63,081	64,963	66,846	68,728	70,610	72,493	74,375	76,257	78,140	80,022
Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Profit After Tax	-47,058	-79,048	-68,323	-55,671	-38,549	-15,448	17,531	61,199	63,081	64,963	66,846	68,728	70,610	72,493	74,375	76,257	78,140	80,022
	(up to 2020)																	
Average Profit Before Tax to Revenues Ratio	21.9%																	
Average Profit After Tax to Revenues Ratio	21.9%																	
(2) Funds Statement																		
Profit After Tax	-47,058	-79,048	-68,323	-55,671	-38,549	-15,448	17,531	61,199	63,081	64,963	66,846	68,728	70,610	72,493	74,375	76,257	78,140	80,022
Loans+Budget	1,176,451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depreciation	0	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294	35,294
Sources	1,129,393	-43,755	-33,029	-20,377	-3,256	19,845	52,825	96,492	98,375	100,257	102,139	104,022	105,904	107,786	109,669	111,551	113,433	115,316
Capital Works	1,176,451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Principal	0	0	0	0	0	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058	47,058
Working Capital	-47,058	-43,755	-33,029	-20,377	-3,256	-27,213	5,767	49,434	51,317	53,199	55,081	56,964	58,846	60,728	62,611	64,493	66,375	68,258
Applications	1,129,393	-43,755	-33,029	-20,377	-3,256	19,845	52,825	96,492	98,375	100,257	102,139	104,022	105,904	107,786	109,669	111,551	113,433	115,316
	(up to 2020)																	
Average Working Capital to Revenues Ratio	21.4%																	
(3) Balance Sheet																		
Liabilities	941,161	941,161	941,161	941,161	941,161	894,103	847,045	799,987	752,929	705,871	658,813	611,755	564,696	517,638	470,580	423,522	376,464	329,406
Capital	188,232	109,184	40,861	-14,809	-53,358	-68,807	-51,275	9,923	73,005	137,968	204,814	273,542	344,153	416,645	491,020	567,278	645,418	725,440
Liabilities and Capital	1,129,393	1,050,345	982,022	926,352	887,802	825,296	795,769	809,910	825,933	843,839	863,626	885,297	908,849	934,284	961,601	990,800	1,021,882	1,054,846
Current Assets	-47,058	-90,813	-123,842	-144,219	-147,475	-174,687	-168,921	-119,486	-68,170	-14,971	40,111	97,074	155,920	216,649	279,259	343,752	410,127	478,385
Fixed Assets	1,176,451	1,141,157	1,105,864	1,070,570	1,035,277	999,983	964,690	929,396	894,103	858,809	823,516	788,222	752,929	717,635	682,342	647,048	611,755	576,461
Assets	1,129,393	1,050,345	982,022	926,352	887,802	825,296	795,769	809,910	825,933	843,839	863,626	885,297	908,849	934,284	961,601	990,800	1,021,882	1,054,846
	(up to 2020)																	
Average Profit Before Tax to Liabilities and Capital Ratio	2.9%																	

Table 1.13.3-2 Financial Statements of Ma'an Wastewater Treatment Plant Extension Project

(Unit: JD at Current Prices)

Item	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(1) Income Statement																		
Revenues	0	0	66,888	88,562	117,245	155,199	205,415	271,849	294,219	318,430	344,633	372,993	403,686	403,686	403,686	403,686	403,686	403,686
O & M Cost	0	0	24,970	27,144	29,508	32,077	34,870	37,907	39,780	41,745	43,808	45,973	48,245	48,245	48,245	48,245	48,245	48,245
Depreciation	0	0	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292
Interest Payment	63,528	127,057	127,057	127,057	127,057	127,057	121,974	116,892	111,810	106,727	101,645	96,563	91,481	86,398	81,316	76,234	71,152	66,069
Expenditures	63,528	127,057	247,319	249,493	251,856	254,426	252,137	250,091	246,882	243,765	240,746	237,828	235,018	229,936	224,853	219,771	214,689	209,607
Profit Before Tax	-63,528	-127,057	-180,430	-160,931	-134,612	-99,227	-46,722	21,758	47,337	74,665	103,887	135,164	168,668	173,750	178,832	183,915	188,997	194,079
Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Profit After Tax	-63,528	-127,057	-180,430	-160,931	-134,612	-99,227	-46,722	21,758	47,337	74,665	103,887	135,164	168,668	173,750	178,832	183,915	188,997	194,079
	(up to 2020)																	
Average Profit Before Tax to Revenues Ratio	14.1%																	
Average Profit After Tax to Revenues Ratio	14.1%																	
(2) Funds Statement																		
Profit After Tax	-63,528	-127,057	-180,430	-160,931	-134,612	-99,227	-46,722	21,758	47,337	74,665	103,887	135,164	168,668	173,750	178,832	183,915	188,997	194,079
Loans+Budget	1,588,207	1,588,207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depreciation	0	0	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292	95,292
Sources	1,524,678	1,461,150	-85,138	-65,638	-39,319	-3,935	48,571	117,050	142,630	169,957	199,180	230,457	263,960	269,042	274,125	279,207	284,289	289,371
Capital Works	1,588,207	1,588,207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Payment of Principal	0	0	0	0	0	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057	127,057
Working Capital	-63,528	-127,057	-85,138	-65,638	-39,319	-130,991	-78,486	-10,006	15,573	42,901	72,123	103,400	136,904	141,986	147,068	152,150	157,233	162,315
Applications	1,524,678	1,461,150	-85,138	-65,638	-39,319	-3,935	48,571	117,050	142,630	169,957	199,180	230,457	263,960	269,042	274,125	279,207	284,289	289,371
	(up to 2020)																	
Average Working Capital to Revenues Ratio	11.4%																	
(3) Balance Sheet																		
Liabilities	1,270,565	2,382,310	2,382,310	2,382,310	2,382,310	2,255,253	2,128,197	2,001,140	1,874,084	1,747,027	1,619,971	1,492,914	1,365,858	1,238,801	1,111,745	984,688	857,632	730,575
Capital	254,113	603,518	423,088	262,157	127,546	28,319	-18,403	3,355	50,692	125,357	229,244	364,409	533,076	706,826	885,659	1,069,573	1,258,570	1,452,649
Liabilities and Capital	1,524,678	2,985,828	2,805,398	2,644,467	2,509,856	2,283,572	2,109,794	2,004,495	1,924,776	1,872,384	1,849,215	1,857,323	1,898,934	1,945,627	1,997,403	2,054,261	2,116,201	2,183,224
Current Assets	-63,528	-190,585	-275,723	-341,361	-380,680	-511,671	-590,157	-600,163	-584,590	-541,690	-469,566	-366,166	-229,263	-87,277	59,791	211,942	369,174	531,489
Fixed Assets	1,588,207	3,176,413	3,081,121	2,985,828	2,890,536	2,795,243	2,699,951	2,604,659	2,509,366	2,414,074	2,318,781	2,223,489	2,128,197	2,032,904	1,937,612	1,842,320	1,747,027	1,651,735
Assets	1,524,678	2,985,828	2,805,398	2,644,467	2,509,856	2,283,572	2,109,794	2,004,495	1,924,776	1,872,384	1,849,215	1,857,323	1,898,934	1,945,627	1,997,403	2,054,261	2,116,201	2,183,224
	(up to 2020)																	
Average Profit Before Tax to Liabilities and Capital Ratio	1.7%																	

1.14 Preliminary Implementation Plan

The preliminary implementation plan of four (4) reuse scheme is shown in next:

Year	2001	2002	2003	2004	2005
Abu Nuseir		■	■		
Fuhis		■	■		
Ma'an		■	■	■	
Tafielah		■	■		

1.15 Impacts of Wastewater Reuse on the Social and Natural Environment

EIA was conducted for the wastewater reuse in the existing five wastewater treatment plant. Outline of the EIA procedure and present condition of five existing treatment plant are described in Supporting Report (Annex to 1.15).

1.15.1 Impacts on the Landscape

All the areas related to the treated wastewater reuse schemes are not protected or landmarked in any way, and given the limitations to the maximum amount of cultivation which may occur as a result of these schemes, there will be no significant impact on the landscape.

1.15.2 Impacts on the Groundwater and Soils

Table 1.15.2-1 summarizes the main parameters related to groundwater and soils in the five wastewater reuse sites. From the viewpoint of water salinity, the effluent from all these WWTPs is moderate in salt content and therefore its impact on groundwater salinity may not be significant when applied for irrigation in the vicinity areas, although infiltration of the irrigation water into the groundwater aquifers may unavoidably happen. At Ma'an and Abu Nuseir, the impacts are considered much more insignificant because the low permeability and the significant thickness of the underlying impermeable aquiclude. At Fuhis, Tafila and Wadi Essir, the lower aquifers become exposed at downstream side and appear as springs. Therefore, water infiltrated the aquifers will flow to the downstream direction and then leave the aquifers from springs.

Table 1.15.2-1 Parameters Related to Groundwater and Soils

Parameter	Ma'an	Abu Nuseir	Fuhis	Tafila	Wadi Essir
Effluent Salinity (TDS mg/L)	800 - 900	900 – 1000	800 – 1000	1000 – 1100	950 – 1050
Effluent SAR	< 5	< 4	< 4	< 3	< 6
Groundwater Salinity (TDS mg/L)	800 – 1250	400 – 700	300 – 500	300 – 500	500 – 600
Groundwater Aquifers	B3	A4	Kurnub	B1, A7	A7, A4
Aquifer Permeability	Very low	Low	High	High	Medium
Soil Type	Mixture of gravel, sand, silt and clay	Humus layer cover	Sandy soils	Marly soils	Humus layer covering marly soils

The proposed irrigation areas at the five sites are all near the wadis. Therefore the condition of drainage for irrigation flow is generally good and salt accumulation in the soil may not be significant either. The comparatively low SAR and moderate salinity indicate that the treated effluent will have very low sodium hazard, and effectively no salinity hazard on the soil with respect to irrigation.

1.15.3 Impacts on the Flora and Fauna

There will be a particular impact on the existing vegetation and wildlife in the wadi into which the treated effluent is currently discharged. Under the proposed schemes, the effluent will be diverted to the irrigated area, reducing, and perhaps eliminating the amount discharged to the wadis, at certain times of the year. Since the wadis do not have a permanent base flow, this will have a significant effect on the downstream floras and fauna, favoring species which are more drought tolerant. However, since the effluent discharge to the wadi is itself an artificial condition, the long term impact of this is insignificant.

There may also be an impact arising from a rise in numbers of pests and insects such as butterflies and beetles as a result of an increase in the area of cultivated crops. These may spread in the area and affect the limited natural vegetation. However, given that fodder crops are already being cultivated in these areas, the introduction of these species has probably already begun, so the impact will tend to be an increase in the numbers, rather than to cause the introduction of new species.

There is also a potential impact from the introduction of vector borne diseases such as malaria or leishmaniasis. Since the vectors which carry these diseases are attracted by stagnant water, this would only be a factor if the treated effluent were being stored at the irrigated areas by the farmers. Provided the water is not stored, the increase in numbers of vectors will be minimal. There is probably an existing population of vectors in the area as a result of the treatment works.

None of the above impacts on the local flora and fauna are of major importance. All are related to a change in existing conditions, either following the introduction of new crops to the area, or due to a redirection of the treated effluent away from the wadis. No significant impacts of concern have been identified.

1.15.4 Impacts on Farmers Income and Profitability

A variety of agricultural activities are going on around the five WWTPs, and many other landowners are willing to continue and expand their irrigation if the water is made available. The followings are impacts of the wastewater reuse scheme on the farmers and the agricultural activities in these areas.

(1) Increase in Income from Expansion of Irrigated Agriculture

Table 1.15.4-1 summarizes the schemes of irrigated agricultural lands at each of the five sites by the year of 2010 after the implementation of the treated wastewater reuse project.

Table 1.15.4-1 Schemes of Irrigation Agricultural Lands by 2010

Parameter	Ma’an	Abu Nuseir	Fuhis	Tafila	Wadi Essir
Farming area to be increased by 2010 (dumums)	900	750	700	700	400
Cropping patterns of the new irrigation scheme (dumums)					
Olives	55	200	55	80	55
Wheat and Barley	80	200	80	20	80
Date Palm	150	100	80	40	80
Alfalfa	800 (Dec. & Jan.)	500 (Dec. & Jan.)	80 (April) 550 (Nov. - Mar.)	700 (Dec. & Jan.)	300 (Dec. & Jan.)

Currently farmers in these areas are growing the crops shown in Table 1.7-8 but in much smaller scale. Some farmers depend on rainfall for the crops. They are also growing vegetables and fruit trees. The proposed scheme will expand the irrigated area and introduce new cropping patterns in these areas for a better utilization of the treated wastewater effluent and a substantial increase of the lands' productivity. The overall impacts will be positive.

(2) Employment

The irrigation reuse schemes will generate direct job opportunities in the agricultural sector and more farmers will be able to go back to their lands. New farmers might also become interested if their lands become part of the schemes. Other indirect opportunities might be created relevant to transportation and marketing.

(3) Marketing Opportunities and Consumers Confidence

During the survey, it became evident that consumers are very skeptical of products that are irrigated by treated wastewater. Although, water shortages in Jordan makes the wastewater reuse option viable in their views, however, they have voiced concerns vis-à-vis:

- proper reuse applications by farmers including irrigating vegetables and crops that could be eaten raw ;
- quality of the treated wastewater;
- level of awareness among farmers on the consequences of improper practices; and
- enforcement and monitoring of products by the concerned governmental authorities.

Most of the farmers have the common sense that the treated effluent can be used for restricted irrigation, but there is consensus on the fact that vegetables irrigated by the treated wastewater effluent cannot be well marketed. Therefore, cultivation of trees and fodder crops may be the right choice for wastewater reuse, because the market for these crops are much better.

(4) Changes in Cropping Patterns and Irrigation Techniques

This issue mainly concerns the areas that are currently under irrigation. With respect to the proposed new irrigated areas under the scheme, cropping patterns will be selected to suite the quality of treated wastewater. Changes in these patterns due to wastewater reuse are not foreseen. However, changes in the current cropping patterns might occur if farmers are facing marketing problems and/or if their crop yields decline due to water quality.

Some farmers who use sprinkler irrigation will have to change this irrigation practice to drip or furrow irrigation. The majority of the farmers have drip system and hence no changes in irrigation techniques are required. However, if the treatment process continues to produce high TSS values, there will be a high potential for clogging of emitters in drip irrigation systems. This could be decreased with proper planning and design and using large orifices emitters.

1.15.5 Impacts on Public Health

Any use of wastewater for irrigation must consider its consequences for public health. Wastewater, especially domestic wastewater, contains pathogens that can spread disease when not managed properly. The primary objective of any wastewater reuse project must be to minimize or eliminate potential health risks.

The threat to human health can come from four pathogen groups: viruses, protozoa, bacteria, and helminths. WHO concludes that the highest threat comes from helminths and the lowest from viruses.

In the five WWTPs, Nematode eggs (helminths) were shown to be zero as a result of the analysis that was conducted during the study. Also the 12-month results of WAJ monitoring does not indicate any helminths in the effluent. However, total fecal coliform counts (TFCC) were found at most of the WWTPs except for Fuhis WWTP where final disinfection by chlorination results in zero TFCC. At Ma'an WWTP, TFCC exceeds WHO and JS guidelines for irrigation. If this condition is not changed, the concern for public health and safety can quickly grow to a lack of confidence. This increase in concern will impact marketability on the irrigated crops.

At present surface irrigation is practiced by farmers in same areas. This practice does not affect the marketability of the products, but increases the direct contact of the farm labors with the treated wastewater. From the viewpoint of public health, it is recommendable that all the WWTPs apply chlorination for pathogen control of the treated wastewater effluent.

1.15.6 Community Conflicts and Perceptions

(1) Water Allocation and Current Users
In the social survey of this study, it was found that some farmers have signed contract to receive treated wastewater for irrigation at low nominal fees such as two farmers at Ma'an. However, in most of the cases, farmers who wish to use the treated effluent are unofficially pumping water from the wadis. They have at least incurred capital costs including pumping and conveyance from the treatment plants or the wadis to their farms. These farmers are competing users of the treated wastewater in the future.

In the proposed irrigation scheme, new areas will be developed for farming close to the treatment plant, and all users have to pay tariff for the treated wastewater. At that time, caution should be taken regarding ownership of the areas and the present condition of water use.

(2) Competition with Non-agricultural Users including Bedouin Communities
The proposed wastewater reuse schemes are located close to the vicinity of the treatment plants. In certain period of time, these areas might be used by Bedouins for animal grazing. They may also become temporary users of the treated effluent. Also some non-agricultural residents may wish to use the treated effluent to irrigate their gardens. Although the quantity of such kind of non-agricultural use may not be great, this matter should be taken into consideration during the project implementation.

There are no other potential users (industrial and urban) in these areas that are likely to compete with agricultural users.

(3) Acceptability of the Wastewater Reuse Scheme

In general, the wastewater reuse schemes at the five WWTPs are welcome by farmers especially those who wish to expand their farms for irrigated agriculture. However, there are several issues that farmers are worrying about, such as the exact location of the reuse scheme, the quality of the treated effluent in the future, and the tariff of water use. It is important that WAJ should take actions to ensure that the WWTPs are producing treated wastewater of sufficient quality to meet the irrigation standard, so that farmers will not hesitate to accept the reuse scheme and consider it worth to bear the tariff for obtaining irrigation water.

1.15.7 Suitability of the Treated Effluent for Irrigation

(1) Water Salinity (ECw)

In the FAO guidelines on the tolerance of crops to irrigation water salinity, ECw (expressed in the unit of dS/m) is used as the determinative parameter. From the water quality analysis results of this study, the ECw of the effluent from the five WWTPs ranges from 1.52 dS/m (Fuhis) to 2.05 dS/m (Ma'an). Taking the highest value as the limit condition, the suitability of water salinity for irrigation can be evaluated.

The value of 2.05 dS/m indicates a slight to moderate restriction on present irrigation use. Assuming that irrigation water is the only source of salt, the soil salinity ECe resulting from a long-term use of the treated effluent for irrigation is expected to be in the order of 3.1dS/m[1]. Given such a water quality, and assuming a leaching fraction of 15-20%, the relative yield of the proposed crops in the reuse schemes is shown in Table 1.15.7-1. Due to high tolerance to salinity, reduction in yield potential of wheat and barley, and date palm are not anticipated. All the remaining crops are likely to suffer substantial yield reductions exceeding the 10% recommended by FAO.

Table 1.15.7-1 Crop Tolerance, Yield Potential as influenced by Irrigation Water Salinity of ECw = 2.05 dS/m and leaching Requirements (Proposed Crops)

Crop	ECw, dS/m	Soil Salinity, dS/m	Soil Salinity Threshold, [2] dS/m	Slope % Per dS/m, [3]	Yield, %	Leaching Requirement %
Wheat[4]	2.05	3.1	6	7.1	100	7%
Barley	2.05	3.1	8	5	100	5%
Alfalfa	2.05	3.1	2	7.3	92	26%
Date Palm	2.05	3.1	4	3.6	100	11%
Olives	2.05	3.1				
Fruit tree	2.05	3.1	1.2-4.7	9.6-24	65-100	10-52%

[1] Assuming a 40-30-20-10 percent crop water use pattern from the upper to the lower quarter of the rooting depth, and a 15% leaching fraction, with a concentration factor of 1.5.
[2] The maximum allowable soil salinity without yield reduction
[3] Percentage yield reduction per unit increase in soil salinity
[4] Less tolerant during emergence & seedling

In order to obtain 100% yield, however, salt removal by leaching would be necessary. The leaching requirement needed to maintain the full yield for all proposed crops is estimated in the table. Leaching requirements for fruit trees range between 10 to 46%. Such a high leaching requirement may not be attainable or desirable considering the simultaneous leaching effect of Nitrates to groundwater. Except for guava, most of the remaining fruit trees will require leaching in the order of 32-38%. The actual crop production will depend on such amounts being provided, climatic and soil condition, adequate drainage, crop variety and water availability. Since treated effluent water is available throughout the year, extended intervals between irrigation that induce additional yield loss are unforeseeable. Actual yield loss will also depend on stage of growth. Wheat and barley for example is less tolerant to salinity in the surface soil during emergence and seedling establishment and ECe threshold is recommended not to exceed 4 or 5 dS/m. This limits the maximum permissible salinity of the treated effluent during the germination and early seedling stage to 2.7 - 3.3 dS/m, otherwise blending would be needed.

(2) Potential Infiltration Hazard

Infiltration hazard is often related to ECw and the sodium adsorption ration (SAR). According to the water quality analysis result, SAR of the treated effluent ranges from 1.4 – 5.7. Comparing with the FAO guidelines, both ECw and SAR of the treated effluent do not present any degree of restriction on use, irrespective of the soil type. However, when changes occur in the Calcium and Magnesium content of the applied water following irrigation due to dissolution of soil minerals into the water, the relative proportion of the Sodium might increase which would increase the sodium hazard. Factors affecting such changes are related to the carbonate and bicarbonate content in the treated effluent. Taking Ma'an WWTP as example (the highest ECw), a review of the treated effluent quality parameters in this regard, namely, ECw, and HCO_3/Ca ratio, indicates that Ca concentration expected to remain in near-surface soil water following irrigation will be reduced to about 30.8 mg/L (1.54 meq/l), thus pushing the SAR value to 5.9. Given the ECw of the treated effluent, no unfavorable changes to the soil chemistry would be expected, and hence infiltration problems are not foreseeable even in clay soils.

(3) Suitability Using Specific Ion Toxicity

Toxicity problems occur when certain ions are taken up with soil water and accumulate in the leaves to an extent that result in damage to the plant and reduced yield. The most common toxicity problems of concern when using marginal quality water for irrigation is Sodium, Chloride, Boron and certain trace elements toxicity (namely, As, Pb, Se, Al, F, Fe, Mn, Zn, Ni, Cr). Boron toxicity might occur with sensitive fruit crops such as Lemon and Black Berry, since injury has been found in some cases using water with less than 5 mg/l (Ayers and Westcot 1985). However, trace elements toxicity is not likely to occur considering the sewage nature in Ma'an treatment plant.

Chloride ions

The chloride content of treated water depends on its concentration in the municipal water. The concern is increased with the municipal use, and later by evaporation in the wastewater treatment process. Chloride toxicity can occur by direct leaf absorption during sprinkler irrigation and following surface irrigation for an extended period of time.

Crops' tolerance to chloride and Sodium is not yet so well documented. However, based on relative tolerance of selected crops to foliar injury from saline water applied by sprinklers (FAO 29), alfalfa and barley are not likely to suffer foliar injury given the Cl^- concentration of 155 - 340 mg/L (4.4 – 9.7 meq/L) in the five WWTPs. Almond, Apricot, Citrus and Plum, however, are more susceptible to foliar injury at levels less than 5 meq/L. Cl toxicity can also be problematic for grapes at concentrations between 5-10 meq/L.

Since no toxicity rating is provided for the fruit crops, it is difficult to predict their susceptibility to Cl injury using sprinkler. It should be mentioned that direct foliar absorption and injury should not be a concern if the Jordanian Standards regarding the strict prohibition of the use of sprinkler irrigation with treated effluent is enforced for health considerations. Currently farmers using treated effluent for irrigation were found to use sprinklers on a limited scale, thus highlighting the need for farmers' education regarding the related health hazards.

Most tree crops are sensitive to Chloride when surface irrigation methods is used. But as mentioned above, the extent to which Cl toxicity is likely to develop cannot be determined, in the absence of documented rating. However, existing information suggest that the Cl concentration in Ma'an treated Effluent may present threat when using surface method for the irrigation of some varieties of Stone Fruits. Since research is incomplete regarding the evaluation of Cl toxicity using surface irrigation, it is possible that the remaining fruit trees may be more or less tolerant. Because of the high investment cost associated with trees, it is highly recommended that farmers are advised on the need for good irrigation management and Cl leaching.

Sodium ions

The SAR of the treated effluent in the five WWTPs, namely 1.4 – 5.7, indicates a slight to moderate restriction on use for surface irrigation, and potential for sodium toxicity. The Soil Exchangeable Sodium (ESP) expected to result from long-term use of the reated effluent (5 ESP) indicates the unlikeness of such injury with alfalfa, wheat and barley. Adequate leaching however will be required. On the other hand, due to sensitivity of most tree crops to Sodium, Deciduous fruits, Grapefruit, Orange, Peach, and Tangerine are likely to suffer from sodium injury.

Sodium toxicity can also occur from direct absorption of Sodium ions through leaves wet by overhead sprinklers. Given the highest sodium concentration in the treated effluent (1.4 meq/L at Wadi Essir) and based on relative tolerance of selected crops to foliar injury from saline water applied by sprinklers, alfalfa and barley are not likely to suffer foliar injury, when using sprinkler irrigation. Na toxicity is likely to be problematic for Almond, Apricot, Citrus and Plum and grapes being more susceptible to foliar injury at lower concentration levels. This however, should not be a concern if the prohibition of the use of sprinkler irrigation is observed.

Nutrient Substances (T-N and T-P)

The concentrations of NO_3 at 3.4 – 18.2 mg/L and NH_4 at 5.5 – 122 mg/L in the five WWTPs are equivalent to a T-N concentration less than 100 mg/L. The highest T-N happened at Ma’an WWTP due to improper management of the pond system. For the other WWTPs, T-N concentration is much lower. Taking Ma’an WWTP as the limit condition, this high T-N value presently meet the Jordanian standard with regards to the application of treated effluent for the irrigation of fruit trees and fodder. However it is excessive even by the standard of tolerant crops and will cause adverse effects on several crops and their marketability, such as grapes, grain crops apricots citrus and other fruit trees. Existing research indicates that T-N concentrations of about 15-25 mg/L or less are required in the effluent in order not to exceed the requirements of most crops. Typical Nitrogen requirements (Kg/ha) for alfalfa, wheat and barley are in the order of 224-538, 56-91, and 71, respectively. These values are certainly exceeded by the present amounts of nitrogen in Ma'an treated effluent, given the crops water application rate. Hence, some of the nitrogen not used by the crops will leach out of the soil, mostly as nitrates, thus posing undesirable nitrate pollution to the groundwater. In addition nitrogen applied in high concentrations can also have detrimental effect on livestock. However, it is expected that the extension and rehabilitation of Ma'an treatment plant will be designed to a higher T-N standard as determined by the above mentioned agronomic needs of nutrients.

Despite the limited information on the effect of irrigation with phosphorous rich effluents, many soils are successfully irrigated with treated effluent having P-concentrations of about 5-15 mg/L, mostly as PO_4-P. Hence, the T-P concentration of about 3.8 - 14 mg/L in the treated effluent from the five WWTPs, is not likely to cause significant adverse effect on the selected crops.

<u>SS & pH</u>

In most of the WWTPs, the suspended solids (SS) concentration ranges from 21 – 44 mg/L except for Ma'an where the measured SS is as high as 225 mg/L. In this case, there is a high potential for the clogging of emitters in drip irrigation systems. Therefore, rehabilitation of the Ma'an WWTP for decreasing the SS content is also necessary. On the other hand, plugging of emitters can be decreased with proper planning and design, and use of large orifices emitters.

The pH values of the effluent from all the five WWTPs are within the acceptable range for irrigation water.

<u>Microbial Quality</u>

Of the five WWTPs, total fecal coliform was detected from Abu Nuseir (222 – 300 MPN/100 mL), Wadi Essir (750 – 800 MPN/100 mL), Tafila (1272 MPN/100 mL) and Ma'an (5228 MPN/100 mL) but none from Fuhis. No living nematodes were detected from these WWTPs. The Jordanian Standard JS 893 allows the application of treated effluent on fruit Trees, forestation, crops and grains and fodder without any criteria on the fecal coliform or nematode eggs. Hence using the treated effluent for irrigation of corps of this category is not restricted in this regard, provided that irrigation is stopped two weeks before harvesting of fruit trees and before grazing of fodder crops, and no fruit is picked off the ground. For vegetables the permissible TFCC is 1000 MPN/100 mL, and the treated effluent from Ma'an and Tafila WWTPs is restricted for such kind of use.

In the case of sprinkler irrigation, water with high TFCC is prohibited regardless crop type. This is under the consideration of protection of field workers from bacterial affection. In this regard, it is recommendable that wastewater treatment processes should be improved or chlorination of the treated effluent be practiced for the five WWTPs.

The intestinal nematode eggs do not exist in the treated effluent from the five WWTPs. This meets the Jordanian Standard JýS 893 for all crops. Although there is no helminth egg removal criteria in the standard at present, this problem should also be taken in to account because helminth will pose serious health risk for the farmers.

1.15.8 Farmers' Willingness Towards Wastewater Reuse

The social survey was carried out in the five wastewater reuse project areas. The survey team has carried out focus groups and individual interviews with about 100 farmers representing 43 farms in the vicinity of the 5 WWTPs. The interviews were based on the designed questionnaire sheets so that the collected information could be quantitatively analyzed. This section is a summarization of the farmers' willingness towards wastewater reuse.

(1) Awareness of Water Shortage Problems

In general, people in Jordan are aware of the water shortage problem. Almost all the farmers in the project areas pointed out this problem and thought it is critical, because they have been suffering from the chronic drought that started 3 – 4 year ago. Of all the farmers interviewed, 97.3% answered 'aware' and 2.7% answered 'not aware'. The main reasons behind water shortage were pointed out as low rainfall, high population growth, scarcity of surface and groundwater resources, mismanagement of water, worn-out network, and inefficient water use as shown in Fig 1.15.8-1.

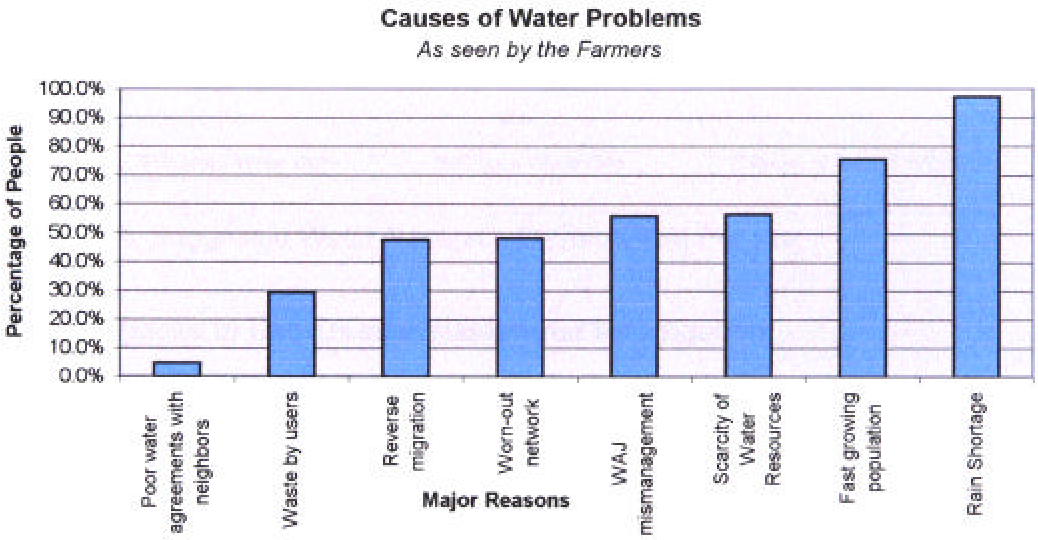

Fig. 1.15.8-1 The Main Reasons of Water Shortage Problems

To respond and deal with water shortage, the overall analysis indicated that farmers perceived treated wastewater as a resource that should not be wasted but must be utilized to meet irrigation demands (59%), whereas surface water and groundwater development were considered as the second and third options (42% and 36%, respectively).

(2) Willingness to Use Treated Wastewater for Irrigation

<u>Acceptance of wastewater reuse for irrigation</u>

In Ma'an, Fuhis an Wadi Essir, 100% of the farmers interviewed are willing to use the treated wastewater for irrigation, while in Tafila and Abu-Nuseir, the percentages are 92% and 89%, respectively. The farmers' rationale for the acceptance of wastewater reuse is from different aspects: some think the treated wastewater is suitable because they have had the water analyzed at university; some basically think it is cheaper than other sources; some are very conscious of water shortage in Jordan and think that wastewater reuse may be a solution. However, certain farmers are worrying about quality issues and consequences on agricultural land and marketing as those in Tafila and Abu-Nusier where a small group showed strong objection to the reuse of treated wastewater. None of the farmers explained religious reasons against wastewater reuse.

<u>Willingness to expand farming activities</u>

In Ma'an, 100% of the farmers are willing to use the treated wastewater and expand their farming areas to the vicinity of the WWTP, and then come Tafila and Wadi Essir as 92% and 90%, respectively. This is understandable given that agriculture constitutes the primary source of income for most of the farmers in these areas. In contrast, the majority of the farmers who are willing to use the treated wastewater in Abu Nuseir and Fuhis don't want to expand their farming area. The underlying reasons are that agriculture is not the main profession for the residents in these two areas. As a matter of fact, the majority of the residents there belong to the retired age group, and therefore they are not willing to relocate their farms and start new 'ventures' in the future.

<u>Perception of effluent quality</u>

Although most of the farmers are willing to use the treated wastewater for irrigation, they have their own perception of the wastewater quality mainly from the appearance of the effluent from each of the WWTPs whether or not this reflects the actual quality. On answering their perception of the effluent quality at three levels as 'very good', 'moderate' and 'very poor', 34% farmers in Tafila and 9% in Wadi Essir thought it to be 'very good'. Surprisingly, the judgment of 'very poor' was also mainly from these two areas as about 19% (Tafila) and 54% (Wadi Essir). In Ma'an and Fuhis, all farmers answered 'moderate' as their perception of effluent quality, and in Abu Nusier, 85% gave the same answer. By analyzing the results carefully, it was found that farmers with lower education level often answered the question arbitrarily and gave extreme judgment. The major answer of 'moderate' has shown the farmers' general perception of effluent quality.

<u>Perception of marketability of crops irrigated by treated wastewater</u>

Another major factor to influence the farmers' willingness to use the treated wastewater is their perception of the marketability of crops. Fig. 1.15.8-2 summarizes the results of the social survey regarding this matter.

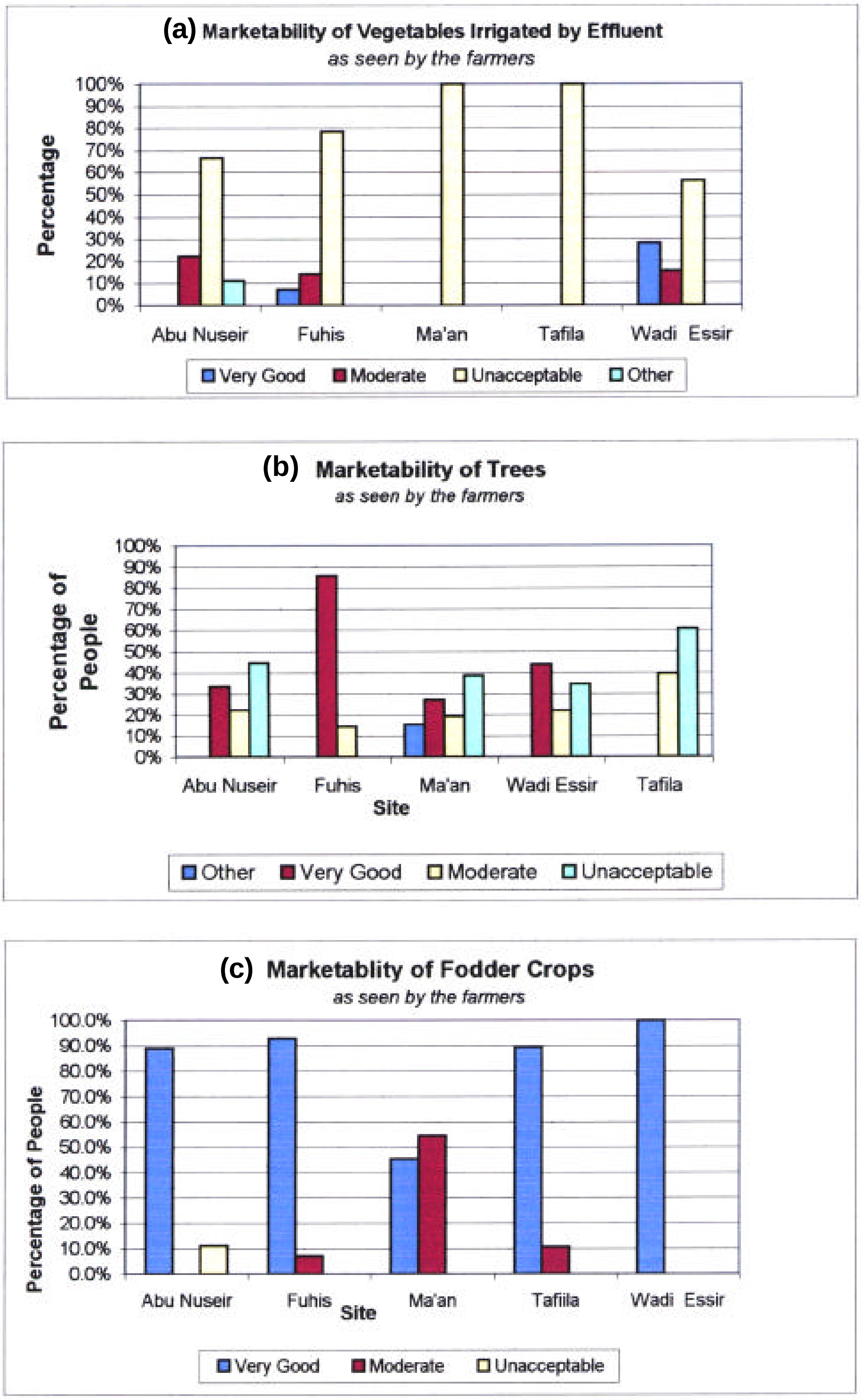

Fig. 1.15.8-2 Farmers' Perception of the Marketability of Crops Irrigated by Treated Wastewater

As is shown in the figure, most of the farmers are worrying about the marketability of vegetables irrigated by the treated effluent, and considered it unacceptable. Such kind of perception is the strongest at Ma'an and Tafila where 100% of the farmers answered 'unacceptable'. The percentages of the same answer at Fuhis, Abu Nuseir and Wadi

Essir are in turn as 78%, 66% and 57%. However, certain farmers considered the marketability to be ‘very good’ or ‘moderate’. The main reason for the positive answer is that some farmers compared themselves to the farms down in the Jordan Valley area where farmers have being receiving treated effluent from the KTR – KAC system for many years for irrigation of winter and summer crops.

As for the marketability of trees, whether fruits or olives, the percentages of negative answers decrease significantly. At Fuhis, 85% farmers considered it ‘very good’ and 15% as ‘moderate’. At Abu Nuseir and Wadi Essir, the positive answers (‘very good’ and ‘moderate’) take more than 50% and 60%, and at Ma’an the positive answers are more than the negative ones with about 15% other answers. 60% farmers at Tafila considered the marketability to be ‘unacceptable’. The reason might be from the fact that some farmers at Tafila are using the untreated wastewater from the sewer system to irrigate their olive orchids. They may have experienced marketing difficulties.

The farmers’ perception of the marketability of fodder crops is almost positive except for about 10% negative answers at Abu Nuseir.

Although there are different considerations on the marketability of different crops, more than 90% of the farmers are seeing the profitability of the treated effluent reuse for agriculture.

1.16 Mitigation Measures and Monitoring

1.16.1 Irrigation Management Issues

Management of water, soil, crop and operational procedures, including precautions to protect agricultural workers, play an important role in mitigating the potential problems related to treated effluent reuse. The following sections discuss the field management practices necessary for successful reuse.

(1) Salinity Control

The control of the salts in the soil can be achieved by controlling the water movement in the soil. This involves several interrelated factors such as (a) quantities and distribution of rainfall, (b) quantities and qualities of irrigation water, (c) prevailing drainage conditions, (d) methods of irrigation and leaching practices, (e) land preparation for better water distribution (f) timing of irrigation to prevent excessive root zone depletion and water stress (g) types of crops and (h) soil type and topography (FAO 29).

<u>Leaching practices</u>

Leaching can be done at any time. Soil and crop monitoring should be useful to determine the need for leaching. The following procedures are suggested for increasing the efficiency of leaching and reducing the amount of water needed. This should also help minimize the potential threat of NO_3 leaching on groundwater pollution:

- Leach during the early irrigation season since the evapotranspiration losses are lower;
- Use tillage to slow overland water flow;

- Use alternate ponding and drying instead of continuous ponding. The former less wasteful, though more time consuming;
- Schedule leachings, where possible, at periods of low crop water use. Alternatively, after the cropping season.

Given the usual inefficiencies of water application, the water losses due to deep percolation which are normally between 15% for drip and 50% for surface irrigation; the leaching requirements are met for most of the plants. Hence, the actual extra water needed to accomplish leaching will ultimately depend on the irrigation method used as determined by the crop, water quality and health requirements, and the estimated contribution of effective rainfall in leaching, based on local conditions. It is expected that a certain amount of natural leaching would have occurred in all areas to different extents by the onset of the irrigation period which should not be neglected. Winter leaching can be enhanced even in a dry year by early winter irrigation to refill the soil profile with water before the rain. The latter will then complete the soil water replenishment and accomplish all or part of the required leaching with almost salt-free water.

Irrigation methods

The method of irrigation directly affects the salts accumulation in the soil. With furrow irrigation using the moderately saline water of the treated effluents in all plants, the salinity may concentrate five to ten times on top of the ridges and hence affect germination. Placement of seed to avoid areas likely to be salinized is therefore required. In general, fewer problems are encountered with border irrigation. Basin irrigation with good land leveling is the most suitable for salinity leaching. Land leveling is hence essential to furrow, border and basin irrigation.

Since the depth of water applied with surface irrigation methods cannot be easily adjusted per irrigation, more frequent irrigation for salinity control may result in a decrease in water use efficiency and leaching of Nitrates.

Drip irrigation has provided better yields with higher salinity water (EC_w>1 ds/m), due to the daily replenishment of the water used by the crop and the low moisture tension levels maintained throughout the season. However, salt may accumulate at the outside edges of the area wetted by emitters and might be moved by rain into the root zone. It is therefore recommended that regular irrigation continues during a rain and that new plantings in the salty areas should not be made without prior leaching. However, careful management of drip irrigation systems is required to decrease clogging of emitters.

(2) Management of Toxicity Problems

Given the chloride and sodium ions concentrations in the different sites' water, the high temperatures and low humidity during the irrigation period, leaf burn of sensitive crops may occur with sprinkler irrigation. Sprinkler irrigation is prohibited for application of treated effluent by Jordanian standards, irrespective of the microbiological quality. However, MWI is currently reviewing the standard and related laws. Should the standards be amended to allow greater degree of flexibility to meet specific conditions of wastewater reuse, sprinkler irrigation might not be excluded for applying treated effluent provided that the latter meets the WHO guidelines with respect to Category A crops. This in turn necessitates the need for farmers extension and education regarding the adequate practices for toxicity management.

Management options to reduce toxicity and improve yield include leaching in a manner similar to that for salinity. Increasing the frequency of irrigation reduces the severity of a toxicity problem. Land grading, profile modification and adequate drainage are essential practices that offer better control and distribution of water for proper leaching.

(3) Management of Nutrients

A tailoring in the supply of nutrients is required for nutrient control. This arises from the sigmoid pattern of plant growth. During the active growth period an abundant supply of nutrients should be provided, while the lowest is required during the initial growth and ripening stages. Blending or changing water supplies (if possible) should be helpful. Such an alternative during the ripening period will also minimize the pathogen contamination of crops. During the period of low nutrient requirements, light irrigation would be advisable, whereby the minimum depth required to supply the crop water demand shall be applied. If water applied nutrients are still excessive, irrigation to cause a moderate but increasing water stress as the crop approaches maturity is required. During the non-irrigation season, crop rotations should be planned to utilize the residual nutrients in the soil.

(4) Management of Drip Systems

The main cause of clogging is solid particles in suspension. Filtration can prevent immediate blockage by removing particles longer than the width of the emitter flow path. Granular filtration helps remove particles with irregular shapes. Other methods include efficient backwashing of the filters and flushing the ends of the line and installing long laterals when the topography permits. Algae and other growths enhanced by the high nutrient levels in all sites would also contribute to the clogging problems. Use of oxidants such as chlorine or chlorine dioxide is an effective control measure, though costly and requires careful management to use safely. Precipitation of calcium carbonate enhanced by high temperatures or high pH is another cause of plugging. Control of pH, or cleaning the system periodically should prevent deposits build-up to such levels where clogging might occur.

1.16.2 Mitigation and Monitoring of the Chemical Constituents

(1) General Considerations

Currently the Boron level in Wadi Essir treated effluent, excludes its use for the irrigation of very sensitive crops such as lemon and Blackberry. Although not likely to cause any toxicity problem in the presence of sulphates in the soil, the Selenium in Fuheis treated effluent is on the upper limit recommended by FAO. More samples should be taken to establish the level of Se in the effluent. Periodical sampling of the crops and forages might be needed to determine if it is a real concern. Despite the municipal nature of the effluent in almost all treatment plants, future monitoring of industries to ensure their compliance with existing regulations might be needed, and waste discharge requirements to the sewers are met.

Constant monitoring of all the parameters relevant to agricultural reuse should be ensured. Parameters, should include ECw, SAR, Cl, Na, B, heavy metals, T-N, T-P, TFCC and intestinal nematodes during the irrigation period.

(2) Trace Elements

As discussed earlier, FAO 29 guidelines do not indicate the specific concentration at which toxicity might occur. Crops sensitive to specific ions at concentrations less than those of the different sites' water, have been categorized as crops which may suffer from crop toxicity and have been listed in the chapters on “Suitability of water for irrigation”. Almond, Apricot, Citrus and Plum are likely to suffer leaf injury due to Cl and Na absorption with overhead sprinklers in all sites if sprinkler irrigation is allowed depending on the specific effluent microbial quality. Grape may suffer leaf injury in all plants but Tafila. Some varieties of stone fruits may suffer Cl toxicity using surface irrigation in Ma’an and Wadi Essir and stone fruits, Citrus, Berries and Vine in Abu Nuseir, and Fuhis. Finally Grapefruit, Orange, Peach and Tangerine may suffer Na toxicity in all plants using surface irrigation.

Exclusion of such crops could be considered, depending on local experience with their tolerances. Because of the high investment cost associated with trees, it is highly recommended that farmers are advised on the need for good irrigation management and Na and Cl leaching.

(3) Nutrients

Options for nutrient control include control of the overuse of fertilizers by farmers. Depending on the crop nutrients requirement and their availability in the soil, evaluation of the different nutrients content with respect to crop suitability should be made on an individual crop basis for each site and hence, subsequent decisions on the need for dilution and supplemental fertilizers can be made. It is therefore recommended that farmers should be advised on the fertilizer requirements of the various crops with due regard to its availability in the soil, thus highlighting the need for extension.

Other options for control are embedded in the treatment process. Treatment procedures to remove nutrients from the sewage effluent in Ma’an and Fuheis should be considered. These include denitrification, a practice which has recently become a requirement in the design of wastewater treatment plants in Jordan.

(4) Suspended Solids and pH

Farmers should be advised on the field management practices needed for successful irrigation reuse, including adequate leaching for salinity and toxicity, application methods, and measures to mitigate the potential of clogging of emitters in drip irrigation system. Where leaching is unattainable for some crops, farmers might contend with considerable yield reductions. It is therefore necessary to assess the farmer's profitability based on crop production. Tariffs should be determined accordingly.

1.16.3 Health Protection

The Jordanian Standard JS 893 allows the application of treated effluent on Category B crops (cereal crops, industrial crops, fodder crops, Pasture and trees) without any criteria on the fecal coliform or nematode eggs. Sprinkler irrigation is completely prohibited and fruits should not be picked off the ground. If successfully enforced, such measures, in addition to the crop restriction under consideration in this study, should protect the crop handlers and consumers, and those living near the fields. This however falls seriously short of protecting the farmers.

WHO guidelines group the measures necessary for health protection under waste water treatment, crop restriction, treated effluent application methods and control of human exposure. Table 1.16.3-1 lists the microbial guideline recommended by WHO. The intestinal nematode egg guideline value is designed to protect field workers and consumers. This can be achieved with a minimum retention time of 8-10 days. The fecal coliform guideline is intended for the protection of consumers and can be achieved with supplementary disinfection to conventional treatment process. Where farm workers are the only exposed population, no bacterial guideline are recommended, since there is little evidence indicating a risk to such workers from bacteria.

In view of the above and in order to ensure the minimum requirement for the protection of farm workers, efficient removal of the nematode eggs, should be ensured in Abu Nuseir. Adding polishing lagoons would hence be a more appropriate measure to upgrade its effluent quality for agriculture use. In the absence of such lagoons, only localised irrigation of Category B crops should be allowed, provided that exposure of field workers and the public does not occur (WHO Recommended Microbial Quality Guideline). Control of application methods and exposure should hence be ensured and irrigation with surface and sprinkler should be strictly prohibited in view of the associated health risks.

The helminth egg removal in the remaining treatment plants allows the use of category B crops, i.e. irrigation of cereal crops, industrial crops, fodder crops, pasture and tree, with no restriction on fecal coliform, provided that no fruits are picked off the ground, irrigation is stopped before harvest and grazing, and sprinkler irrigation is not used, particularly where the TFC does not meet the WHO guideline. Other measures needed to ensure the health protection of farmers include health education, provision of medical facility, adequate potable water supply, protective clothing, and clearly marking irrigation pipes. Outlets fittings should also be designed to prevent misuse.

1.16.4 Crop Marketability

Lack of enforcement on application methods, and crop restriction, if associated with unreliable microbiological effluent quality will result in loss of confidence in the agricultural produce on the part of farmers and consumers with adverse effects on farmers profitability. Crop marketability will also depend on adequate practices at the farm level for the management of toxicity and nutrients. As mentioned in the previous sections, excess nitrogen will affect the yield and product quality of grapes, wheat, peaches, apricots apples and their storage life. Adequate extension and education should hence be provided.

Religious factors have not played any role in public perceptions towards wastewater reuse. However, water quality and irrigation practices have been perceived as the limiting factors for marketing products irrigated by the treated effluents. As part of the irrigation scheme, having a transparent system that complimented with good enforcement and monitoring is essential to facilitating marketing the reuse schemes products.

Table 1.16.3-1 Recommended Microbial Quality Guideline for Wastewater Reuse in Irrigation[a]

Category	Reuse Conditions	Exposed Group	Intestinal nematodes[b] (arithmetic mean no. of eggs per liter[c])	Faecal coliforms (geometric mean no. per 100 mL[c])	Wastewater treatment expected to achieve microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports field, public parks[d]	Workers Consumers Public	1	1000[b]	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees[e]	Workers	1	Not applicable	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation.

a In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account, and these guidelines modified accordingly.
b Ascaris, Trichuris and hookworms.
c During the irrigation period.
d A more stringent guideline (≤ 200 faecal coliforms/100 ml) is appropriate for public lawns, with which the public may have direct contact.
e In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Source: WHO (1989)

1.16.5 Groundwater

For all the reuse schemes, it is rather important to ensure that the quality of the effluents meet irrigation reuse standards although these standards are not as stringent as recharge and surface water discharges standards. Regular monitoring of effluent quality and maintaining and upgrading the treatment plants accordingly is very important. The most important parameters are BOD, TDS, T-N, TFCC and nematodes. The sources of trace elements and heavy metals should be regularly monitored. It is particularly important that any industrial discharge that might reach the municipal sewer system should meet the pretreatment standards before connecting to the system.

1.16.6 Biodiversity

The reuse irrigation schemes should be well fenced and closed to wildlife such as foxes and hares, in order to avoid damage to farms and other cultivated areas.

The occurrence of pests and diseases should be monitored and actions quickly taken in the case of a pest outbreak in natural vegetation. The occurrence of vector borne diseases and their hosts (mosquitoes, sand flies, rats etc.) should be monitored. Wildlife in the irrigated areas should also be monitored to ensure that such wildlife do not carry any vector borne diseases. The storage of treated effluent in open tanks on the farms should be prohibited, in order to discourage mosquito breeding in the area.

In order to control the propagation of introduced species, the introduction of species should be restricted to the designated reuse areas, and any spread outside the designated areas should be monitored and prohibited.

The introduction of exotic plants such as acacia, eucalyptus and pine trees in the proposed irrigated areas should be minimized, and the use of olive and fruit trees, which are already cultivated in the areas, should be encouraged.

1.16.7 Water Allocations and Users' Competition

As noted earlier, a good portion of the treated effluents are being used for irrigation either in the vicinity of the treatment plants or by the downstream users. In certain project areas, namely Ma'an, a number of the farmers are officially using this source and have in fact incurred capital expenses for providing the adequate infrastructure. The issue of users' competition to get the treated wastewater did not come out as in the survey for the following reasons:

- Farmers will incur high pumping and conveyance costs to get the treated effluents;
- The current water quality constituents limitations of irrigating certain crops;
- The wastewater reuse practice is recent and farmers are exploring its various aspects.

However, as fresh water resources become more limited, competition between farmers will extend beyond the fresh sources to include the treated effluents. Moreover, the current wastewater users have also established irrigation schemes and some have incurred capital investment of conveyance and pumping to utilize the effluents. These two factors might create competition among users. Water rights of the current users should be maintained and the reuse schemes should be collaboratively planned with the stakeholders of each reuse scheme to avoid potential conflicts on water supplies.

1.17 Project Evaluation

1.17.1 Economic and Financial Evaluation

(1) Wastewater Reuse Projects

The wastewater reuse projects are, as a results of analysis, both financially and economically promising compared with water supply and wastewater treatment projects because of lower unit water prices.

As the current treated wastewater price of 10 fils per m^3 is unreasonably low from any angles, it was premised first of all that it must be raised gradually every year, finally to 48 fils in 2010. In economic analysis, the unit benefits were ultimately measured by the gross agricultural profit per m^3 of treated wastewater used.

In performing financial analysis, the discount rate was assumed as 5% in anticipation of the provision of a kind of soft loans for the implementation of the projects.

The summary of the economic and financial analysis of the 4 projects concerned is as follows:

Economic/Financial Criteria

WW Reuse Projects	FIRR (%)	Unit Wastewater Price	EIRR (%)
Ma'an	4.1	44	7.4
Abu Nuseir	12.0	21	19.1
Fuhis	12.6	20	18.7
Tafielah	0.4	69	8.9
Total	6.4	35	12.2

Note: Discount Rate: Financial=5%, Economic=10%

Managerial Indices (Unit: %)

Project	Profit/Revenues*	Working Capital/Revenues**	Profit/Liabilities and Capital***
WW Reuse Projects	21.9	21.4	2.9

Note: Standard Levels:*=10%, **=10%, ***=5%

As the above table shows, both Fuhis and Abu Nuseir projects are excellent with markedly high FIRR's and EIRR's on one hand, and with conspicuously low unit wastewater prices on the other. When the four projects are combined together, it is revealed that both FIRR and EIRR are at a reasonable level compared with discount rates, and also the unit wastewater price is substantially low compared with the set level. In terms of managerial indices, both profitability and liquidity are excellent, attesting to the high financial sustainability of the projects as a whole.

In conclusion, the 4 wastewater reuse projects combined are found to be financially as well as economically feasible from every angle, and therefore recommended as a solid candidate for implementation.

(2) Ma'an Wastewater Treatment Plant Extension Project

Generally speaking, the wastewater treatment projects are financially as well as economically difficult to be feasible without drastically raising the sewerage tariff because of a higher investment cost compared with wastewater reuse and water supply projects.

The current average sewerage tariff of 147 fils per m^3 is too low to meet the cost of this kind of projects. It is therefore assumed at the outset that it be raised gradually every year, finally to 468 fils in 2010. In economic analysis, the unit benefits of sewage was determined to be 368 fils per m^3 based on households' affordability.

In performing financial analysis, the discount rate was set at 5% in anticipation of the provision of a kind of soft loans for the implementation of the project.

The summary of the economic and financial analysis of the project is as follows:

Economic/Financial Criteria

Project	FIRR (%)	Unit Wastewater Price	EIRR (%)
Ma'an WW Treatment	5.3	420	4.5

Note: Discount Rate: Financial=5%, Economic=10%

Managerial Indices (Unit: %)

Project	Profit/Revenues*	Working Capital/Revenues**	Profit/Liabilities and Capital***
Ma'an WW Treatment	14.1	11.4	1.7

Note: Standard Levels:*=10%, **=10%, ***=5%

As the above table shows, the project is financially feasible with a higher FIRR than the discount rate, and with the unit wastewater price lower than the set one. Although, the project has an EIRR lower than the OCC, this point should not be overemphasized because it is a socially oriented project. In terms of managerial indices, both profitability and liquidity are above the standard levels, attesting to the financial sustainability of the project.

In conclusion, the Ma'an wastewater treatment plant extension project can be said to be financially as well as economically sufficiently eligible for implementation.

1.17.2 Environmental Evaluation

It is anticipated that there is no serious negative environmental impacts to be caused by reuse of treated wastewater for irrigation purpose according to the results of EIA (refer to Chapter 1.15). On the contrary, the reuse of treated wastewater will contribute for the reduction of renewable groundwater abstraction. Consequently, the reuse scheme will mitigate the regional groundwater level decline which is one of the most serious environmental problems in Jordan.