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JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF WATER AND IRRIGATION
THE HASHEMITE KINGDOM OF JORDAN

THE STUDY ON WATER RESOURCES MANAGEMENT IN THE HASHEMITE KINGDOM OF JORDAN

FINAL REPORT VOLUME IV

SUPPORTING REPORT FOR

PART-A WATER RESOURCES MANAGEMENT MASTER PLAN

CHAPTER 3 WASTEWATER EFFLUENT

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The Study on Water Resources Management in the Hashemite Kingdom of Jordan

FINAL REPORT VOLUME IV
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PART-A "WATER RESOURCES MANAGEMENT MASTER PLAN"

Chapter 3 Wastewater Effluent

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WASTEWATER SECTOR

1. Institutional framework

Since several years the water agencies of Jordan are under reorganization to increase effectiveness and responsiveness (Water Utility Policy, July 1997).

The *Ministry of Water and Irrigation (MOWI)* is the responsible body in Jordan for the water sector. It is empowered by the By-Law No. 54 of 1992.

Main functions (related to the water sector) of the Ministry comprise the following:

1. Formulation of policy framework and strategy
2. National water planning
3. Regulation on activities
4. Planning of water resources development
5. Formulation and implementation of water and wastewater programs
6. Implementation of research and development
7. Preparation of socio-economic and environmental studies
8. Monitoring of activities
9. Development of human resources
10. Data collection required for decision making
11. Establishment of central data bank
12. Establishment of an information system (Geographic Information System)
13. Dissemination of information and implementation of awareness campaigns

With the transfer of water resources studies and monitoring functions and staff from the Water Authority of Jordan to the MOWI, water resources planning and management functions are formally consolidated within the Ministry.

Two authorities are affiliated with the Ministry of Water and Irrigation, the Water Authority of Jordan and the Jordan Valley Authority. A Secretary General reporting to the Minister heads each authority.

Generally, the *Water Authority of Jordan (WAJ)* created by Law 18/1988 is responsible as a national government agency for the provision of water and wastewater services including the development and management of sewerage systems, treatment plants and reuse of the effluent in all communities and for all facilities, where private sector is not yet involved (compare section 2.3). WAJ is also responsible for water resources management including the protection of the resources.

It is intended to separate the bulk water from retail supply and, therefore, the role of WAJ will also change. In future the main responsibilities of WAJ will be the following:

1. Monitoring of private supply and wastewater disposal contracts
2. Monitoring of management contracts (BOT providers)
3. Management of water resources, bulk supplies as well as wastewater disposal of systems, which are not privatized

4. Provision of support to smaller retail distribution units, which are not operated by the private sector

According to its statutes, WAJ is an autonomous corporate body with financial and administrative independence. Generally Accepted Accounting Principles (GAAP) will be adopted. A revision of the WAJ law is under preparation to support three major reforms: protection of resources, private sector participation and sewerage connections.

The *Jordan Valley Authority (JVA)* (created by Law 19/1988 as an extension of Law 18/1977) shall develop water resources, improve environment and living conditions and carry out related works in the Jordan Valley. JVA is responsible for development of water resources for irrigational, municipal, industrial and tourist consumption. It shall plan, design and construct required infrastructure for transport (roads), water supply, sanitation and electric energy supply. It continues to handle a wide range of development responsibilities in the Valley. In addition, future development will focus on such sectors as tourism, industry, manufacturing, advanced technologies and others. The private sector is called upon to assume a proper role in development of the Jordan Valley as well as operation and maintenance activities that are being restructured on a more commercial basis.

The *Ministry of Agriculture (MOA)* is responsible for agricultural irrigation and irrigation water quality. It works in close cooperation with the MOWI on standard settings for treated wastewater reuse. MOA carries out research projects in field of wastewater reuse and its effect on crops.

The *Royal Society for the Conservation of Nature (RSCN)* and the *Jordanian Environmental Society (JES)* provide training, advisory services and awareness programs in the field of environmental protection and ecology.

2. Water policy

The Ministry of Water and Irrigation prepared a Water Strategy for Jordan. It was adopted by a joint session of the Board of Directors of both the Jordan Valley Authority (JVA) and the Water Authority of Jordan (WAJ). The strategy was approved by the Council of Ministers in 1997. Under the strategy, the Ministry and its two authorities formulate a series of policies.

2.1 Irrigation water policy

The *Policy Paper No. 2 "Irrigation Water Policy"* of February 1998 details the long-term objectives outlined in the Water Strategy of Jordan. It states water related issues of resource development: agricultural use, resource management, technology transfer, water quality, efficiency, cost recovery, management and other issues. In the following paragraphs such issues are summarized, which are of particular significance for the reuse of treated wastewater for agricultural irrigation.

Under the heading "Resource development and use" it is outlined that wastewater is a resource and cannot be treated as "waste". It shall be collected and treated to obtain a water quality that allow its reuse in irrigation unrestricted by health and public health considerations or unduly constrained by high salinity contents. After satisfying the local municipal and industrial needs from unallocated water resources, water resources shall be allocated to agricultural production including livestock. This means that in case of reuse of treated wastewater priority should be given to industrial use in comparison to agricultural use.

Advanced methods as drip irrigation, micro-sprinkler irrigation are favored over less efficient methods. Night application of irrigation water, especially in the dry season, shall be encouraged to reduce evaporation losses. Programs shall be prepared to raise the public and farmers' awareness of the availability of irrigation water, its rational and economic use and on the impacts of its quality.

Under the title "Irrigation water quality" it is said, where marginal quality water, such as treated wastewater effluent, is a source of irrigation water, care should be taken, to the maximum extend possible, to have the quality improved to standards that allow it to use for unrestricted irrigation. This can be achieved through blending with fresher water sources.

The water price shall at least cover the cost of operation and maintenance, and, subject to some other constraints, it should also recover part of the capital cost of the irrigation water project. The ultimate objective shall be full cost recovery subject to economic, social and political constraints. Part of the capital cost shall be recovered through the application of a one-time charge against irrigation rights. This is applied as a rate per unit area of the irrigated farm. The size of the portion thus recovered shall not be less than half the irrigation network development cost.

2.2 Wastewater management policy

The following paragraph summarizes present policy as stated in the *Policy Paper No. 4 "Management of Wastewater"* of June 1998.

The following key issues are presented in order to develop the Wastewater Management Policy:

1. Provision of adequate wastewater collection and treatment facilities for all the major cities in Jordan
2. Protection of the environment and public health in the areas affected by the proposed systems, especially, surface waters and groundwater.
3. Consideration of treated effluents as a source for irrigation reuse.
4. Improvement of the socio-economic conditions in the areas to be served by the proposed systems.

The policy focuses on the management of wastewater as a water resource and includes, amongst others, development, management, wastewater collection and treatment as well

as the reuse of wastewater and sludge in the agriculture, pricing, selected priority issues, standards and regulations.

Wastewater shall be collected and treated in accordance with WHO and FAO Guideline as the basis for effluent quality requirements for reuse in irrigation. The use of treated wastewater in irrigation (unrestricted irrigation) shall be given the highest priority and shall be pursued with care.

Industrial wastewater shall be recycled as much as possible within the factories. Industries shall treat the remainder of wastewater to meet the standards/regulations set for the ultimate wastewater reuse for its disposal through the collection system and/or into receiving environment.

Sludge from treatment plants shall be used for power generation, if proven technically, economically and financially feasible. It shall be processed so it may be used as fertilizer and soil conditioner for agricultural purposes.

Generally, the "polluter pays" principle shall be applied. Wastewater charges, connection fees, sewerage taxes ant treatment fees shall cover at least the operation and maintenance costs. The ultimate aim is for full cost recovery. Treated effluent shall be priced and sold to end users at a price covering at least the operation and maintenance costs of delivery.

Through private sector participation, management of infrastructure and services shall be transferred from the public to the private sector, in order to improve performance and upgrade the level of services.

2.3 Water utility policy

According to the *Water Utility Policy of July 1997* the Government intends through private sector participation, to transfer infrastructure and services from the public to the private sector, in order to improve performance and ensure the delivery of services to the population. The private sector shall be involved through management contracts, concessions and other forms in water utilities. BOT/BOO models shall be applied for water and wastewater projects. Private sector activities shall be continually monitored and assessed. In accordance with formulated Water Utility Policy, WAJ has embarked on a course of increasing private sector participation for both capital investment and management of services

The Ministry will set municipal water and wastewater charges at a level, which will cover at least the cost of operation and maintenance. It will also move towards the recovery of all part of capital costs of water infrastructure. Until the financing is full, and the national savings reach levels capable of domestic financing of development projects, project financing will depend on concessionary loans, private borrowing and/or BOO and BOT arrangements.

Under point 6 of the Water Utility Policy paper it is said that the Ministry intends to raise the effluent quantity of wastewater treatment plants from 60 million in the year

1997 to a volume of 200 million m^3 per year in the year 2020. In light of this, the Ministry is developing a wastewater master plan, which will establish targets for providing wastewater collection systems and treatment facilities to not yet serviced areas throughout the country.

Privatization of Jordan's water sector has started with a water and wastewater management contract (supported by World Bank) for Greater Amman. Contract was awarded to LEMA, a consortium of Suez Lyonnaise des Eaux - Montgomery Watson Arabtech Jardaneh. The consortium has started work in 1999. The contract comprises retail water supply including wastewater collection for the Greater Amman area. It does not include pretreatment in Ain Ghazal, conveyance of wastewater to the plant in As Samra and its treatment by this plant. Implementation of the planned new wastewater treatment plant in As Samra is intended applying the BOT concept. The contract comprises wastewater treatment by the plants in Wadi Essir and Abu Nuseir. Additionally to these measures, WAJ is considering further management contracts as well as BOT schemes for desalination of brackish and sea water and for conveyance.

3. Related standards and regulations

As far as wastewater collection, treatment, disposal and reuse are concerned, most important standards and regulations are the following:

- Treated Domestic Wastewater (Jordanian Standard JS 893/1995)
- Industrial Wastewater (Jordanian Standard JS 202/1991)
- Peace Treaty Requirements (between Jordan and Israel)
- Uses of sludge in agriculture (Jordanian Standard JS 1145/1996)
- WAJ's regulation for the quality for the industrial wastewater to be connected to the sewerage system
- WAJ's specifications for the sewerage works

The *Standard on Treated Domestic Wastewater* (Jordanian Standard JS 893/1995) defines the requirements of effluent discharge from treatment plants or reused for various types of irrigation, fisheries, discharge into natural receiving water (wadis and catchment areas) and artificial recharge of groundwater. Sampling frequency and method as well as standard methods for water analysis is specified. Generally, the treated wastewater has to meet the criteria as shown in Table 3-1. Percentage of samples, which does not meet the specified criteria, must not exceed 20 % of the number of samples collected and analyzed.

The standard pays special attention to the agricultural irrigation:

- Irrigation must not take place within two weeks before harvesting (fruit collection)
- Sprinkler irrigation is prohibited to use
- Irrigation of crops eaten raw by treated domestic wastewater is not allowed
- Closed pipes or lined canals must be used when conveying treated domestic wastewater through areas of high permeability, which might effect the groundwater aquifer or surface water used for drinking purposes

- Dilution of treated wastewater on-site with fresh water to meet the criteria is prohibited

In addition the standard states clearly that it is prohibited to recharge artificially groundwater aquifers used for drinking purposes by treated domestic wastewater.

Table 3-1: Quality criteria for treated domestic wastewater according to Jordanian Standard 893/1995

Quality parameters mg/l except otherwise indicated	Vegetab-les eaten cooked	Fruit trees, forestation, industrial crops and grains	Discharge to wadis and catchment areas	Artificial recharge	Fisheries 2)	Public parks	Fodder 1)
BOD_5 3)	150	150	50	50	-	50	250
COD	500	500	200	200	-	200	700
DO	> 2	> 2	> 2	> 2	> 5	> 2	> 2
TDS	2,000	2,000	2,000	1,500	2,000	2,000	2,000
TSS	200	200	50	50	25	50	250
PH	6 – 9	6 – 9	6 – 9	6 - 9	6.5 - 9	6 - 9	6 – 9
Color (PCU) 4)	-	-	75	75	-	75	-
FOG	8	8	8	Nil	8	8	12
Phenol	0.002	0.002	0.002	0.002	0.001	0.002	0.002
MBAS	50	50	25	15	0.2	15	50
NO_3-N	50	50	25	25	-	25	50
NH_4-N	-	-	15	15	0.5	50	-
T-N	100	100	50	50	-	100	-
PO_4-P	-	-	15	15	-	15	-
Cl	350	350	350	350	-	350	350
SO_4	1,000	1,000	1,000	1,000	-	1,000	1,000
CO_3	6	6	6	6	-	6	6
HCO_3	520	520	520	520	-	520	520
Na	230	230	230	230	-	230	230
Mg	60	60	60	60	-	60	60
Ca	400	400	400	400	-	400	400
SAR	9	9	9	9	-	12	9
Residual Cl_2 5)	0.5	-	-	-	-	0.5	-
Al	5	5	5	1	-	5	5
As	0.1	0.1	0.05	0.05	0.05	0.1	0.1
Be	0.1	0.1	0.1	0.1	1.1	0.1	0.1
Cu	0.2	0.2	0.2	0.2	0.04	0.2	0.2
F	1.0	1.0	1.0	1.0	1.5	1.0	1.0
Fe	5.0	5.0	2.0	1.0	0.5	5.0	5.0
Li	2.5	5.0	1.0	1.0	-	3.0	5.0
Mn	0.2	0.2	0.2	0.2	1.0	0.2	0.2
Ni	0.2	0.2	0.2	0.2	0.4	0.2	0.2
Pb	5.0	5.0	0.1	0.1	0.15	0.1	5.0
Se	0.02	0.02	0.02	0.02	0.05	0.02	0.02
Cd	0.01	0.01	0.01	0.01	0.015	0.01	0.01
Zn	2.0	2.0	15	15	0.6	2.0	2.0

Table 3-1: Quality criteria for treated domestic wastewater according to Jordanian Standard 893/1995 (continued)

CN	0.1	0.1	0.1	0.1	0.005	0.1	0.1
Cr	0.1	0.1	0.05	0.05	0.1	0.1	0.1
Hg	0.001	0.001	0.001	0.001	0.00005	0.001	0.001
V	0.1	0.1	0.1	0.1	-	0.1	0.1
Co	0.05	0.05	0.05	0.05	-	0.05	0.05
B	1.0	1.0	2.0	1.0	-	3.0	3.0
Mo	0.01	0.01	0.01	0.01	-	0.01	0.01
TFCC (MPN/100 ml) (6)	1,000	-	1,000	1,000	1,000	200	-
Pathogens	-	-	-	-	100,000 9)	nil	-
Ameba & Gardia (cyst/l) 7)	< 1	-	-	-	-	nil	-
Nematodes (eggs/l) 8)	< 1	-	< 1	-	-	< 1	< 1

-) N/A
1) Trace elements and heavy metals values are calculated based on the quantity of wastewater used for irrigation (1,000 m^3/donum/a), in case the quantity of water increases above the aforementioned figure the concentrations of trace elements and heavy metals decreases accordingly.
2) These figures depend upon the type of fish, pH, TDS, and T^o.
3) BOD_5 in WSP is filtered sample, but in mechanical treatment plant is non-filtered one.
4) Unit weight measured by unit of Platinum Cobalt.
5) Contact time not < 30 min.
6) Most Probable Number / 100 ml.
7) One cyst/l
8) Mean Safaris, Enclostoma, and Trycus.
9) Salmonella / 100 ml.

The *Standard on Industrial Wastewater* (Jordanian Standard JS 202/91) specifies the requirements to be fulfilled for the effluent from industries discharged into surface water or naturally recharging the groundwater or those reused for irrigation purposes. The standard does not give any indication for requirements in case of discharge of industrial wastewater into the public sewer network. This subject is of WAJ's regulation for the industrial wastewater to be connected to the sewerage system.

The maximum allowable limits of water quality parameters as stated in the standard are generally more restrictive compared with the ones valid for the treated domestic wastewater (see Table 3-1). Industrial wastewater effluent must not have any negative impact on the

- public environment, social and economic development
- quality of groundwater and surface water and aquatic life
- health and safety of the workers and consumers of harvested products in case of industrial wastewater effluent is use for agricultural irrigation

For such criteria not mentioned in the list of maximum allowable limits it is referred to the detailed environmental impact assessment (EIA), which has to be prepared for any industrial factory.

In addition the Annex II of the *Peace Treaty Requirements* have to be respected as far as the effluents of the considered treatment plants are discharged directly or indirectly into common receiving water (such as the Jordan or the Yarmouk River), where a water quality standard is required allowing unrestricted agricultural use (see Annex 2.1).

The Jordanian Standard JS 1145/96 describes the regulation on *Uses of Sludge in Agriculture* (sludge produced in wastewater treatment plants). According to the standard it is prohibited to use untreated sludge for agricultural purposes. As defined, treated sludge is understood as sludge exposed to any of the following treatment methods:

Level 1: It aims to a reduction of pathogens and helminth eggs in the sludge. It can be achieved by one of the following processes:

- Aerobic digestion
- Aerobic drying
- Anaerobic digestion
- Fermentation
- Treatment by raising the pH of the liquid sludge

Level 2: It requires a higher reduction of pathogens in the sludge than the one of level 1. It can be achieved by one of the following processes:

- Fermentation
- Drying by heating
- Heating aerobic digestion

With respect to the fact that most of the treatment plants in Jordan dispose of drying beds, sludge treatment of level 1 can be achieved by these facilities. However, concerning the sludge drying process it has to be respected that the sludge thickness for drying should not exceed 23 cm and the sludge must remain in the drying beds for at least 3 months, whereby daily temperature should be over 0 °C for 2 months out of three months.

Sludge treated by level 1 process may be used as a conditioner for improving the Badia soil characteristics (Badia = desert region of Jordan). It is required to plough it directly especially those lands that are identified for forestation. Treated sludge shall be added during the period between early April and late June.

The use of treated sludge underlies certain requirements concerning

- the maximum allowed content of certain trace elements in sludge (Table 3-2)
- the maximum annual allowed application of certain trace elements on agricultural land (Table 3-2)
- the maximum accumulation of certain trace elements in the soils (Table 3-2)
- the maximum allowed content of certain biological pollutants (Table 3-3)

Using treated sludge in the agriculture, potential pollution of groundwater basins, reservoirs, wadis, surface water and water-harvesting projects have to be taken into consideration.

The use of treated sludge for agricultural purposes is controlled by related "official organizations". However, such organizations are not specified in the standard.

Table 3-2: Maximum allowed limits of trace elements in treated sludge

Element	Concentration in sludge (mg/kg dry)	Average application of element (kg/ha/365 days)	Maximum accumulation of element in soil (kg/ha)
As	75	2	41
Cd	85	1.9	39
Co	150	1.8	36
Cr	3,000	150	3,000
Cu	4,300	75	1,500
Hg	57	0.85	17
Mo	75	0.9	18
Ni	420	21	420
Pb	840	15	300
Se	100	5	100
Zn	7,500	140	2,800

dry: total dry solids

Table 3-3: Maximum allowed limits of biological pollutants in treated sludge

Microorganisms	Limits of pollutant in sludge (first level treatment)	Limits of pollutant in sludge (2nd level treatment)
Fecal coliforms (MPN)	$2*10^6$ per g	$1*10^3$ per g
Salmonella	-	< 3 / 4 g dry
Viable nematode eggs	-	< 1 / 4 g dry
Intestinal viruses	-	< 1 (unit) / 4 g dry*

dry: total dry solids

The Ministry of Water and Irrigation has prepared a new *Regulation for the Commercial and Industrial Wastewater to be Discharged into the Public Sewerage System*, which came in force December 1998 and has replaced the existing one of 1988.

The solid and liquid wastes, prohibited for discharging into the public sewerage systems, are specified. Limits of their physical and chemical properties are given. Maximum allowed concentration of certain toxic elements and heavy metals in the wastewater are presented. The regulation states that dilution with freshwater is not allowed to reach the limits.

The regulation states that the disposal of any commercial or industrial wastewater, whether it is polluted or unpolluted, is prohibited before getting a written approval from

the Water Authority. The approval application for connections to the public sewerage system shall contain the proposed industrial activities, the quantity of freshwater required, the expected physical, chemical and biological properties of wastewater produced as well as a description of proposed pre-treatment (if any). Preliminary approval is issued on the basis of this information. It will be reconsidered after six months of commercial or industrial plant's operation and a final approval will be prepared. The Water Authority can demand a pre-treatment of the wastewater prior to the discharge into the sewerage network depending on its harm in the collection network, in the treatment plant, on the treatment process or after its final disposal.

The Water Authority shall charge the commercial and industrial institutions shall be charged for the connection to the network. The consumed water that is subjected to the wastewater service fee shall include

- the water supplied by the public supply system,
- the groundwater extracted by own wells of the factory,
- the water supplied by tankers.

Additionally, the Water Authority shall charge these institutions, if their wastewater to be discharged into the public sewerage system exceeds the concentration of 1,500 mg COD/l. The additional fee is calculated on the basis of the COD-load.

WAJ has published in 1995 *General Technical Specifications for Sewerage Works.* It specifies general and technical requirements, excavation and earthwork, backfilling, concrete and reinforced concrete, pipes and pipe laying, manholes as well as the outline for bill of quantities.

4. Supervision of wastewater treatment and disposal

The *Water Authority* conducts daily, weekly and monthly water sampling and analysis to supervise the treatment operation and to assure effluent compliance with the set standards. Most of the wastewater treatment plants have a small laboratory for routine water quality analyses. It serves for self-surveillance of the treatment efficiency. Additional water quality analysis is undertaken in the central laboratory of WAJ. In particular the following parameters are analyzed: pH, EC (electric conductivity), TDS (total dissolved solids), TSS (total suspended solids), BOD_5, COD, SO_4, NO_3, MBAS, PO_4, total coliforms, fecal coliforms.

The *Ministry of Health (MOH)* carries out additional water quality analysis with emphasis on coliforms and nematode eggs in addition to other parameters. The monitoring program includes all 17 treatment plants of Jordan. Water quality analysis comprises pH, BOD_5, COD, TDS (total dissolved solids), TSS (total suspended solids). Microbiological analysis includes total coliforms and fecal coliforms and pathogenic enteric bacteria. Results are summarized in special reports. MOH inspects periodically and regularly the treatment plants to make sure that no adverse health effects are resulting from the plants.

The *General Corporation for Environmental Protection (GCEP)* carries out inspection and has enforcement responsibilities. However, GCEP does not conduct water sampling and analysis itself, but has contracted the Royal Scientific Society (RSS) to carry out programs to study treatment efficiency, effect of treated wastewater on the receiving water and the suitability of treated wastewater for agricultural reuse. Results of the studies are handed over to WAJ.

The results of water quality analysis (bacteriological tests) done by WAJ and the Ministry of Public Health differ in some cases significantly. In the frame of this report we rely in particular on the results found by WAJ (if no other source is mentioned).

The reuse of treated wastewater is supervised by WAJ and MOH, if the irrigated land (restricted irrigation) is within the treatment plant area. MOH, the *Ministry of Agriculture (MOA)* and the GCEP monitors restricted irrigation by treated wastewater downstream of the plant. Finally, the *Jordan Valley Authority (JVA)* and the MOA supervise the unrestricted irrigation by treated wastewater mixed with freshwater. Supervision is based on the criteria as laid down in the Jordanian Standard 893/1995. It is said that 4 donums of vegetables was destroyed in 1998, because the standards were not respected. In 1996 even 1,200 donums were destroyed.

5. Basic sector data

Jordan's population is estimated to some 4.9 million (1999). Annual growth rate during the last years (1994/2000) was 3.6 %, with a decreasing tendency. The population has been augmented by mainly three population influxes: after the Arab-Israeli war of 1948 (450,000 Palestinian refugees) and 1967 (400,000 Palestinian refugees) and the returnees (300,000 people) during the Gulf Crisis of 1990. About 78 % of the population lives in urban areas, while 22 % located in rural areas. Most of the urban population lives in the northern Governorates of Amman, Zarqa, Irbid, and Balqa. Basic demographic data are summarized in Table 5-1.

Table 5-1: Demographic data

Urban areas	mio. people	3.59
	%	78
Size of household (h.h.)	c/h.h.	6,1
Rural areas	mio. people	1.01
	%	22
Size of household (h.h.)	c/h.h.	6,6
Total Jordan	mio. people	4.60
Size of household (h.h.)	c/h.h.	6,2
Population growth	%	3.5

Total water use in 1997 amounted to about 880 MCM, where the use for agricultural irrigation dominates with about two third of the total water demand. Portion of municipal and industrial water use is one third only (see Table 5-2).

Table 5-2: Water use (1997)

Municipal	MCM	239
	%	27
Industrial	MCM	37
	%	4
Irrigation	MCM	592
	%	67
Livestock	MCM	11
	%	1
Total	MCM	879

About half of Jordan's population is connected to public wastewater disposal systems. The remainder of the population relies on cesspools and other on-site facilities. However, public systems are concentrated in the cities, insofar as two third of the urban population and only less than 5 % of the rural population is served by public disposal systems (see Table 5-3).

Table 5-3: Wastewater disposal (1997)

		Publ.system	**Cesspools**	**Others**
Urban areas	%	64.7	35.0	0.3
Rural areas	%	2.8	95.0	2.2
Total Jordan	%	49.2	50.0	0.8

Generally, drainage is done by separate systems, where wastewater is collected in mostly closed pipes and stormwater is discharged in mainly open canals and natural watercourses (wadis, rivers). However, it is reported that in some of the sewerage systems there is a considerable number of connections of stormwater to the system leading locally to surcharge of the sewers.

Total length of sewers is estimated to some 3,200 km resulting in a specific pipe length of 1.2 m per connected person. This value is rather low, again reflecting that most of the population served are living densely populated urban areas (0.8 m/c in Greater Amman, which has a share of more than 75 % of the total connected population in Jordan). The number of capita per house connection is some 16 - also high due the same reasons. Table 5-4 shows present the situation concerning existing sewerage.

Table 5-4: Wastewater collection (1999)

		Total Jordan	**Gr. Amman**
Population connected	mio.	2.58	1.95
(of Jordan's total population)	%	56	42
Length of sewers	km	3,200	1,500
Length per connected capita	m/c	1.2	0.8
House connections	h.c.	158,400	105,900
Capita per house connection	c/h.c.	16.3	18.4

Wastewater is treated in 16 treatment plants located in the urban centers of Jordan. Most of the plants rely on treatment by wastewater stabilization ponds consisting of mechanical treatment, anaerobic, facultative and maturation ponds. About 85 % of the wastewater is treated by these systems, while activated sludge process is applied for 5 % and trickling filters for 10 %.

It has to be mentioned that half of the installed treatment capacity belongs to As Samra treatment plant with about 68,000 m^3/d. The present discharge to this plant, however, is the double of its design capacity. About 80 MCM of wastewater per year is treated in available facilities. Almost 60,000 tons of BOD_5 are annually discharged to the existing plants.

The specific wastewater generation is calculated to about 85 l/c/d including municipal, tourist and industrial wastewater. Specific BOD_5-load is relatively high in Jordan and is estimated to some 65 g/c/d. The specific load comprises municipal and industrial sources of organic load, too, which gives a wrong picture of sources of pollutional load. In some cases the reason for this could be that the portion of BOD_5-load coming from industrial activities are higher than the portion of water use reflects it. Therefore, the real specific load generated per person could be lower.

Details of existing wastewater treatment are shown in Table 5-5.

Table 5-5: Wastewater treatment (1999)

		Total Jordan	**As Samra**
Existing treatment plants (total number)	no.	17	1
Wastewater stabilization ponds	no.	6	1
Aerated ponds	no.	1	-
Activated sludge/Extended aeration	no.	5	-
Trickling filters	no.	5	-
Installed capacity	m^3/d	157,100	68,000
Population connected	mio.	2.58	1.95
(of Jordan's total population)	%	56	42
Inflow of treatment plants	m^3/d	217,800	166,900
	MCM/a	79	61
Effluent of treatment plants	m^3/d	168,800	125,100
	MCM/a	62	46
BOD_5-load inflow (average)	mg/l	778	760
	kg/d	169,400	126,800
	t/a	61,800	46,300
(related to total BOD_5 -load)	%	100	75
Spec. wastewater generation	l/c/d	84	86
Spec.BOD_5-load	g/c/d	66	65

Wastewater effluent is generally not measured in the treatment plants. Losses due to seepage and evaporation within the treatment plants are estimated (as weightened average) to 22 % of the influent. This high portion may be justified by the fact that 85 % of the wastewater is treated by pond systems and maturation ponds, where these losses are of high importance, follow even some of the plants of conventional treatment processes. Therefore, about 60 MCM of wastewater would be available at treatment facilities outlet. In addition, losses have to be considered taking place during transmission and storage in particular for the effluents flowing in the wadis and stored in King Talal, Wadi Shua'ab and Kafrein Reservoirs. Again these losses were estimated to 10 %. Finally, 50 MCM/a may be available at the agricultural land for restricted and unrestricted irrigation (see Table 5-6).

Treated wastewater presently reused for agricultural irrigation purposes would be then estimated to some 8 % of the total irrigation water use. Restricted irrigation by the treatment plant's effluent is applied in the direct neighborhood of the plants and downstream of them without any dilution with freshwater. Unrestricted irrigation takes place, in particular, in the Jordan Valley by treated effluent in particular of As Samra treatment plant after mixing with freshwater (generally one portion wastewater to 3 portion freshwater). Treated wastewater quantity for restricted irrigation is estimated to about 15 MCM and for unrestricted irrigation to about 35 MCM.

Table 5-6: Quantities of reused treated wastewater (1999)

Total irrigation water (including treated sewage)	MCM/a	630
Total wastewater for irrigation	MCM/a	50
Portion of total irrigation water	%	8
Wastewater for restricted irrigation[1)]	MCM/a	15
Wastewater for unrestricted irrigation [2)]	MCM/a	35
Via King Talal Reservoir[3)]	MCM/a	34
Via Wadi Shua'ab Reservoir[4)]	MCM/a	0.8
Via Kafrein Reservoir[5)]	MCM/a	0.2

1) Inside, near to or downstream of the treatment plants' area (estimation)
2) Deducted by 10 % for transmission/storage losses and local use. Used after mixing (about 1 : 3) with freshwater in the Jordan Valley
3) Treated effluent of As Samra, Baqa, Jerash and Abu Nuseir Treatment Plants
4) Treated effluent of Salt and Fuhis Treatment Plants
5) Treated effluent of Salt and Fuhis Treatment Plants Treated effluent of Salt and Fuhis Treatment Plants

Restricted irrigation is done for about 16,000 donums and unrestricted irrigation for about 91,000 donums (see Table 5-7). While restricted irrigation is limited to fodder, cereal as well as olive, citrus and forest trees and bananas, comprises unrestricted irrigation various vegetables, additionally.

Tables 5-6 and 5-7 summarize the present situation regarding reuse of treated wastewater and irrigated areas.

Table 5-7: Areas irrigated by treated wastewater (1998)

		Total Jordan	**As Samra**
Area of restricted irrigation near treatment plants			
Fodder	donums	1,770	300
Olives	donums	1,697	1,500
Forests	donums	3.187	1,500
Total	donums	6,654	3,300
Area of restricted irrigation downstream of treatment plants			
Fodder, cereal [1)]	donums	2,000	
Forests trees [2)]	donums	500	
Fruit [3)]	donums	6,500	
Vegetables [4)]	donums	0	
Total	donums	9,000	
Area of unrestricted irrigation downstream of treatment plants [5)]			
Fodder, cereal [1)]	donums	6,500	
Forests trees [2)]	donums	1,000	
Fruit [3)]	donums	25,000	
Vegetables [4)]	donums	58,500	
Total	donums	91,000	

1) Barley, sudan grass, alfalfa, maize (forage)

2) Acacia, cassorina, eucalyptus, etc.

3) Olive, citrus, banana, others

4) Different vegetables

5) After mixing (about 1 : 3) with freshwater in the Jordan Valley

6. Cost for wastewater disposal and tariff for wastewater services

In the *Water Utility Policy, July 1997* of MOWI it is said that municipal water and wastewater charges shall be set at a level, which will cover at least the cost of operation and maintenance. The Ministry will also move towards the recovery of all or part of the

capital costs of water infrastructure. Profitable undertakings in industry, tourism, commerce and agriculture shall be made to pay fair cost. The Ministry will attempt to set differential prices for the water based on water quality, the end users and the social and economic impact of prices on the various economic sectors and regions of the country.

According to calculations of wastewater services cost for wastewater treatment (in 1999 for operation and maintenance only) ranges between 0.010 (As Samra) and 0.240 JD/m^3 (Tafielah). The lowest cost were found for wastewater stabilization pond systems, while the highest costs were found for plants using activated sludge and trickling filters.

For emptying the cesspools of buildings not connected to the public sewerage system cost for the haul of 1 m^3 of sludge to the nearest treatment plant or other disposal site was determined to be between 1 and 2 JD.

Tariffs for water supply and wastewater disposal services (applied for residents and non-residents and effective since October 1997) are shown in Table 6-1. The tariff structure is composed of three segments: For the lower and upper segment the tariff is proportional to the consumption. For the segment in between the tariff is constantly increasing. Figure 6-1 visualizes the structure. Only such customers, who are connected to the sewerage system, have to pay for wastewater disposal.

Table 6-1: Tariffs for water and wastewater services

Residential Consumers

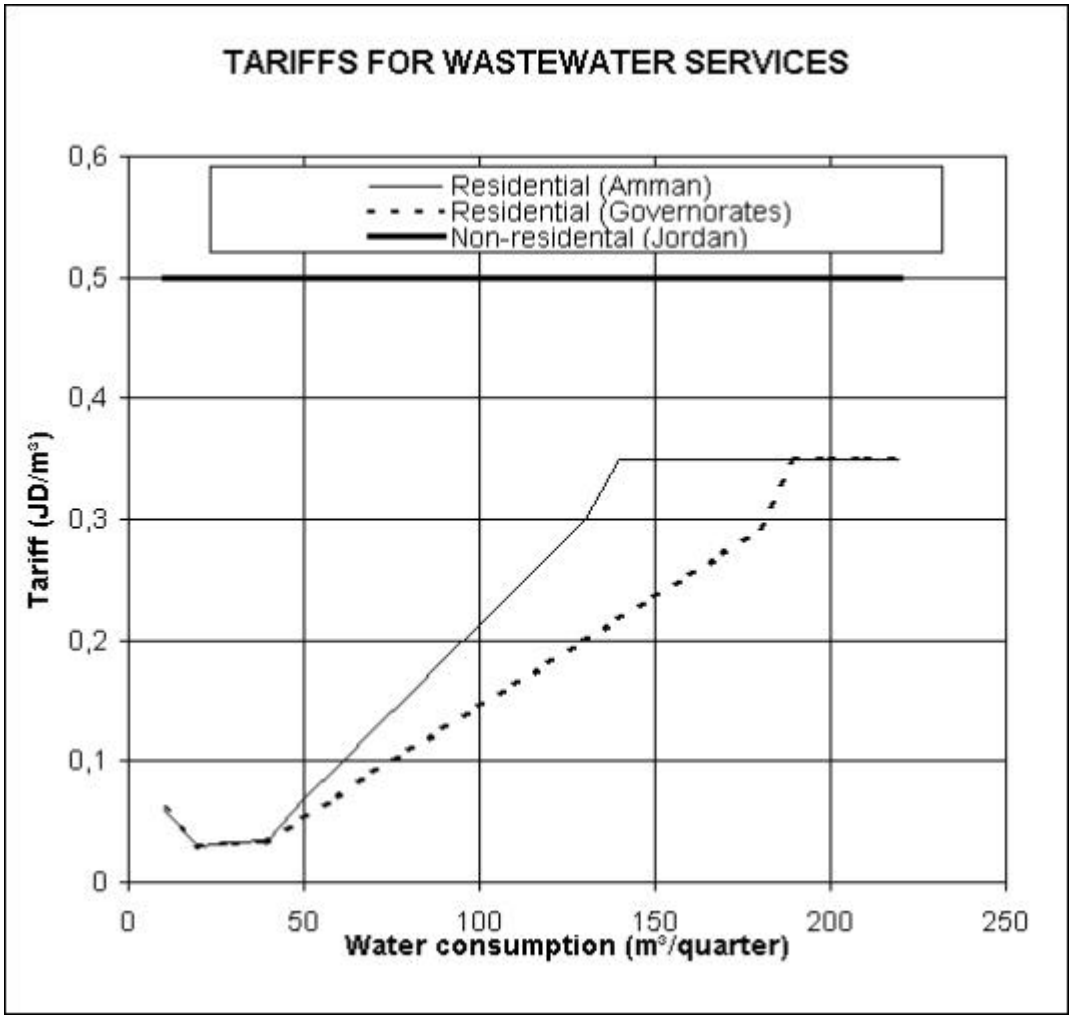
Consumption m^3/quarter	Water meter fee JD/quarter	Water tariff JD/quarter	Wastewater tariff JD/quarter
Amman			
0 – 20	0.3	2	0,6
21 – 40	0.3	0.14X - 0.8	0.04X - 0.2
41 – 130	0.3	$0.006556X^2$ - 0,12224X	$0.002889X^2$-0,07556X
> 130	0.3	0.85X	0.35X
Governorates			
0 – 20	0.3	1,3	0,6
21 - 40	0.3	0.075X - 0.2	0.035X - 0.1
41 - 185	0.3	$0.004517X^2$ - 0,10558X	$0.001828X^2$-0,038103X
> 185	0.3	0.85X	0.35X

1) X = water consumption in m^3/quarter

Non-residential consumers(Jordan)

	Water tariff JD/m^3	Wastewater tariff JD/m^3
Tariff	1	0,5

Figure 6-1: Tariff structure for wastewater services



ANNEX to 3.1.1

Description of Existing Treatment Plant

Annex to 3.1.1
Description of Existing Wastewater Treatment Plants

Contents

1. ABU NUSEIR TREATMENT PLANT

The wastewater of Abu Nuseir Housing Area (belonging to Greater Amman) is collected and discharged to the treatment plant of the same name. Only less than 1 % of the wastewater of Greater Amman is discharged to this plant. Remaining wastewater of Amman is treated in As Samra and Wadi Essir treatment plant, whereby the treatment plant in As Samra receives about 99 % of the sewage generated in Greater Amman area.

At the entrance of the wastewater treatment in Abu Nuseir a stormwater overflow tank (equalizing tank) is located to receive excess stormwater and to treat it partially by settling process. Physical treatment facilities comprise 2 screens (manual) and 2 aerated grit chambers. Biological treatment is based on an activated sludge process comprising primary settling tanks, rotating biological cylinders, activated sludge tanks and secondary settling tanks (see Figure 1). Treated wastewater may be chlorinated, if required.

Excess sludge is treated by aerated digesters and sludge thickeners. Formerly, the thickened sludge was dewatered by a belt filter. However, the press is now out of operation due to high operation cost. At present, the thickened sludge of the Abu Nuseir Treatment Plant is transported by tankers to Ain Ghazal pretreatment plant and conveyed together with the raw wastewater of Amman to the As Samra Treatment Plant. The existing treatment plant lacks basic facilities for sludge dewatering and stabilization such as sludge drying beds.

The design capacity of the treatment plant (put in operation in 1988) is 4,000 m^3/d, of which presently one third is used only. Therefore, one of the two trains is in use only and, in addition, the rotating biological cylinders are not operated. There are significant problems with floating/bulking sludge in the secondary settling tank which is most probably due to development of filamentous bacteria in the activated sludge. The reasons for this problem could be the particular quality of the wastewater and/or the operation of the treatment plant. The causes have to be studied and specific measures defined to reduce the development of bulking sludge.

Main receiving water is Wadi Bereen discharging via Wadi Zarqa finally into the King Talal Reservoir. The effluent of the plant (<20 mg BOD_5/l) does meet the requirements according to the relevant Jordanian Standard 893/1995 for discharge into wadis and catchment areas. Due to the chlorination of the effluents of the plant the fecal coliform count is less than 1,000 in 100 ml, but the helminth eggs are still too high to allow unrestricted agricultural irrigation. The effluent can be reused for restricted irrigation only.

The treatment plant of Abu Nuseir is operated by the consortium of Suez Lyonnaise des Eaux - Montgomery Watson Arabtech Jardaneh. Related contract comprises retail water supply including wastewater collection for the Greater Amman area and operation of Wastewater Treatment Plant Abu Nuseir. 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 fourth month (heavy metals).

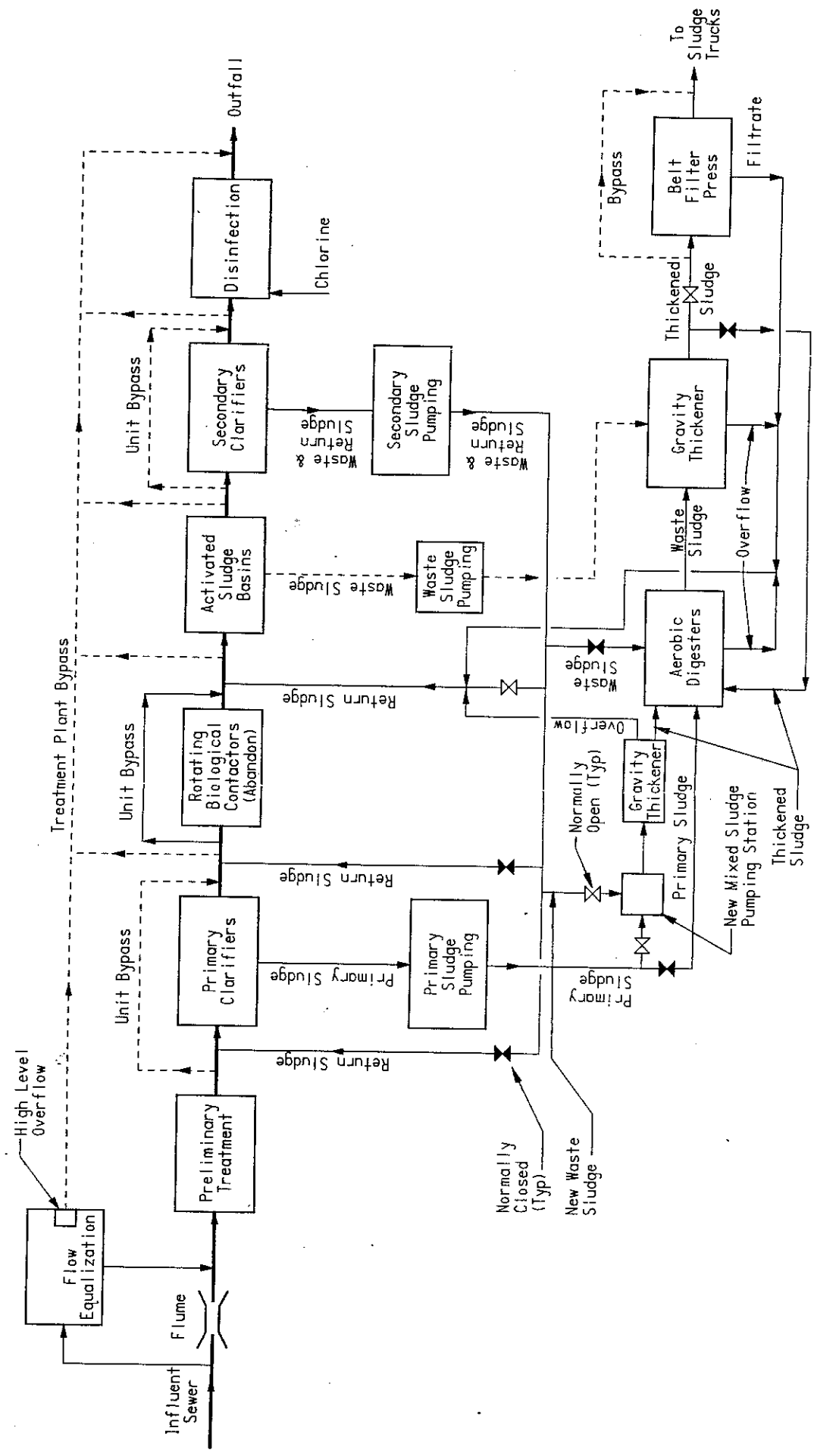


FIGURE 1: Schematic Layout of Existing Wastewater Treatment Plant - ABU NUSEIR

BASIC DATA OF TREATMENT PLANT: Abu Nuseir

(Data of 1999, if not another year indicated) 1

Town:	Amman
Governorate:	Amman
Treatment plant:	Abu Nuseir
Date of visit:	21.3.2000
Responsible engineer:	Mufeed Abdul Jabbar, LEMA
Contacted person:	Mufeed Abdul Jabbar, LEMA
Telephone:	06/5235472(plant), 05/4871631(priv)

Population

Tot.population living in towns with sewerage:	inhabitants	22.400
Population growth	%	3,6

Wastewater disposal

Public system	%	62
Cesspools	%	38
Others	%	0

Wastewater collection

Towns/villages connected (the most important)	-	Abu Nuseir Housing Area
Population connected (as coverage treatment)	c	13.800
Coverage	%	62
Important industries	-	no important water polluting industries connected
Number of stormwater overflows works	no.	1 (at the treatment plant)
Length of sewers	km	22,0
Length per connected capita	m/c	1,6
House connections	h.c.	2.200
Capita per house connection	c/h.c.	6,3
Return factor (acc. to Design Report)	-	0,8
Monthly peak factor	-	1,10
Employees for wastewater collection	E	together with As Samra
Factor: Sewer length per connected capita/coverage		2,6

BASIC DATA OF TREATMENT PLANT:

Abu Nuseir 1

Wastewater treatment

Wastewater treatment technology			AS+RBC
Wastewater treatment technology			Activated sludge plus rotating biological cylinders
In operation since			1988
Composed of treatment facilities			
	Facility		Equalizing/stormwater tank
	Number of units	-	1
	Total dimension		
	Facility		Screens
	Number of units	-	2 (manual)
	Total dimension		
	Facility		Aerated grit chamber
	Number of units	-	2
	Total dimension		
	Facility		Primary settling tanks
	Number of units	-	2
	Total dimension		(2 x 209) m3
	Facility		Rotating biological contactors (none in use)
	Number of units	-	2
	Total dimension		(2 x 520) m3
	Facility		Act.sludge tanks (caroussels)
	Number of units	-	2
	Total dimension		(2 x 2,100) m3
	Facility		Secondary settling tanks
	Number of units	-	2
	Total dimension		(2 x 418) m3
	Facility		Aerated digesters
	Number of units	-	2
	Total dimension		(2 x 1,100) m3
	Facility		Chlorination unit
	Number of units	-	1
	Total dimension		
	Facility		Sludge thickener
	Number of units	-	1
	Total dimension		(2 x 250) m3
	Remarks:		Only one train in operation Existing sludge belt filter press out of operation

Installed capacity	m^3/d	4.000
Population served (assuming 65 g/c/d)	c	13.800
Coverage (assuming 65 g/c/d)	%	62
Inflow treatment plant (average)	m^3/d	1.411
	MCM/a	0,515
Estimated losses by seepage/evaporation	%	5
Estimated effluent of the treatment plant	m^3/d	1.340
	MCM/a	0,489
BOD_5-load influent (according to WAJ data)	mg/l	634
	kg/d	895
	t/a	327
BOD_5-load effluent (according to WAJ data)	mg/l	17
	kg/d	23
	t/a	8
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	< 1,000 (due to chlorination)
Helminth eggs	eggs/l	>1
Spec.wastewater generation	l/c/d	102
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	823
Sludge management		Sludge by tankers to As Samra TP via Ain Ghazal Existing sludge press out of operation

BASIC DATA OF TREATMENT PLANT:

Abu Nuseir 1

Cost of wastewater treatment

Operation and maintenance cost	JD/a	86.387
Operation/maintenance cost related to influent	JD/m^3	0,168

Performance of wastewater collection

Employees for wastewater collection	E	together with As Samra
Number of employees per 1,000 house conn.	E/1000 h.c.	1,3
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,9
Average number of complaints per month	1/month	#
Average number of complaints per km sewer	1/month/km	#WERT!

Performance of wastewater treatment

Treatment efficiency (BOD_5 acc.to WAJ data)	%	97
Expected efficiency (acc.to experience)	%	90 - 95
Used treatment capacity (hydraulic)	%	35
Odor problems	-	not particularly
Specific treatment problems		floating sludge at sec.settling tanks
Power-cuts		1 per year, no problem
Operation/maintenance arrangement available		?
Employees for wastewater treatment	E	18
Recommended number of employees (WWTP)	E	3

Environmental impacts of effluent

Discharge of effluent into	Wadi Bereen to King Talal Reservoir
Requirements acc. to JS 893/1995 (according to WAJ data)	respected

Reuse of effluent for agricultural irrigation

Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		neclectable upstream of King Talal Reservoir
Practice of unrestricted irrigation		downstream of King Talal Reservoir (after dilution)
Irrigation near treatment plant	donums	7

Evaporation/infiltration losses of treatment plants:

		%
Wastewater stabilization ponds	WSP	25
Activated sludge process/Trickling filters	AS/TF	5
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP	10
Aerated ponds incl. maturation ponds	Aer.ponds	20

2. AQABA TREATMENT PLANT

Aqaba Treatment Plant receives wastewater of the city of Aqaba only. The wastewater discharge to the treatment plant relies on 2 pumping stations. Stormwater inflow into the sewerage network is not relevant because annual precipitation in the Aqaba region is very low (50 mm/a). The total length of the sewerage system is some 210 km or about 4.1 m per inhabitant (resident). The reasons for this relatively high value have to be seen, particularly, in the high number of big hotels and in large areas of Aqaba provided with all infrastructure including sewer networks but not yet built up.

Beside the wastewater generation by residents sewage is produced to a high extend by the tourist facilities of Aqaba comprising more than 4,100 beds. So, specific wastewater generation is more than 180 l/c/d related to capita number of residents. Due to high water consumption, the BOD_5-concentration in the raw sewage is relatively low (350 mg BOD_5/l).

The wastewater stabilization pond system of the treatment plant of Aqaba comprises the following facilities: manual screen, two identical parallel trains of sealed facultative pond and a maturation pond (see Figure 2). Anaerobic ponds do not exist. A chlorination plant is not available.

In 1997, the anaerobic ponds were desludged for the first and the only time, since the treatment facilities were put in operation in 1987. Sludge was emptied of the ponds and filled in excavated trenches within the treatment plant area and covered by earth.

The average BOD_5-concentration in the effluent was 110 mg/l in 1999 and exceeds the relevant Jordanian Standards 893/1995 for discharge into wadis and catchment areas. The natural receiving water of the effluent is the Wadi Araba, which mouths into the Gulf of Aqaba. However, it was decided to avoid any discharge into the Gulf to protect the aquatic environment and the quality of seawater. Therefore, the treated wastewater of the plant is partly evaporated and infiltrated at the plant site and partly reused for agricultural irrigation. It is estimated that out of the total inflow to the plant

- 30 % is used for irrigation
- 40 % is evaporated and/or infiltrated by the so-called evaporation ponds
- 30 % is evaporated in the facultative and maturation ponds

In several unsealed ponds (downstream of the maturation ponds) of a total surface of 200,000 m^2 the treated wastewater is evaporated and infiltrated into the groundwater. These ponds are mostly arranged in series so that the water quality is by far better than the one measured at the outlet of the maturation ponds. It is said that about 120 species of birds are counted at the area of these evaporation/infiltration ponds.

Presently 250 donums are used for agricultural irrigation, 1,000 donums for forest irrigation south of the plant and 300 donums for forest irrigation north of the plant. The effluent quality does not meet the biological requirements for unrestricted reuse of treated wastewater for agricultural irrigation. The fecal coliform counts range between 5,000 up to 1 million per 100 ml. Due to the treated wastewater having still high contents of organic compounds it is not advisable to use the existing chlorination plant for reduction of the bacterial pollution (fecal coliform count).

There is still sufficient space available north of the plant, which could be transformed in agricultural land and be used to extend irrigation activities. Additionally, green spaces within the town of Aqaba could be irrigated by treated wastewater, in particular, the trees and bushes along the roads. This kind of reuse of treated wastewater is also supported by the responsible persons of local WAJ-Office.

The hydraulic capacity of the 1987 completed plant is meanwhile reached. Therefore, in 1999 U.S. American Consulting Engineers Montgomery and Watson have prepared a Feasibility Study for a new treatment plant for Aqaba. The study and implementation will be financed by USAID.

According to the proposal made in the Feasibility Study wastewater shall be pretreated by screens and 2 aerated grit chambers. Biological treatment shall be based on an activated sludge process (extended aeration) comprising activated sludge tanks and secondary settling tanks. Additional treatment shall be provided by maturation (polishing) ponds using the existing ponds.

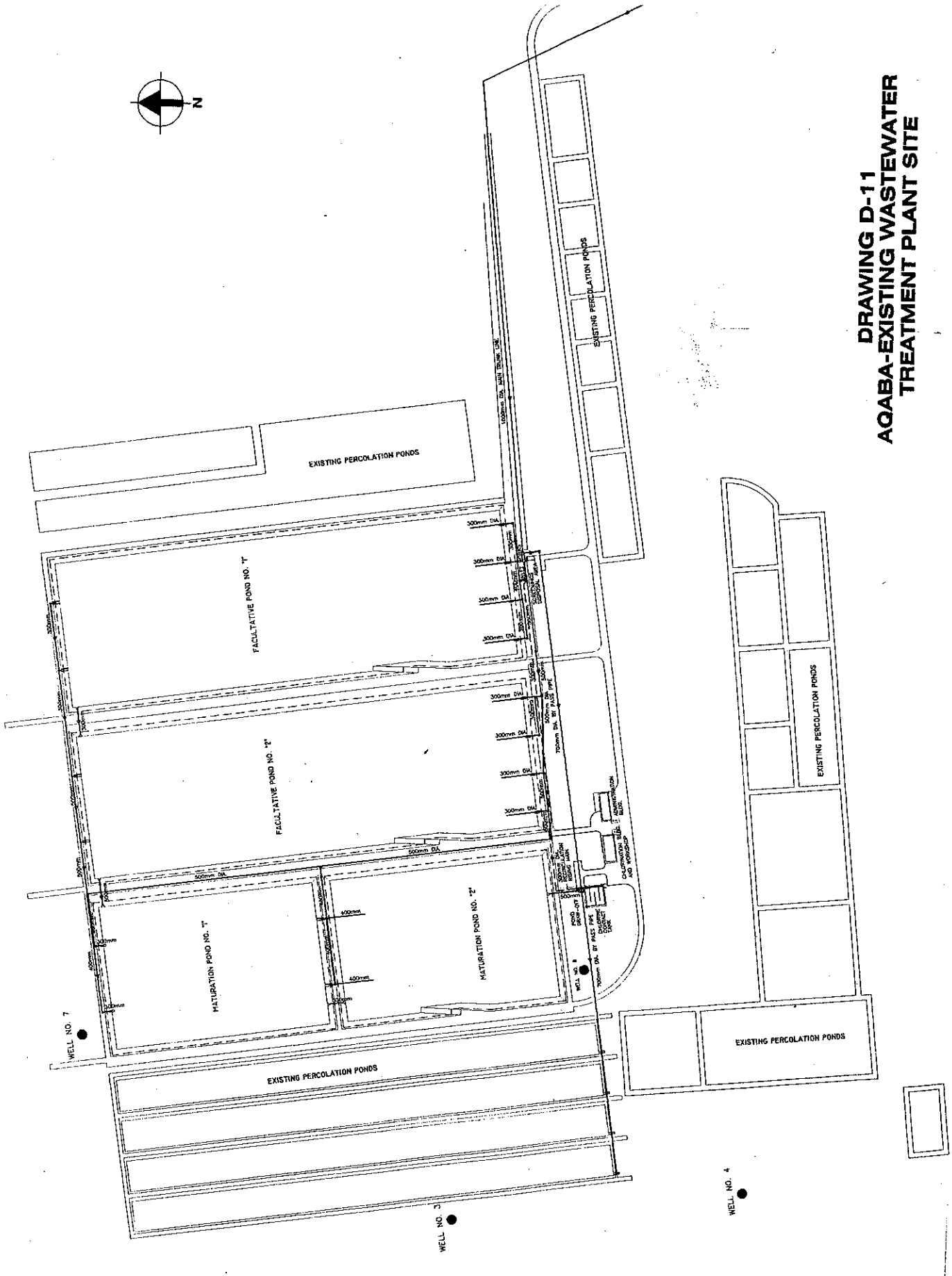


FIGURE 2: Schematic Layout of Existing Wastewater Treatment Plant - AQABA

BASIC DATA OF TREATMENT PLANT:

Aqaba
2

(Data of 1999, if not another year indicated)

Town:	Aqaba
Governorate:	Aqaba
Treatment plant:	Aqaba
Date of visit:	3.4.2000
Responsible engineer:	Jamal Musa Reyati
Contacted person:	Jamal Musa Reyati
Telephone:	03/2016818

Population

Tot.population living in towns with sewerage:	inhabitants	74.000
Population growth	%	3,6

Wastewater disposal

Public system	%	64
Cesspools	%	36
Others	%	0

Wastewater collection

Towns/villages connected (the most important)	-	Aqaba including hotels (about 4,100 beds)
Population connected (as coverage treatment)	c	47.600
Coverage	%	64
Important industries	-	no important water polluting industries connected
Number of stormwater overflows works	no.	none (not important, 50 mm annual precip.only)
Length of sewers	km	229,0
Length per connected capita	m/c	4,8
House connections	h.c.	5.030
Capita per house connection	c/h.c.	9,5
Return factor (acc. to Design Report)	-	0,9
Monthly peak factor	-	1,15
Employees for wastewater collection	E	16
Factor: Sewer length per connected capita/coverage		7,5

BASIC DATA OF TREATMENT PLANT:

Aqaba 2

Wastewater treatment

Wastewater treatment technology		WSP
Wastewater treatment technology		Wastewater stabilisation ponds
In operation since		1987
Composed of treatment facilities		
Facility		Screen
Number of units	-	1 (manual)
Total dimension		
Facility		Facultative ponds
Number of units	-	2 (in parallel)
Total dimension		2 x 105,000 m3
Facility		Maturation ponds
Number of units	-	2 (in series)
Total dimension		2 x 50,000 m3
Facility		Evaporation/infiltration ponds
Number of units	-	about 20
Total dimension		200,000 m2 and 1.5 m deep
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		-
		-

Installed capacity	m^3/d	9.000
Population served (assuming 65 g/c/d)	c	47.600
Coverage (assuming 65 g/c/d)	%	64
Inflow treatment plant (average)	m^3/d	8.774
	MCM/a	3,203
Estimated losses by seepage/evaporation	%	25
Estimated effluent of the treatment plant	m^3/d	6.581
	MCM/a	2,402
BOD_5-load influent (according to WAJ data)	mg/l	353
	kg/d	3.097
	t/a	1.130
BOD_5-load effluent (according to WAJ data)	mg/l	111
	kg/d	730
	t/a	267
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	4,700 up to 1 mio.
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	184
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	879
Sludge management		Desludging of anaerobic ponds once in in 13 years (1997) Sludge dried in ditches and covered by earth within the treatment plant area.

BASIC DATA OF TREATMENT PLANT:

Aqaba 2

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	50.900
Operation/maintenance cost related to influent	JD/m^3	0,016
Performance of wastewater collection		
Employees for wastewater collection	E	16
Number of employees per 1,000 house conn.	E/1000 h.c.	3,2
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,7
Average number of complaints per month	1/month	350
Average number of complaints per km sewer	1/month/km	1,5
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	69
Expected efficiency (acc.to experience)	%	80 - 90
Used treatment capacity (hydraulic)	%	97
Odor problems	-	in some months, no complaints
Specific treatment problems		some scum in the facultative ponds
Power-cuts		3 per year (for 1 h), no problem
Operation/maintenance arrangement available		basic
Employees for wastewater treatment	E	12
Recommended number of employees (WWTP)	E	11
Environmental impacts of effluent		
Discharge of effluent into		hydrographically Wadi Araba
Requirements acc. to JS 893/1995		not respected
(according to WAJ data)		(practically all effluent is evaporated/infitrated and partly reused for agricultural Irrigation)
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		within and close to plant site
Practice of unrestricted irrigation		not done
Irrigation near treatment plant	donums	1.550

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

3. AS SAMRA TREATMENT PLANT

About 99 % of the wastewater collected in Greater Amman is discharged to the treatment plant in As Samra, while only 1 % is treated in the treatment plants of Wadi Essir (see Section 17) and Abu Nuseir (see Section 1).

The existing sewerage system in the Amman-Zarqa River Basin area (discharging wastewater to the As Samra Treatment Plant) includes three adjacent, but distinct sewerage systems (see Figure 3.1):

Amman (in Zarqa basin)
About 65 % of the wastewater discharged to As Samra Treatment Plant is collected by this sewerage system and discharged via Ain Ghazal (AGTP) to the plant. The sewerage system covers the Municipality of Amman, Jubeiha, Tela'a Al Ali, Khilda, Umm El Soumaq, Marj El Hammam, Abu Alanda, Quweismeh, parts of Wadi Essir and parts of Sweileh. Sewage is discharged by a siphon (DN 1200, 38 km) to As Samra. Total length of the trunk mains network tributary to Ain Ghazal is approximately 270 km.

Russeifa-West Zarqa Sewer System
This area contributes by about 28 % of the sewage discharged to As Samra Plant. To this sewerage system belong the northeastern part of Amman (Tariq and Marka), the community of Russeifa and West-Zarqa. Flow collected by the Russeifa-West Zarqa system drains by gravity to the West Zarqa Pumping Station. This station pumps into the siphon to the As Samra Plant. Total length of trunk mains of this sub-system is about 50 km.

East Zarqa-Hashimiyya Sewer System
About 7 % of the wastewater treated in As Samra are collected in this system serving areas of East Zarqa and Hashimiyya. The network discharges the sewage by gravity to the Hashimiyya Pumping Station. The station pumps wastewater directly to As Samra via a DN 500 force main. Total length of trunk mains is about 30 km.

According to the Master Plan and Feasibility Study prepared by HARZA in 1997, the design capacity of nearly 65 % of the trunk sewers (350 km of DN 300 and larger) was found to be adequate to collect and convey peak dry weather flows to the regional wastewater conveyance system through the year 2025. However, detailed field investigations of the sewer network revealed that much of the existing system cannot operate at its design capacity due to the effects of silt and debris accumulations. Furthermore, during wet weather periods, improper stormwater connections to the sanitary sewer system result in increases in flow far beyond the normal peaking pattern associated with wastewater

Wastewater collected in Amman (in Zarqa Basin) is pretreated in Ain Ghazal (2 automatic screens and 2 aerated grit chambers) and from there discharged by a 38 km long conveyor (DN 1200) to As Samra treatment plant location. Hydraulic constraints at the existing wastewater pumping stations in West Zarqa and Hashimiyya limit the capacity of wastewater conveyance facilities as well.

A new conveyor (32 km, DN 1500) is presently under construction and will conduct the sewage of Ain Ghazal to As Samra instead of using the existing siphon since end 2001.

In addition, thickened sludge of the treatment plants in Abu Nuseir, Baqa, Fuhis, Salt and Wadi Essir is transported by tankers to Ain Ghazal pretreatment plant and conveyed together with the raw wastewater of Amman to the As Samra treatment plant. This practice of sludge disposal is totally unsatisfactory. The sludge management of these plants calls for immediate adequate solution.

The wastewater stabilization pond system (anaerobic, facultative and maturation ponds of in total 181 ha, see Figure 3.2) of As Samra plant is currently only adequate to meet the basic wastewater needs of half a million people. The plant is totally overloaded by a wastewater flow, which is exceeds the design flow by about 150 %. It has no nitrogen removal capability. In addition, the existing treatment plant lacks basic facilities for sludge management. The sludge in the anaerobic ponds was removed only once in 15 years, which is by far too less.

The exposed deficiencies of the treatment plant result in effluents of poor quality, only partially treated wastewater. Formerly existing odor problems have been reduced partially by measures of deodorization at the inlet structure. Nevertheless, significant improvements, both in terms of capacity and level of treatment, are required just to overcome the existing deficiencies at the site.

The effluent of the plant (> 100 mg BOD_5/l) is quite unsatisfactory. It is discharged to the Wadi Dhuleil, which joins the Wadi Zarqa, the major tributary to the King Tala Reservoir. Effluent does not meet the requirements according to the relevant Jordanian Standard 893/1995 for discharge to wadis and catchment areas. Serious environmental negative impacts downstream of the treatment plant result of the remaining pollutional load of the treated wastewater. The effluent can be reused for restricted irrigation only due to the high fecal coliform counts (> 100,000 per 100 ml).

One of the main tasks for operation and maintenance of a stabilization pond system is the regular desludging of the ponds, in particular the anaerobic ponds, which is obviously not done in As Samra in an adequate manner.

The Ministry of Water and Irrigation intends to construct new treatment facilities in As Samra applying the Build-Operate-Transfer (BOT) method. The project includes design, construction and operation and maintenance of a new treatment plant with tertiary treatment capability for a projected average daily capacity of 267,000 m^3 per day as well as take-over, operation and maintenance of the existing ponds with a current average flow of 170,000 m^3. Additionally, the contract will comprise the takeover, operation and maintenance of the conveyor pipeline from Ain Ghazal to As Samra including the pretreatment facilities in Ain Ghazal. Bidders for pre-qualification are invited in March 2000.

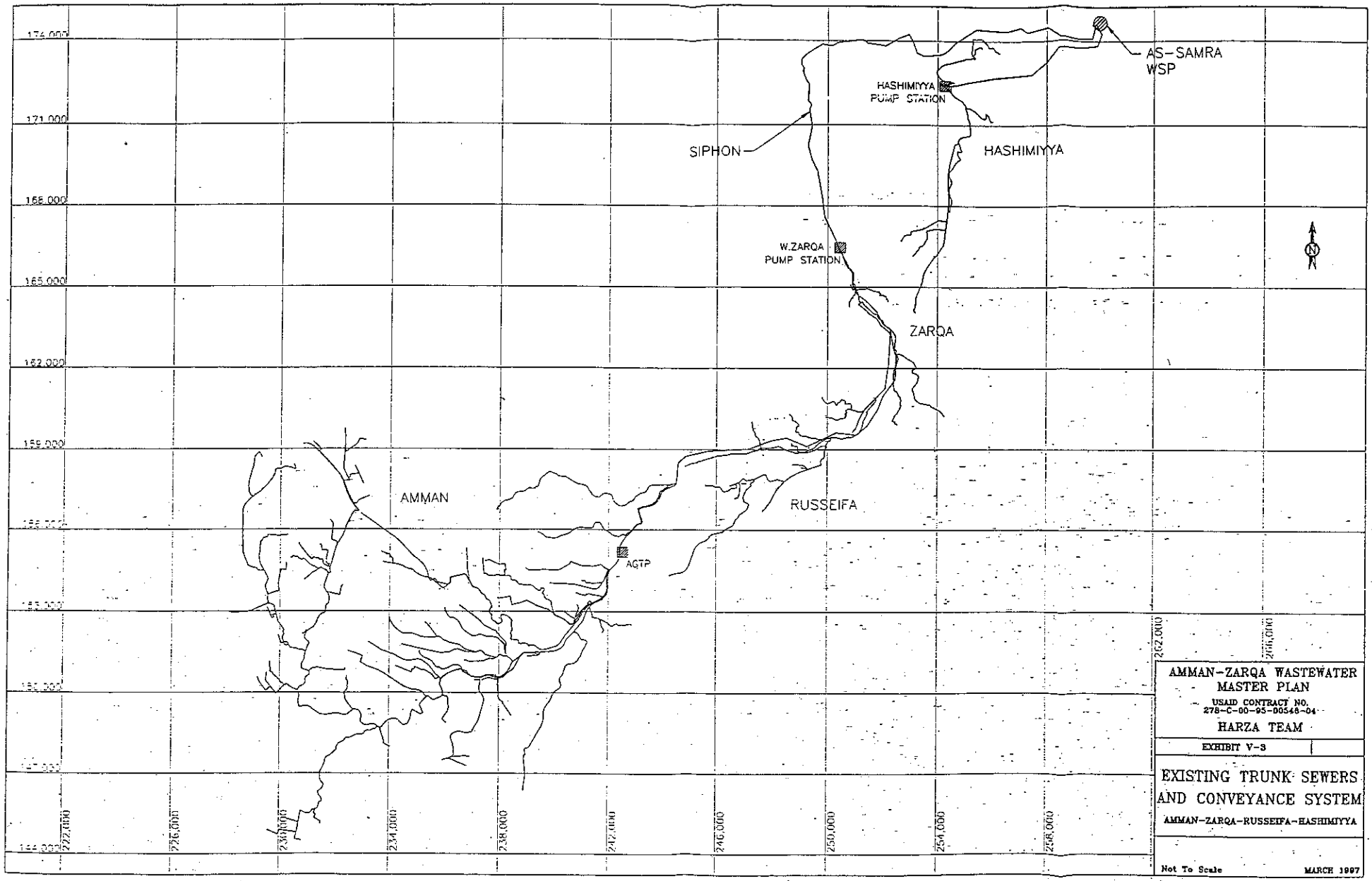


FIGURE 3.1: Existing Trunk Sewers and Conveyance System - AS SAMRA

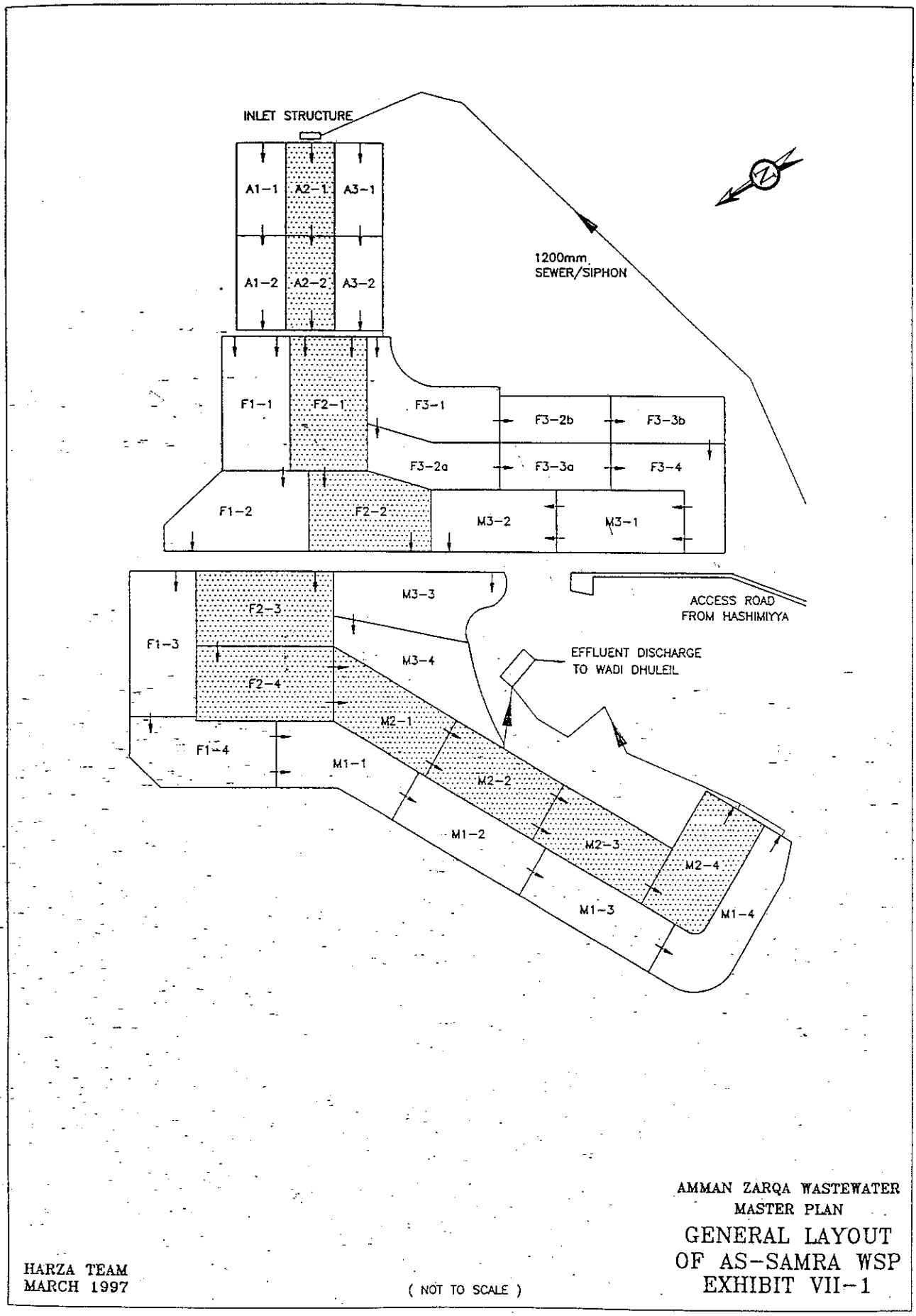


FIGURE 3.2: Schematic Layout of Existing Wastewater Treatment Plant - AS SAMRA

BASIC DATA OF TREATMENT PLANT:

(Data of 1999, if not another year indicated)

As-Samra
3

Town:	Amman
Governorate:	Amman
Treatment plant:	As-Samra
Date of visit:	9.3.2000
Responsible engineer:	Mohamed Saleh
Contacted person:	Mohamed Saleh
Telephone:	37/3811936

Population			
	Tot.population living in towns with sewerage:	inhabitants	2.170.000
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	90
	Cesspools	%	10
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Amman (part belonging to Wadi Zarqa Basin), Zarqa, Russeifa, Hashimiyya
	Population connected (as coverage treatment)	c	1.951.000
	Coverage	%	90
	Important industries	-	37 industries (slaughterhouse etc.)
	Number of stormwater overflows works	no.	-
	Length of sewers	km	1.500,0
	Length per connected capita	m/c	0,8
	House connections	h.c.	105.883
	Capita per house connection	c/h.c.	18,4
	Return factor (acc. to Design Report)	-	0,87
	Monthly peak factor	-	1,10
	Employees for wastewater collection	E	133
	Factor: Sewer length per connected capita/coverage		0,9

BASIC DATA OF TREATMENT PLANT:

As-Samra 3

Wastewater treatment

Wastewater treatment technology		WSP
Wastewater treatment technology		Wastewater stabilisation ponds
In operation since		1985
Composed of treatment facilities		
Facility		Screen (in Ain Ghazal)
Number of units	-	2 (autom.)
Total dimension		-
Facility		Aerated grit cham. (in Ain Ghazal)
Number of units	-	2
Total dimension		
Facility		Anaerobic ponds
Number of units	-	3 x 2
Total dimension		
Facility		Facultative ponds
Number of units	-	3 x 4
Total dimension		
Facility		Maturation ponds
Number of units	-	3 x 4
Total dimension		
Facility		Chlorination unit
Number of units	-	1
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		Total ponds' area: 181ha
		-
		-

Installed capacity	m^3/d	68.000
Population served (assuming 65 g/c/d)	c	1.951.000
Coverage (assuming 65 g/c/d)	%	90
Inflow treatment plant (average)	m^3/d	166.855
	MCM/a	60,902
Estimated losses by seepage/evaporation	%	25
Estimated effluent of the treatment plant	m^3/d	125.141
	MCM/a	45,677
BOD_5-load influent (according to WAJ data)	mg/l	760
	kg/d	126.810
	t/a	46.286
BOD_5-load effluent (according to WAJ data)	mg/l	118
	kg/d	14.767
	t/a	5.390
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	140,000
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	86
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	1.258
Sludge management		-

BASIC DATA OF TREATMENT PLANT:

As-Samra 3

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	629.620
Operation/maintenance cost related to influent	JD/m^3	0,010
Performance of wastewater collection		
Employees for wastewater collection	E	133
Number of employees per 1,000 house conn.	E/1000 h.c.	1,3
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,9
Average number of complaints per month	1/month	
Average number of complaints per km sewer	1/month/km	0,0
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	84
Expected efficiency (acc.to experience)	%	80 - 90
Used treatment capacity (hydraulic)	%	245
Odor problems	-	yes
Specific treatment problems		overloading of plant
Power-cuts		no problem
Operation/maintenance arrangement available		?
Employees for wastewater treatment	E	50
Recommended number of employees (WWTP)	E	57
Environmental impacts of effluent		
Discharge of effluent into		Wadi Dhuleil to Wadi Zarqa to King Talal Reservoir
Requirements acc. to JS 893/1995		not respected
(according to WAJ data)		-
		-
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		at plant site and upstream of King Talal Reservoir
Practice of unrestricted irrigation		downstream of King Talal Reservoir (after dilution)
Irrigation near treatment plant	donums	3.300

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

4. BAQA TREATMENT PLANT

Baqa Wastewater Treatment Plant receives sewage from the Baqa Camp, Northern Suwaileh, Ain Albasha, Safout, Abu Nuseir Village, Moobis, Abu Hamad, Umm Dananir and Al Maisah. The strength of the influent wastewater is rather high - 1,400 mg BOD_5/l in the average. This is due to the low consumption per capita in the settlements connected.

The plant was completed in 1988 (design capacity of 6,000 and is presently extended and upgraded to 15,000 m^3/d). Due to the former overloading of the treatment plant, significant odor problems existed affecting not only the settlements in the neighborhood, but also the highway, which passes very close to the treatment plant. Before the plant consisted of two parallel trains. A new train was added and the capacity of the existing works was increased. In March 2000 the new train and one of the old trains were in operation.

The following description of the plant concerns the treatment system after completion of all extension and upgrading works. The recently completed physical treatment facilities consist of 2 screens (automatic) and 2 aerated grit chambers. All pretreatment facilities are covered now to reduce the generation of odor. Biological treatment is based on trickling filter technology comprising in three trains primary settling tanks, trickling filters, solid contact aeration tanks and secondary settling tanks. A maturation pond serves for tertiary treatment (see Figure 4). Treated wastewater may be chlorinated, if required.

Excess sludge is treated by sludge thickeners. The thickened sludge of the treatment plant of Baqa is transported by tankers to Ain Ghazal pretreatment plant and conveyed together with the raw wastewater of Amman to the As Samra treatment plant. The existing treatment plant lacks basic facilities for sludge dewatering and stabilization such as sludge drying beds.

Main receiving water is Wadi Rumman discharging finally into the King Talal Reservoir. The effluent's quality was until now very unsatisfactory (80 - 100 mg BOD_5/l) did not meet the requirements according to the relevant Jordanian Standard 893/1995 for discharge into wadis and catchment areas. However, the quality of effluent will certainly improved considerably as soon as the construction measures are completed. The fecal coliforms count at the outflow of the plant did not allow unrestricted agricultural irrigation. If the maturation pond will be put in operation again and the existing chlorination facility is continuously used, the effluent could be reused even for unrestricted irrigation. Presently, almost no treated wastewater flowing in the Wadi Ruman is used for irrigation upstream of the King Talal Reservoir.

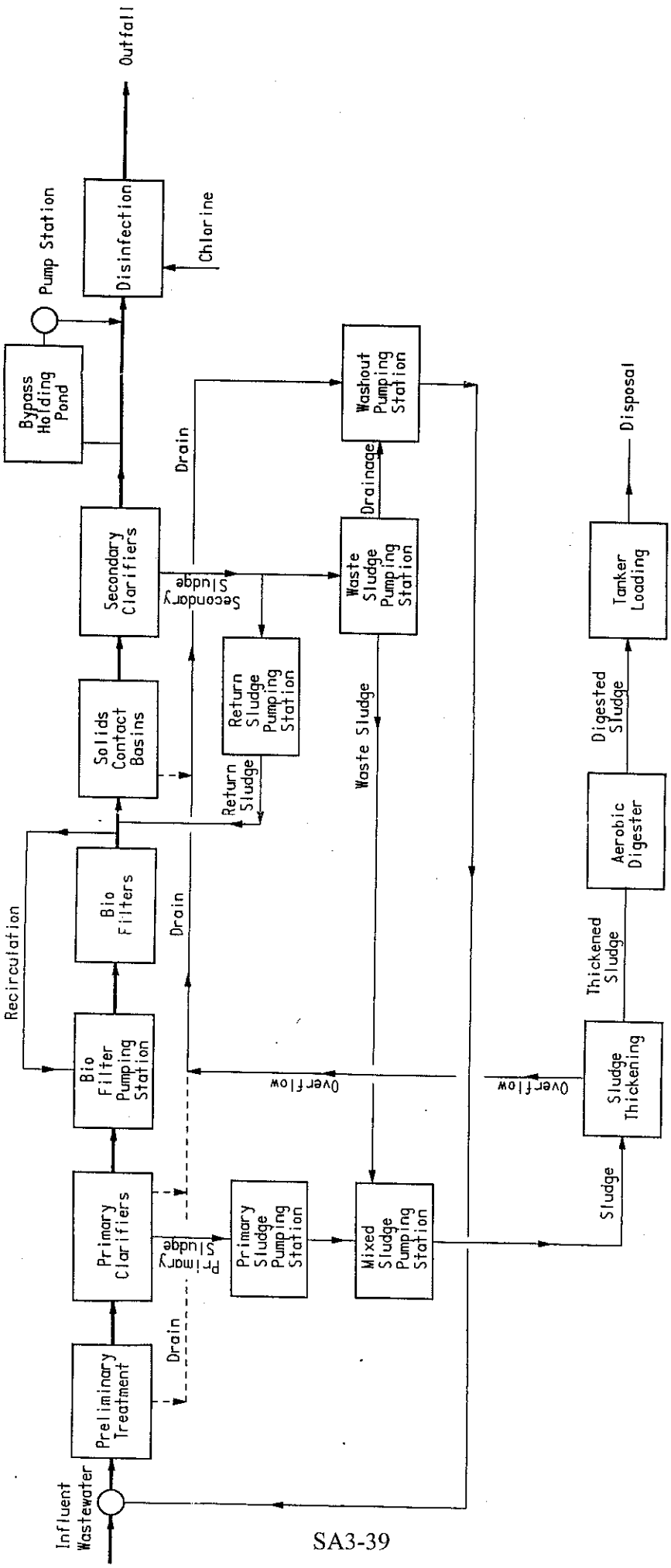


FIGURE 4: Schematic Layout of Existing Wastewater Treatment Plant - BAQA

BASIC DATA OF TREATMENT PLANT:

Baqa
4

(Data of 1999, if not another year indicated)

Town:	Baqa
Governorate:	Balqa
Treatment plant:	Baqa
Date of visit:	19/21.3.2000
Responsible engineer:	Ahmed Rashaydeh
Contacted person:	Ahmed Rashaydeh
Telephone:	06/4725812

Population			
	Tot.population living in towns with sewerage:	inhabitants	174.000
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	94
	Cesspools	%	6
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Baqa Camp, North Suweileh, Ayn Al Basha, Safout, Umm M Abu Nuseir village, Moobis, Abu Hamad, Umm Dananir, Al
	Population connected (as coverage treatment)	c	164.000
	Coverage	%	94
	Important industries	-	Slaughterhouse, dairies, juice factories
	Number of stormwater overflows works	no.	1 (at the treatment plant)
	Length of sewers	km	189,0
	Length per connected capita	m/c	1,2
	House connections	h.c.	8.673
	Capita per house connection	c/h.c.	18,9
	Return factor (acc. to Design Report)	-	0,8
	Monthly peak factor	-	1,10
	Employees for wastewater collection	E	13
	Factor: Sewer length per connected capita/coverage		1,2

BASIC DATA OF TREATMENT PLANT:

Baqa 4

Wastewater treatment

Wastewater treatment technology		TF + MP 2)
Wastewater treatment technology		Trickling filters plus maturation ponds
In operation since		1988(ext.99)
Composed of treatment facilities		
Facility		Screen
Number of units	-	2
Total dimension		-
Facility		Aerated grit chamber
Number of units	-	2
Total dimension		
Facility		Primary settling tank
Number of units	-	1new + 3old
Total dimension		(700 + 3 x 460) m3
Facility		Trickling filters
Number of units	-	1new+2old
Total dimension		(2,800 + 2 x 2,800) m3
Facility		Solid contact aeration tanks
Number of units	-	2new+2old
Total dimension		(2 x 140 + 2 x 140) m3
Facility		Secondary settling tanks
Number of units	-	2new+4old
Total dimension		(2 x 1,130 + 4 x 1,130) m3
Facility		Maturation ponds
Number of units	-	1
Total dimension		7,000 m3
Facility		Chlorination unit
Number of units	-	1 (only in operation, if needed)
Total dimension		
Facility		Sludge thickener
Number of units	-	1new+2old
Total dimension		(1x300+2x300) m3
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		March 2000: several units not in operation due to ongoing upgrading measures Dimensions of facilities: after completion of measures

Installed capacity	m^3/d	15.000 (extended from 6,000 to 15,000 m3/d)
Population served (assuming 65 g/c/d)	c	164.000
Coverage (assuming 65 g/c/d)	%	94
Inflow treatment plant (average)	m^3/d	10.284
	MCM/a	3,754
Estimated losses by seepage/evaporation	%	10
Estimated effluent of the treatment plant	m^3/d	9.256
	MCM/a	3,378
BOD_5-load influent (according to WAJ data)	mg/l	1.038
	kg/d	10.675
	t/a	3.896
BOD_5-load effluent (according to WAJ data)	mg/l	80
	kg/d	740
	t/a	270
		Influent BOD5 is of 1998 (1999 value 1,434 is too high)
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	2,500
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	63
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	1.093
Sludge management		Sludge by tankers to As Samra TP via Ain Ghazal

BASIC DATA OF TREATMENT PLANT:

Baqa 4

Cost of wastewater treatment

Operation and maintenance cost	JD/a	220.250
Operation/maintenance cost related to influent	JD/m^3	0,059

Performance of wastewater collection

Employees for wastewater collection	E	13
Number of employees per 1,000 house conn.	E/1000 h.c.	1,5
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,7
Average number of complaints per month	1/month	490
Average number of complaints per km sewer	1/month/km	2,6

Performance of wastewater treatment

Treatment efficiency (BOD_5 acc.to WAJ data)	%	92
Expected efficiency (acc.to experience)	%	90 - 95
Used treatment capacity (hydraulic)	%	69
Odor problems	-	not part.(after compl.of measures)
Specific treatment problems		no, when ongoing construction measures completed
Power-cuts		1 per month, no problem
Operation/maintenance arrangement available		?
Employees for wastewater treatment	E	30
Recommended number of employees (WWTP)	E	10

Environmental impacts of effluent

Discharge of effluent into	Wadi Rumman to King Talal Reservoir
Requirements acc. to JS 893/1995	not respected
(according to WAJ data)	but in future after completion of measures

Reuse of effluent for agricultural irrigation

Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		neclectable upstream of King Talal Reservoir
Practice of unrestricted irrigation		
Irrigation near treatment plant	donums	5

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

5. FUHIS TREATMENT PLANT

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

At the entrance of the wastewater treatment in Fuhis a stormwater overflow tank (equalizing tank) is located to receive excess stormwater and to treat it partially by settling. Physical treatment facilities consist of 2 screens (1 automatic and 1 manual) and 2 non-aerated grit chambers. Biological treatment is based on an activated sludge process (extended aeration) comprising activated sludge tanks and secondary settling tanks. Additional treatment is provided by maturation ponds (see Figure 5). Treated wastewater may be chlorinated, if required.

Excess sludge is treated by sludge thickeners. During summer time the thickened sludge is dried by the sludge drying beds of the treatment plant, while during winter time the thickened sludge is transported by tankers to Ain Ghazal pretreatment plant and conveyed together with the raw wastewater of Amman to the As Samra treatment plant. Instead of this, it is proposed to use the existing sludge drying beds throughout the year. Dried sludge is stabilized and could be used in the agriculture as fertilizer and soil conditioner. The second option could be its disposal at a sanitary landfill.

The design capacity of the treatment plant (put in operation in 1996) is 2,400 m^3/d, of which presently one third is used only. To reduce operation cost only one of the two trains could be operated. In a later stage, when the collected wastewater will have increased, the second train could be put in operation again.

There are some problems with floating/bulking sludge in the secondary settling tank which is most probably due to development of filamentous bacteria in the activated sludge. The reasons for this problem could be the particular quality of the wastewater and/or the operation of the treatment plant. The causes have to be studied and specific measures defined to reduce the development of bulking sludge.

Main receiving water is Wadi Shua'ab discharging finally into the Shua'ab Reservoir. The effluent of the plant (< 10 mg BOD_5/l) does meet the requirements according to the related Jordanian Standard 893/1995 for discharge into wadis and catchment areas. Due to the additional treatment of wastewater by the maturation ponds and chlorination of the effluents, the fecal coliform count could be reduced to less than 1,000 in 100 ml. However, at present the fecal coliform count is still higher than 10,000, because effluent is not chlorinated continuously. Therefore, effluent can be reused for restricted irrigation only.

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

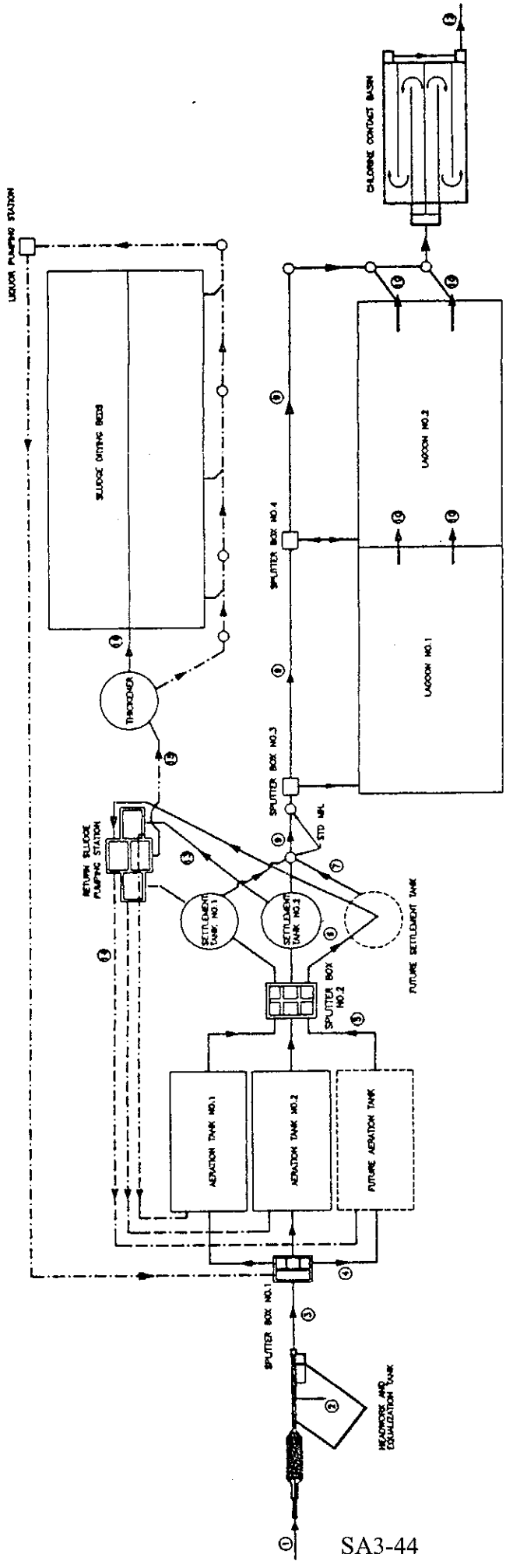


FIGURE 5: Schematic Layout of Existing Wastewater Treatment Plant - FUHIS

BASIC DATA OF TREATMENT PLANT:

Fuhis
5

(Data of 1999, if not another year indicated)

Town:	Fuhis
Governorate:	Balqa
Treatment plant:	Fuhis
Date of visit:	19.3.2000
Responsible engineer:	Abdul Kareem Jarar
Contacted person:	Sameeh Ahmet/Moh. Aliwi,
Telephone:	none

Population			
	Tot.population living in towns with sewerage:	inhabitants	21.600
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	49
	Cesspools	%	51
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Fuhis, Mahis
	Population connected (as coverage treatment)	c	10.600
	Coverage	%	49
	Important industries	-	detergent industry, slaughterhouse
	Number of stormwater overflows works	no.	1 (at the treatment plant)
	Length of sewers	km	79,0
	Length per connected capita	m/c	7,5
	House connections	h.c.	1.276
	Capita per house connection	c/h.c.	8,3
	Return factor (acc. to Design Report)	-	0,8
	Monthly peak factor	-	1,20
	Employees for wastewater collection	E	6
	Factor: Sewer length per connected capita/coverage		15,2

BASIC DATA OF TREATMENT PLANT:

Fuhis 5

Wastewater treatment

Wastewater treatment technology			EA + MP
Wastewater treatment technology			Extended aeration plus maturation ponds
In operation since			1996
Composed of treatment facilities			
Facility			Equalizing/stormwater tank
Number of units	-		1
Total dimension			500 m3
Facility			Screens
Number of units	-		2 (1 auto.+1 manual)
Total dimension			
Facility			Grit chamber
Number of units	-		2 (manual)
Total dimension			
Facility			Activated sludge tanks
Number of units	-		2
Total dimension			(3,200 + 3,200) m3
Facility			Secondary settling tanks
Number of units	-		2
Total dimension			(500 + 500) m3
Facility			Maturation ponds
Number of units	-		2 (in parallel, one out of operation during site visit)
Total dimension			(11,000 + 11,000) m3
Facility			Chlorination unit
Number of units	-		1
Total dimension			
Facility			Sludge thickener
Number of units	-		1
Total dimension			85 m3
Facility			Drying beds
Number of units	-		30
Total dimension			900 m2
Facility			-
Number of units	-		-
Total dimension			-
Remarks:			Thickener only 20 % filled
			-
			-

Installed capacity	m^3/d	2.400
		-
Population served (assuming 65 g/c/d)	c	10.600
Coverage (assuming 65 g/c/d)	%	49
Inflow treatment plant (average)	m^3/d	1.019
	MCM/a	0,372
Estimated losses by seepage/evaporation	%	10
Estimated effluent of the treatment plant	m^3/d	917
	MCM/a	0,335
BOD_5-load influent (according to WAJ data)	mg/l	677
	kg/d	690
	t/a	252
BOD_5-load effluent (according to WAJ data)	mg/l	11
	kg/d	10
	t/a	4
		-
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	15,000
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	96
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	669

Sludge management

thickener daily emptied
in summer: sludge to drying beds
in winter: sludge by tankers to As Samra TP via Ain Ghaz
dried sludge to As Samra (no agr.use)

BASIC DATA OF TREATMENT PLANT:

Fuhis 5

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	82.110
Operation/maintenance cost related to influent	JD/m^3	0,221
Performance of wastewater collection		
Employees for wastewater collection	E	6
Number of employees per 1,000 house conn.	E/1000 h.c.	4,7
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,8
Average number of complaints per month	1/month	100
Average number of complaints per km sewer	1/month/km	1,3
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	98
Expected efficiency (acc.to experience)	%	90 - 98
Used treatment capacity (hydraulic)	%	42
Odor problems	-	not particularly
Specific treatment problems		floating sludge at sec.settling tanks
Power-cuts		several times per month, no problem
Operation/maintenance arrangement available		?
Employees for wastewater treatment	E	22
Recommended number of employees (WWTP)	E	5
Environmental impacts of effluent		
Discharge of effluent into		Wadi Shua'ab to Shua'ab Reservoir
Requirements acc. to JS 893/1995		respected
(according to WAJ data)		
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		at plant site and upstream of Shua'ab Dam (illegally)
Practice of unrestricted irrigation		downstream of Shua'ab Dam (after dilution with freshwate
Irrigation near treatment plant	donums	20

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

6. IRBID (CENTRAL) TREATMENT PLANT

Even if the sewerage is designed as a separate system, during rainfall the sewers collect stormwater also. The entire sewerage system disposes of only one stormwater overflow located at the treatment plant.

The plant was completed in 1987 (design capacity of 11,000 m^3/d). Until 1999 the Central Treatment Plant of Irbid received 100 % of the collected wastewater of Irbid and was overloaded by some 20 %. Meanwhile about 65 % of the wastewater is discharged to the Wadi Arab Treatment Plant (approx. 15 km west of Irbid), since this plant was put in operation in May 1999. Treatment Plant Irbid Central receives 35 % of the sewage collected in northern part of Irbid only.

Now the Central Treatment Plant operates under acceptable hydraulic and pollutional load conditions. The physical treatment facilities consist of 3 screens (2 automatic and 1 manual) and 2 aerated grit chambers (only one in operation). Biological treatment is based on trickling filter and activated sludge technology comprising in two trains primary settling tanks, trickling filters, aeration tanks and secondary settling tanks (see Figure 6). Treated wastewater is chlorinated. Both trickling filters are not in operation since several months due to the sewage distributors of the filter. Up to now they could not be dismantled due to a missing adequate crane, which could put the distributors from the 10m-high roof of the filters.

Excess sludge is thickened in a sludge thickener. Thickened sludge is he pumped to an anaerobic digester (out of operation in March 2000). Gas gained by this digester is used for digester's heating in winter and released in the atmosphere in summer. Sludge of the digester is brought to the dumping ground Al Akeder about 50 km distant from the treatment plant during winter time, while it is dried in drying beds of the treatment plant during summer time. Trucks transport the dried and stabilized sludge to the same dumping. It is not used in the agriculture as fertilizer and soil conditioner.

Sludge handling is not done in a continuous manner, but in batch operation every 2 weeks. This manner of operation leads to overflow of sludge into the effluent and, therefore, to an unsatisfactory quality of the effluent water of the plant. It is recommended to operate the plant in a continuous manner, where separate compartments of the drying beds are filled. In addition, it seems that the entire existing sludge drying beds are not used. With an improvement of the sludge handling the quantity of sludge (to be brought by tankers to the dumping ground) could be reduced and operation costs saved accordingly.

The effluent is discharged by a 30 km long pipeline (after 15 km downstream together with the effluent of Wadi Arab Treatment Plant) to the Jordan Valley for irrigation purposes. This long pipeline was constructed to protect the aquifer and groundwater resources located downstream of the plant, which are exploited for municipal water supply. The effluent of the plant (50 mg BOD_5/l) does not meet all the times the requirements according to the related Jordanian Standard 893/1995 for discharge into wadis and catchment areas or for reuse for unrestricted agricultural irrigation. Due to the chlorination of the effluents, the fecal coliforms count is reduced to some 2,000 in 100 ml. But due to the high organic contents of the effluent, the chlorination is not

really safe to guarantee the required hygienic standards. So, this treated wastewater may be reused for unrestricted agricultural irrigation only. Along the narrow valley of Wadi Arab there are no important areas suitable for irrigation present. Nevertheless, in the Jordan Valley treated wastewater may be reused for restricted irrigation purposes.

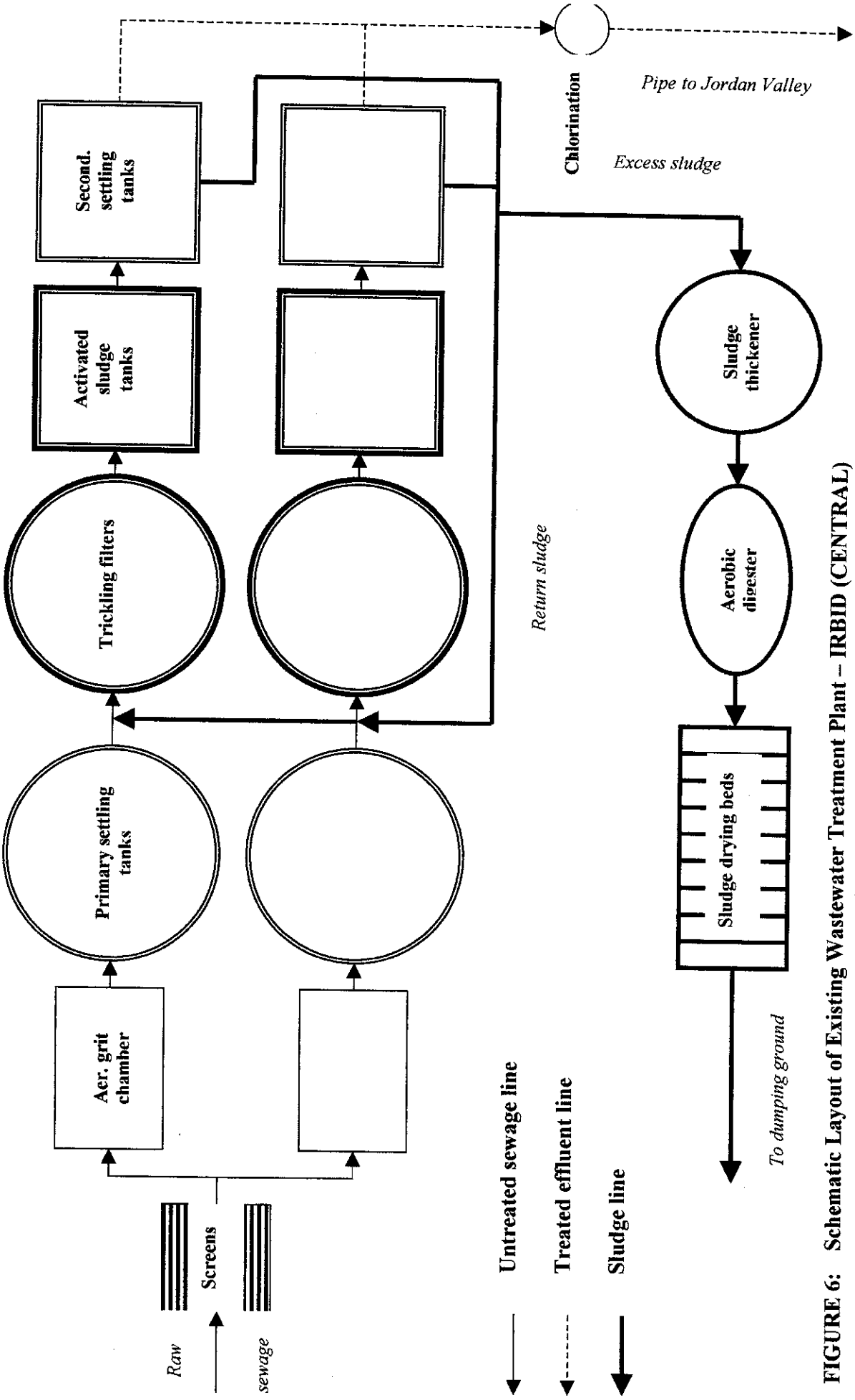


FIGURE 6: Schematic Layout of Existing Wastewater Treatment Plant – IRBID (CENTRAL)

BASIC DATA OF TREATMENT PLANT: Irbid (Central)

(Data of 1999, if not another year indicated)

6

Town:	Irbid
Governorate:	Irbid
Treatment plant:	Irbid (Central)
Date of visit:	26.3.2000
Responsible engineer:	Mazen Abu El-Shaar
Contacted person:	Mazen Abu El-Shaar
Telephone:	02/7401113,7401114

Population		
Tot.population living in towns with sewerage:	inhabitants	92.000
Population growth	%	3,6
Wastewater disposal		
Public system	%	51
Cesspools	%	49
Others	%	0
Wastewater collection		
Towns/villages connected (the most important)	-	Irbid North
Population connected (as coverage treatment)	c	46.480
Coverage	%	51
Important industries	-	no important water polluting industries connected
Number of stormwater overflows works	no.	1 (at the treatment plant)
Length of sewers	km	108,5
Length per connected capita	m/c	2,3
House connections	h.c.	4.830
Capita per house connection	c/h.c.	9,6
Return factor (acc. to Design Report)	-	0,85
Monthly peak factor	-	1,20
Employees for wastewater collection	E	5,25 Together with Wadi Arab
Factor: Sewer length per connected capita/coverage		4,6

BASIC DATA OF TREATMENT PLANT: Irbid (Central)

6

Wastewater treatment

Wastewater treatment technology			TF + AS 1)
Wastewater treatment technology			Trickling filters plus activated sludge
In operation since			1987
Composed of treatment facilities			
	Facility		Screen
	Number of units	-	3 (2 autom.+1 manual)
	Total dimension		
	Facility		Aerated grit chamber
	Number of units	-	2 (only 1 in operation)
	Total dimension		
	Facility		Primary settling tank
	Number of units	-	2
	Total dimension		2 x 750 m3
	Facility		Trickling filters
	Number of units	-	2 (both out of operation)
	Total dimension		2 x 3,100 m3
	Facility		Activated sludge tanks
	Number of units	-	2
	Total dimension		2 x 1,350 m3
	Facility		Secondary settling tanks
	Number of units	-	2
	Total dimension		(11,000 + 11,000) m3
	Facility		Chlorination unit
	Number of units	-	1
	Total dimension		
	Facility		Sludge thickener
	Number of units	-	1
	Total dimension		85 m3
	Facility		Aerobic digester (dome)
	Number of units	-	1
	Total dimension		3,500 m3
	Facility		· Drying beds
	Number of units	-	· 9
	Total dimension		· 1,500 m2
	Remarks:		Both trickling filters out of operation due to · problems of the sewage distributor · Digester out of operation

Installed capacity	m^3/d	11.000
Population served (assuming 65 g/c/d)	c	46.480
Coverage (assuming 65 g/c/d)	%	51
Inflow treatment plant (average)	m^3/d	4.612
	MCM/a	1,683
Estimated losses by seepage/evaporation	%	5
Estimated effluent of the treatment plant	m^3/d	4.381
	MCM/a	1,599
BOD_5-load influent (according to WAJ data)	mg/l	1.179
	kg/d	5.438
	t/a	1.985
BOD_5-load effluent (according to WAJ data)	mg/l	51
	kg/d	223
	t/a	82
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	2,000
Helminth eggs	eggs/l	>1
Spec.wastewater generation	l/c/d	99
Spec.BOD_5-load	g/c/d	117
Total dissolved solids (TDS) at effluent	mg/l	no information
Sludge management		Winter: drying beds not used, sludge is transported by tankers to dumping ground Sommer: dried sludge is transported by trucks to dumping ground (Al Akeder)

BASIC DATA OF TREATMENT PLANT: Irbid (Central)

6

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	202.390
Operation/maintenance cost related to influent	JD/m³	0,120
Performance of wastewater collection		
Employees for wastewater collection	E	5,25
Number of employees per 1,000 house conn.	E/1000 h.c.	1,1
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,5
Average number of complaints per month	1/month	56
Average number of complaints per km sewer	1/month/km	0,5
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	96
Expected efficiency (acc.to experience)	%	95 - 98
Used treatment capacity (hydraulic)	%	42
Odor problems	-	yes (particularly in summer)
Specific treatment problems		deficiencies in sludge treatment, TF out of operation
Power-cuts		2 per year, generator available
Operation/maintenance arrangement available		yes
Employees for wastewater treatment	E	42
Recommended number of employees (WWTP)	E	13
Environmental impacts of effluent		
Discharge of effluent into		hydrographically Wadi Arab (30 km pipe to Jordan Valley)
Requirements acc. to JS 893/1995		not respected
(according to WAJ data)		-
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		some
Practice of unrestricted irrigation		no
Irrigation near treatment plant	donums	7

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

7. JERASH TREATMENT PLANT

Wastewater of the sewerage system of the town of Jerash, Soof and Soof Camp discharges to Jerash Wastewater Treatment Plant. The plant was put in operation in 1983 and was extended in 1990 to a capacity of 3,500 m^3/d. Presently, only half of this capacity is used.

Physical treatment facilities consist of 2 screens (1 automatic and 1 manual) and 2 manually operated grit chambers. Biological treatment is based on an activated sludge process (extended aeration) comprising 2 activated sludge tanks and 2 secondary settling tanks. An old (of 1983) activated sludge tank (carousel with aeration by surface rotors) is presently not operational due to broken rotors. However, it seems that the damaged electro-mechanical equipment may be repaired. 2 maturation ponds in series provide tertiary treatment (see Figure 7). Treated wastewater is disinfected by chlorination.

The maturation ponds have a depth of 5 m, which is by far too deep (it should be in the order of 1 m!) to reach desired tertiary treatment by these maturation ponds. In addition the surface of the first pond is badly designed and leads to significant death zones.

Excess sludge is pumped to sludge thickeners/holding tanks. From there the sludge is discharged to the drying beds every day. In summer sludge is dried during 2 weeks, while in winter this period has to be increased to 2 months. Afterwards dried sludge is disposed at a place within the plant's area for storage. From time to time the stored sludge is brought by trucks to the dumping ground Al Akeder. Costs for transport amount to 1.3 JD/m^3 dried sludge. According to the personnel of the plant the available surface of the drying beds are not sufficient.

Main receiving water is Wadi Jerash – a tributary of Wadi Zarqa, which mouths in the King Talal Reservoir. The effluent of the plant (about 30 mg BOD_5/l) does meet the requirements according to the related Jordanian Standard 893/1995 for discharge into wadis and catchment areas. Due to the additional treatment of wastewater by two maturation ponds (in series) and chlorination of the effluents, the fecal coliform count could be reduced to less than 1,000 in 100 ml. However, there are no comprehensive data on fecal coliform count available to judge the effluent's suitability for unrestricted irrigation. Therefore, effluent can be reused for restricted irrigation only.

At present, treated wastewater is reused neither for restricted nor for unrestricted irrigation purposes upstream of the King Talal Reservoir, even required standards for unrestricted irrigation could be met by the applied/possible treatment process. However, the effluent is reused downstream of the Reservoir in the Jordan Valley after dilution with surface water.

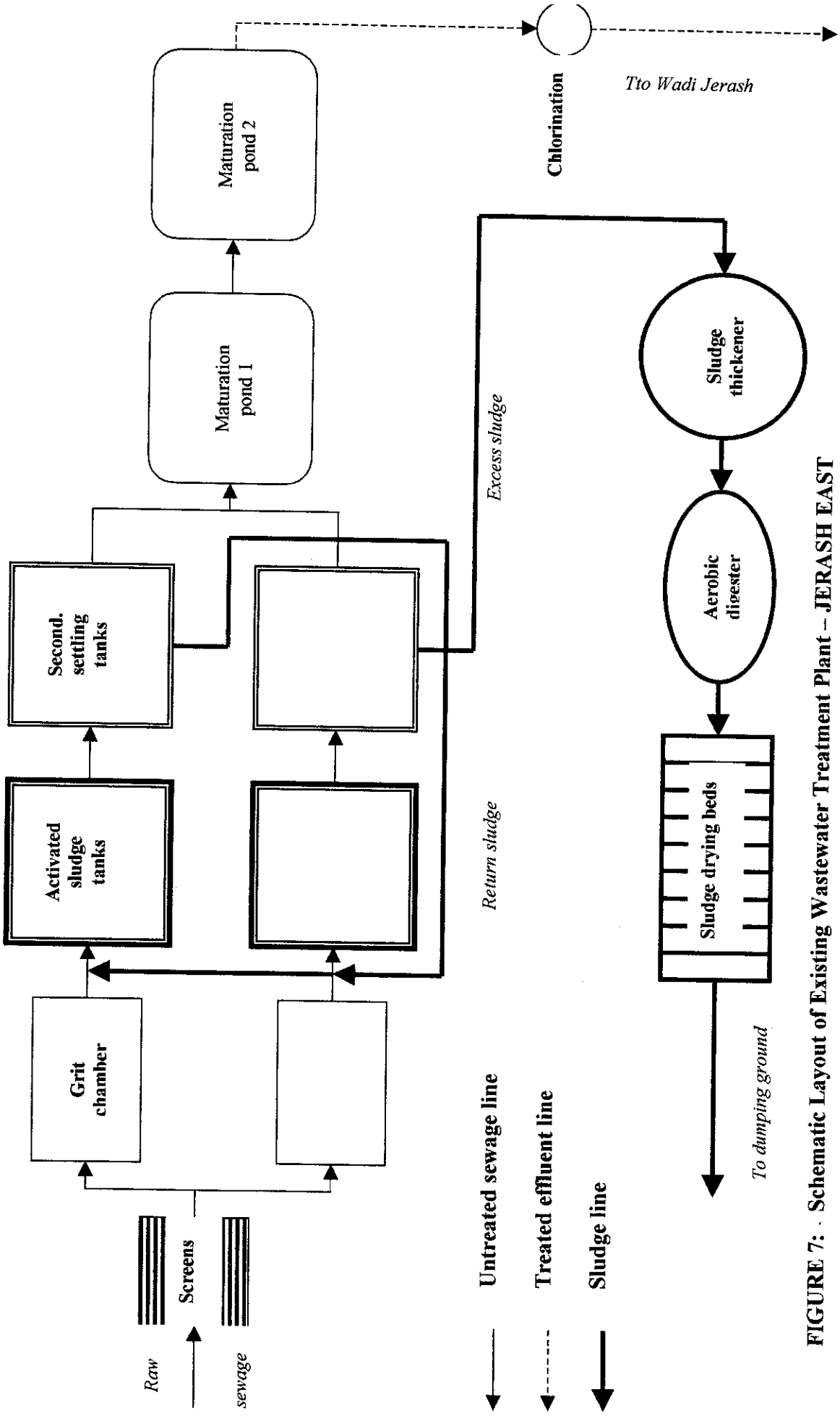


FIGURE 7: · Schematic Layout of Existing Wastewater Treatment Plant – JERASH EAST

BASIC DATA OF TREATMENT PLANT: Jerash (East)

(Data of 1999, if not another year indicated) 7

Town:	Jerash
Governorate:	Jerash
Treatment plant:	Jerash (East)
Date of visit:	28.3.2000
Responsible engineer:	Ziyad Al Ahmmad
Contacted person:	Taiser Assi
Telephone:	02/6351803(02)

Population			
	Tot.population living in towns with sewerage:	inhabitants	51.000
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	54
	Cesspools	%	46
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Jerash Town, Soof and Soof Camp
	Population connected (as coverage treatment)	c	27.600
	Coverage	%	54
	Important industries	-	no important water polluting industries connected
	Number of stormwater overflows works	no.	1 (at the treatment plant)
	Length of sewers	km	119,0
	Length per connected capita	m/c	4,3
	House connections	h.c.	1.268
	Capita per house connection	c/h.c.	21,8
	Return factor (acc. to Design Report)	-	0,8
	Monthly peak factor	-	1,20
	Employees for wastewater collection	E	9
	Factor: Sewer length per connected capita/coverage		8,0

BASIC DATA OF TREATMENT PLANT: Jerash (East)

7

Wastewater treatment

Wastewater treatment technology		EA + MP
Wastewater treatment technology		Extended aeration plus maturation ponds
In operation since		1983(ext.90)
Composed of treatment facilities		
Facility		Screens
Number of units	-	2 (1 auto.+1 manual)
Total dimension		-
Facility		Grit chamber
Number of units	-	2 (manual)
Total dimension		
Facility		Old activated sludge tank (carousel)
Number of units	-	1 (out of operation, rotor damaged)
Total dimension		2,700 m3
Facility		Activated sludge tanks
Number of units	-	2
Total dimension		2 x 2,500 m3
Facility		Secondary settling tanks
Number of units	-	2 (one new and one old)
Total dimension		2 x 360 m3
Facility		Maturation ponds (5 m deep)
Number of units	-	2 (in series)
Total dimension		(20,000 + 10,000) m3
Facility		Chlorination unit
Number of units	-	1
Total dimension		
Facility		Sludge thickener
Number of units	-	1
Total dimension		240 m3
Facility		Drying beds
Number of units	-	30
Total dimension		1,200 m2
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		-
		-
		-

Installed capacity	m^3/d	3.500
Population served (assuming 65 g/c/d)	c	27.600
Coverage (assuming 65 g/c/d)	%	54
Inflow treatment plant (average)	m^3/d	1.603
	MCM/a	0,585
Estimated losses by seepage/evaporation	%	10
Estimated effluent of the treatment plant	m^3/d	1.443
	MCM/a	0,527
BOD_5-load influent (according to WAJ data)	mg/l	1.119
	kg/d	1.794
	t/a	655
BOD_5-load effluent (according to WAJ data)	mg/l	33
	kg/d	48
	t/a	17
		-
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	no information
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	58
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	1.132

Sludge management	Every day: about 40 m3 sludge from thickener to drying beds. Dried sludge is dumped in the treatment plant area and then transported by trucks to the dumping ground Al Akeder (1.3 JD/m3).

BASIC DATA OF TREATMENT PLANT: Jerash (East)

7

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	88.830
Operation/maintenance cost related to influent	JD/m³	0,152
Performance of wastewater collection		
Employees for wastewater collection	E	9
Number of employees per 1,000 house conn.	E/1000 h.c.	7,1
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,8
Average number of complaints per month	1/month	100
Average number of complaints per km sewer	1/month/km	0,8
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	97
Expected efficiency (acc.to experience)	%	90 - 98
Used treatment capacity (hydraulic)	%	46
Odor problems	-	not particularly
Specific treatment problems		too less drying beds
Power-cuts		1 per month (1-2 h), generator available
Operation/maintenance arrangement available		basic
Employees for wastewater treatment	E	22
Recommended number of employees (WWTP)	E	8
Environmental impacts of effluent		
Discharge of effluent into		Wadi Jerash to Wadi Zarqa to King Talal Reservoir
Requirements acc. to JS 893/1995		respected
(according to WAJ data)		
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		some
Practice of unrestricted irrigation		no
Irrigation near treatment plant	donums	5

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

8. KARAK TREATMENT PLANT

The sewerage system of Karak covers the old city of Karak and parts of Al Merg on the highland. Generally, the build-up areas of Karak are difficult to sewer because of its topography. Sewage flows through a siphon before reaching the wastewater treatment plant. New Karak situated on the highland is presently not connected. A sewerage system for this area will require several pump stations.

The sewerage system has a length of about 37 km in 2000. Specific length per connected capita is about 2.7 meter / per capita, which is a rather high value. Some 1,200 house connections are registered. Taking into account the figures of 1999 about 14,000 people are connected, which corresponds to a connection rate of 23 % of the entire population living in the service zone. This percentage is rather low and should be increased.

According to available records of the discharge to the Karak Wastewater Treatment Plant since 1988. The flow to the plant has increased by a factor of 4 since it was put into operation. Wastewater from a slaughterhouse contributes to the pollutional load.

The incoming flow to the treatment plant passes a screen (one manual and one automatic, but not operational in April 2000), two parallel-arranged grit channels and Imhoff tanks. Biological treatment is based on a two-stage trickling filter technology composed of two trickling filters in series followed downstream by a secondary settling tank. A maturation pond serves for tertiary treatment (see Figure 8). Treated wastewater is disinfected by chlorination. Within the plant's area there is sufficient space for the construction of a second train for biological treatment.

Most of the nozzles of the wastewater distributors above the trickling filters are damaged and, consequently, a regular charge of the trickling filters is not given. The nozzles could be repaired locally. According to information got from the plant's personnel annual sludge accumulation at the bottom of the maturation pond amounts to some 25 cm. Therefore, the maturation pond is desludged every year.

Sludge of the secondary settling tanks is pumped back to the Imhoff tanks, where sludge is decomposed in a chamber below the settling volume. Every day excess sludge of the Imhoff tanks is discharged to sludge lagoons. These lagoons do not dispose of possibility to discharge separately the supernatant water from the thickened sludge. Sludge stored in the lagoons is spread twice a month at the drying beds. After a drying of 2 weeks in summer and 4 weeks in winter dried sludge is transported by trucks to the dumping ground Lagoun. Due to limited sludge treatment capacities, in winter even liquid sludge has to be brought to the dumping ground.

Main receiving water is Wadi Karak, which mouths in the Dead Sea. The effluent's quality (45 mg BOD_5/l) meets the requirements according to the relevant Jordanian Standard 893/1995 for discharge into wadis and catchment areas. In the valley of Wadi Karak (downstream of the treatment plant) there are some springs used for potable water supply. Therefore, a 8 km long pipeline was constructed to conduct the plant's effluent to a section of the wadi, where any pollution of these springs is avoided.

The fecal coliform count (more than 1,600 per 100 ml) at the outflow of the plant does not allow unrestricted agricultural irrigation. Presently, treated wastewater is used for restricted irrigation (25 donums) downstream of the plant. It is proposed to extend the reuse of the treated wastewater considerably: The Ministry of Agriculture has started a reforestation project in the Valley of Wadi Karak, where a high portion of the effluent of the Karak Wastewater Treatment Plant could be reused for irrigation of trees.

A Feasibility Study on the "Rehabilitation and Extension of Wastewater Treatment Plants in Karak and Kufranja" will be prepared in 2001. In June 2000 offers for consultancy services were presented to WAJ. The study will be financed by the Kreditanstalt fuer Wiederaufbau, KfW (German Bank for Reconstruction and Development). The proposed project includes the rehabilitation and extension of the existing treatment plant of Karak as well as the extension of the existing sewerage network.

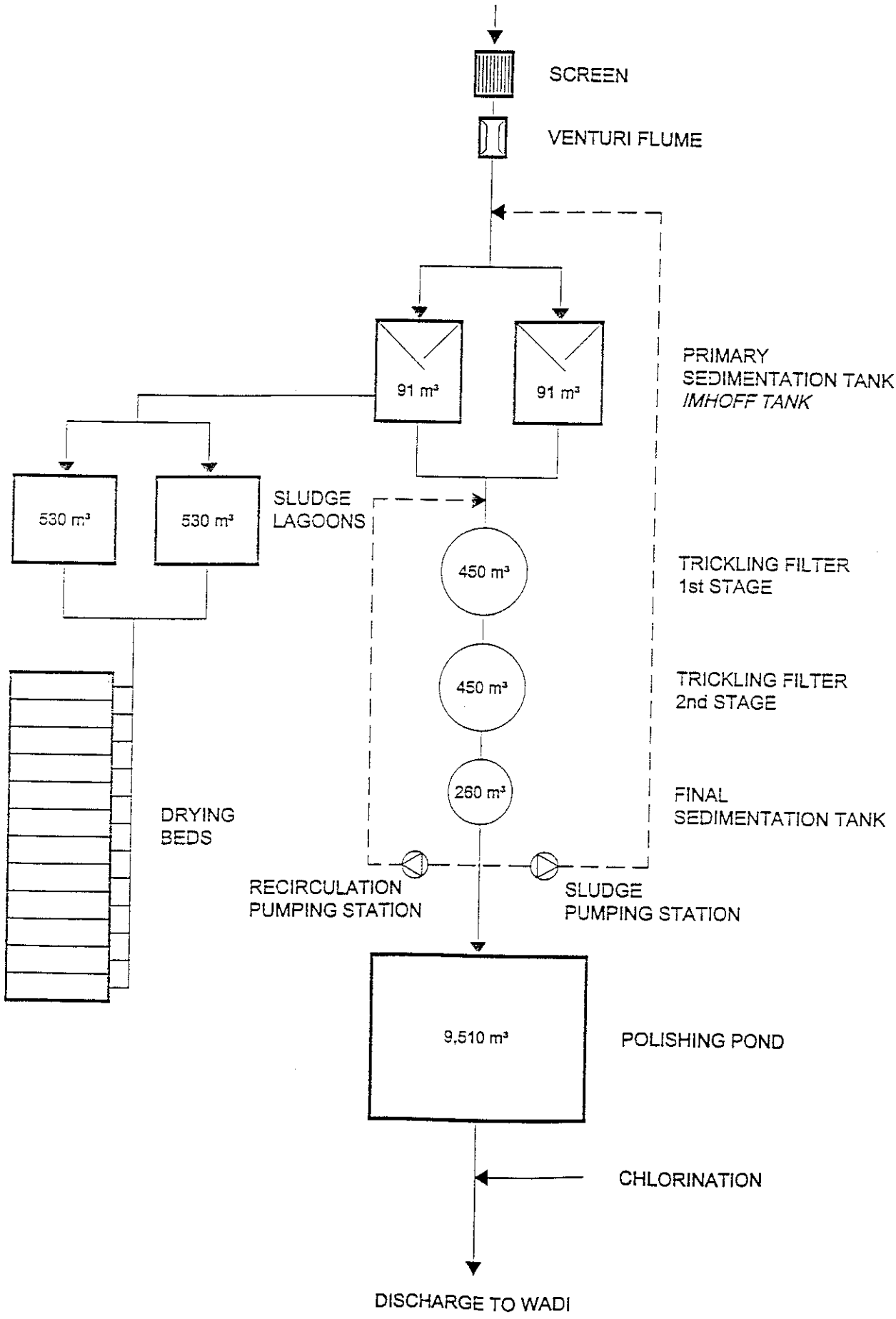


FIGURE 8: Schematic Layout of Existing Wastewater Treatment Plant - KARAK

BASIC DATA OF TREATMENT PLANT: Karak

(Data of 1999, if not another year indicated) 8

Town:	Karak
Governorate:	Karak
Treatment plant:	Karak
Date of visit:	2.4.2000
Responsible engineer:	Muneeb Al Sana'a
Contacted person:	Tawiq Habashneh (Dir.of WAJ Karak)
Telephone:	03/353448

Population			
	Tot.population living in towns with sewerage:	inhabitants	22.200
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	58
	Cesspools	%	42
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Karak only Muta
	Population connected (as coverage treatment)	c	12.900
	Coverage	%	58
	Important industries	-	except of slaughterhouse, no important water poll. industries (
	Number of stormwater overflows works	no.	none
	Length of sewers	km	50,3
	Length per connected capita	m/c	3,9
	House connections	h.c.	1.219
	Capita per house connection	c/h.c.	10,6
	Return factor (acc. to Design Report)	-	0,85
	Monthly peak factor	-	1,15
	Employees for wastewater collection	E	5
	Factor: Sewer length per connected capita/coverage		6,7

BASIC DATA OF TREATMENT PLANT: Karak

8

Wastewater treatment

Wastewater treatment technology			TF + MP
Wastewater treatment technology			Trickling filters plus maturation ponds
In operation since			1988
Composed of treatment facilities			
	Facility		Screen
	Number of units	-	2 (1 manual + 1 autom., but not operational)
	Total dimension		-
	Facility		Grit chamber
	Number of units	-	2 (manual)
	Total dimension		
	Facility		Imhoff tank
	Number of units	-	2
	Total dimension		2 x 91 / 2 x 540 m3 (settling tank/digester)
	Facility		Trickling filters (stage I)
	Number of units	-	1
	Total dimension		450 m3
	Facility		Trickling filters (stage II)
	Number of units	-	1
	Total dimension		450 m3
	Facility		Secondary settling tanks
	Number of units	-	1
	Total dimension		250 m3
	Facility		Maturation ponds
	Number of units	-	1
	Total dimension		9,500 m3
	Facility		Chlorination unit (in operation)
	Number of units	-	1
	Total dimension		85 m3
	Facility		Sludge lagoon
	Number of units	-	2
	Total dimension		2 x 530 m3
	Facility		Drying beds
	Number of units	-	12
	Total dimension		1,300 m2
	Remarks:		Sludge lagoons used holdings without possibility to deviate supernatant water. Space for 2nd train available. Distributor of trickling filters needs repair.
Installed capacity		m^3/d	800
			-
Population served (assuming 65 g/c/d)		c	12.900
Coverage (assuming 65 g/c/d)		%	58
Inflow treatment plant (average)		m^3/d	1.146
		MCM/a	0,418
Estimated losses by seepage/evaporation		%	10
Estimated effluent of the treatment plant		m^3/d	1.031
		MCM/a	0,376
BOD_5-load influent (according to WAJ data)		mg/l	729
		kg/d	835
		t/a	305
BOD_5-load effluent (according to WAJ data)		mg/l	46
		kg/d	47
		t/a	17
			-
Fecal coliforms at effluent (acc.to WAJ data)		1/100 ml	>1,600
Helminth eggs		eggs/l	0
Spec.wastewater generation		l/c/d	89
Spec.BOD_5-load		g/c/d	65
Total dissolved solids (TDS) at effluent		mg/l	896
Sludge management			Every day sludge from the Imhoff tank discharged to the sludge lagoons. Every 2 weeks sludge is spread out in the drying beds. Dried sludge is brought by trucks to the Lagoun dumping ground, even liquid sludge in winter.

BASIC DATA OF TREATMENT PLANT: Karak

8

Cost of wastewater treatment

Operation and maintenance cost	JD/a	67.579
Operation/maintenance cost related to influent	JD/m³	0,162

Performance of wastewater collection

Employees for wastewater collection	E	5
Number of employees per 1,000 house conn.	E/1000 h.c.	4,1
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	1,0
Average number of complaints per month	1/month	60
Average number of complaints per km sewer	1/month/km	1,2

Performance of wastewater treatment

Treatment efficiency (BOD_5 acc.to WAJ data)	%	94
Expected efficiency (acc.to experience)	%	90 - 95
Used treatment capacity (hydraulic)	%	143
Odor problems	-	not particularly
Specific treatment problems		overload of the plant
Power-cuts		1 per month (0.5 h), generator available
Operation/maintenance arrangement available		basic
Employees for wastewater treatment	E	23
Recommended number of employees (WWTP)	E	5

Environmental impacts of effluent

Discharge of effluent into		Wadi Karak (8 km downstream of the plant by a pipe)
Requirements acc. to JS 893/1995		respected
(according to WAJ data)		-

Reuse of effluent for agricultural irrigation

Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		some
Practice of unrestricted irrigation		no
Irrigation near treatment plant	donums	25

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

9. KUFRANJA TREATMENT PLANT

The Kufranja Wastewater Treatment Plant is located in the Wadi Kufranja and receives sewage from the town of Kufranja, Ain Janna, Ajlun and Anjara. The strength of the influent wastewater is rather high - 1,330 mg BOD_5/l in the average. This is due to the low consumption per capita (about 50 l/c/d) in the settlements connected.

The total length of sewers is about 95 km, which corresponds to a specific length per connected capita of about 2.5 m/c - a relatively high value. The total number of house connections amounts to some 2,800. Based on figures for 1999 the connected population was determined to be 38,500. However, substantial improvement of this rate is impossible, because Kufranja has already a quite high connection rate (about 96 %).

The incoming flow to the treatment plant is screened (one automatic and one manual screen) and passes then two parallel-arranged Imhoff tanks. Biological treatment is based on a two-stage trickling filter technology. Stage I comprises two parallel trickling filters and two secondary settling tanks. Stage II consists of a trickling filter and a secondary settling tank (see Figure 9). Treated wastewater is disinfected by chlorination. A maturation pond serves for tertiary treatment. It is recommended to disinfect the treated wastewater downstream of the maturation pond.

The high strength of the raw wastewater (1,330 mg BOD_5/l) leads to a high charge of the trickling filters. This resulted in a blockage of the filter medium (plastic material) to an extend of about 50 % in the trickling filters (stage I) and about 10 % in the trickling filters (stage II). Although the recirculation of water was proposed in the design and the electro-mechanical equipment was available, since the plant was put in operation in 1989, recirculation of water was started some 5 months ago only to reduce the BOD_5-loading of the trickling filters. It seems that the BOD_5-concentration in the effluent improves due to this measure. The filter material of the first stage trickling filters needs urgently cleaning or replacement to recover its initial capacity.

Sludge of the secondary settling tanks is discharged to holding tanks and from there to the Imhoff tanks, where sludge is decomposed in a chamber below the settling volume. Every two weeks excess sludge of the Imhoff tanks is spread at the drying beds. The dried sludge is transported by trucks to the solid waste dumping ground located in about 5 km distance. According to the responsible personnel of the treatment plant the surface of the drying beds is insufficient. The existing bed should be subdivided in smaller units to be able to discharge the excess sludge from the Imhoff tank to the drying beds in shorter time intervals.

Main receiving water is Wadi Kufranja flowing down to the Jordan Valley. The effluent's quality (65 mg BOD_5/l) does not meet the requirements according to the relevant Jordanian Standard 893/1995 for discharge into wadis and catchment areas. The fecal coliform count at the outflow of the plant does not allow unrestricted agricultural irrigation.

Presently, treated wastewater is used for restricted irrigation inside (35 donums) and downstream of the plant (55 donums). The farmers reusing the treated wastewater

complain about the unsatisfactory water quality. However, it seems that along the Wadi Kufranja downstream of the plant site, there is demand for irrigation water. Other resources than treated wastewater are scarce.

A Feasibility Study on the "Rehabilitation and Extension of Wastewater Treatment Plants in Karak and Kufranja" will be prepared in 2001. In June 2000 offers for consultancy services were presented to WAJ. The study will be financed by the Kreditanstalt fuer Wiederaufbau, KfW (German Bank for Reconstruction and Development). The proposed project includes the rehabilitation and extension of the existing treatment plant of Kufranja as well as the extension of the existing sewerage network.

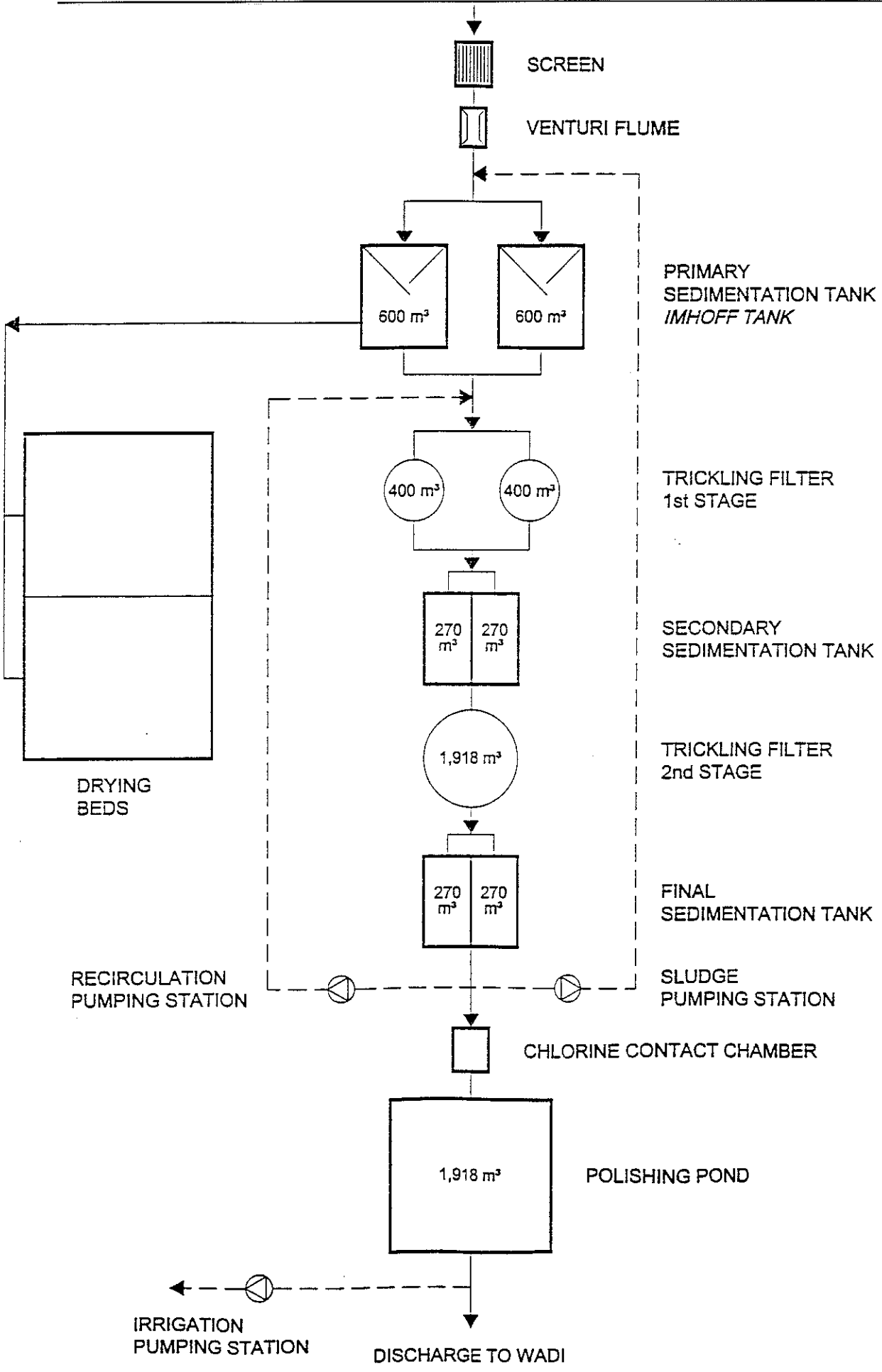


FIGURE 9: Schematic Layout of Existing Wastewater Treatment Plant - KUFRANJA

BASIC DATA OF TREATMENT PLANT: Kufranja

(Data of 1999, if not another year indicated) 9

Town:	Kufranja
Governorate:	Ajlun
Treatment plant:	Kufranja
Date of visit:	29.3.2000
Responsible engineer:	Mohammad Fryhat
Contacted person:	Mohammad Fryhat
Telephone:	02/6454139

Population			
	Tot.population living in towns with sewerage:	inhabitants	53.500
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	66
	Cesspools	%	34
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Kufranja Anjara, Ain Janna, Ajlun
	Population connected (as coverage treatment)	c	35.500
	Coverage	%	66
	Important industries	-	no important water polluting industries connected
	Number of stormwater overflows works	no.	1 (at the treatment plant)
	Length of sewers	km	100,0
	Length per connected capita	m/c	2,8
	House connections	h.c.	2.503
	Capita per house connection	c/h.c.	14,2
	Return factor (acc. to Design Report)	-	0,8
	Monthly peak factor	-	1,20
	Employees for wastewater collection	E	10
	Factor: Sewer length per connected capita/coverage		4,2

BASIC DATA OF TREATMENT PLANT:

Kufranja

9

Wastewater treatment

Wastewater treatment technology			TF + MP
Wastewater treatment technology			Trickling filters plus maturation ponds
In operation since			1989
Composed of treatment facilities			
	Facility		Screen
	Number of units	-	2 (1manual+1 automatic)
	Total dimension		
	Facility		Imhoff tank
	Number of units	-	2
	Total dimension		2 x 600 / 2 x 1,100 m3 (settling tank/digester)
	Facility		Trickling filters (stage I)
	Number of units	-	2
	Total dimension		2 x 400 m3
	Facility		Secondary settling tanks (stage I)
	Number of units	-	2
	Total dimension		2 x 270 m3
	Facility		Trickling filters (stage II)
	Number of units	-	1
	Total dimension		1,900 m3
	Facility		Secondary settling tanks (stage II)
	Number of units	-	2
	Total dimension		2 x 270 m3
	Facility		Chlorination unit
	Number of units	-	1
	Total dimension		
	Facility		Maturation ponds
	Number of units	-	1
	Total dimension		1,900 m3
	Facility		Sludge holding tank (for return sludge)
	Number of units	-	1
	Total dimension		900 m2
	Facility		Drying beds
	Number of units	-	3
	Total dimension		3,300 m2
	Remarks:		Trickling filters (stage I): about 50 % of the surface blocked Trickling filter (stage II): about 10 % of the surface blocked Meanwhile improvements due to recycled water (since 5 months).
Installed capacity		m^3/d	1.800
Population served (assuming 65 g/c/d)		c	35.500
Coverage (assuming 65 g/c/d)		%	66
Inflow treatment plant (average)		m^3/d	1.734
		MCM/a	0,633
Estimated losses by seepage/evaporation		%	10
Estimated effluent of the treatment plant		m^3/d	1.561
		MCM/a	0,570
BOD_5-load influent (according to WAJ data)		mg/l	1.331
		kg/d	2.308
		t/a	842
BOD_5-load effluent (according to WAJ data)		mg/l	65
		kg/d	101
		t/a	37
Fecal coliforms at effluent (acc.to WAJ data)		1/100 ml	no information
Helminth eggs		eggs/l	0
Spec.wastewater generation		l/c/d	49
Spec.BOD_5-load		g/c/d	65
Total dissolved solids (TDS) at effluent		mg/l	935
Sludge management			Every two weeks sludge from the Imhoff tank discharged to the drying beds. Dried sludge is brought by trucks to the dumping ground (5 km distant).

BASIC DATA OF TREATMENT PLANT: Kufranja

9

Cost of wastewater treatment

Operation and maintenance cost	JD/a	82.850
Operation/maintenance cost related to influent	JD/m^3	0,131

Performance of wastewater collection

Employees for wastewater collection	E	10
Number of employees per 1,000 house conn.	E/1000 h.c.	4,0
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	1,0
Average number of complaints per month	1/month	63
Average number of complaints per km sewer	1/month/km	0,6

Performance of wastewater treatment

Treatment efficiency (BOD_5 acc.to WAJ data)	%	95
Expected efficiency (acc.to experience)	%	90 - 95
Used treatment capacity (hydraulic)	%	96
Odor problems	-	yes (particularly in summer)
Specific treatment problems		blockage of trickling filters
Power-cuts		1per week (2-5 h), generator available
Operation/maintenance arrangement available		basic
Employees for wastewater treatment	E	21
Recommended number of employees (WWTP)	E	7

Environmental impacts of effluent

Discharge of effluent into		Wadi Kufranja to Jordan Valley
Requirements acc. to JS 893/1995		not respected
(according to WAJ data)		-

Reuse of effluent for agricultural irrigation

Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		insite of plant: 35 donums, outside of plant: 55 donums
Practice of unrestricted irrigation		no
Irrigation near treatment plant	donums	90

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

10. MA'AN TREATMENT PLANT

The Ma'an Treatment Plant receives its wastewater from the sewerage system of Ma'an only.

At the inlet of the plant a screen (1 mechanical and 1 automatic) is available. However, presently influent to the plant bypasses the facility and, therefore, is not screened. The wastewater stabilization pond system of Ma'an consists of 2 anaerobic ponds (operated in series), 3 facultative ponds (operated in parallel) and 1 maturation pond. Pipe connections within the plant allow to operate the anaerobic and facultative ponds either in parallel or in series (see Figure 10). Disinfection of the effluent is possible by a chlorination plant, but was not in operation in March 2000. Treated wastewater may be recirculated from the outlet of the maturation pond to the headworks. Drying beds for sludge are not available.

Land within the treatment plant area is sufficient to extend the plant by 3 more facultative ponds and a maturation pond.

In 1996, the anaerobic ponds were desludged for the first and the only time, since the treatment facilities were put in operation in 1989. Sludge was emptied of the ponds and filled in excavated trenches within the treatment plant area for drying and infiltration.

The inflow of the 1989 completed plant has reached its hydraulic capacity and is meanwhile overloaded by almost 10 %. The average BOD_5-strength (influent) of about 550 mg/l is relatively low (in comparison to other plants in Jordan).

The natural receiving water of the effluent is the Wadi Al Hamam. The average BOD_5-concentration in the effluent of the plant is unsatisfactory (120 mg/l) and exceeds the relevant Jordanian Standards 893/1995 for discharge into wadis and catchment areas.

In summer about 500 m^3/d of treated wastewater is reused for agricultural irrigation, while this quantity decreases to some 200 m^3/d in winter. Private farmers pay 2 Fils/m^3 for treated wastewater, which is used outside of the treatment plant area. At present, about 70 donums of farmland are irrigated by treated wastewater. In addition, within and close to the treatment plant area about 50 donums are irrigated. However, the quality of the effluent does not meet the biological requirements for unrestricted agricultural irrigation. Fecal coliform counts reach values up to more than 1,000,000 per 100 ml. Due to the poorly treated wastewater having still high contents of organic compounds it is not advisable to use the existing chlorination plant for reduction of the bacterial pollution (fecal coliform count).

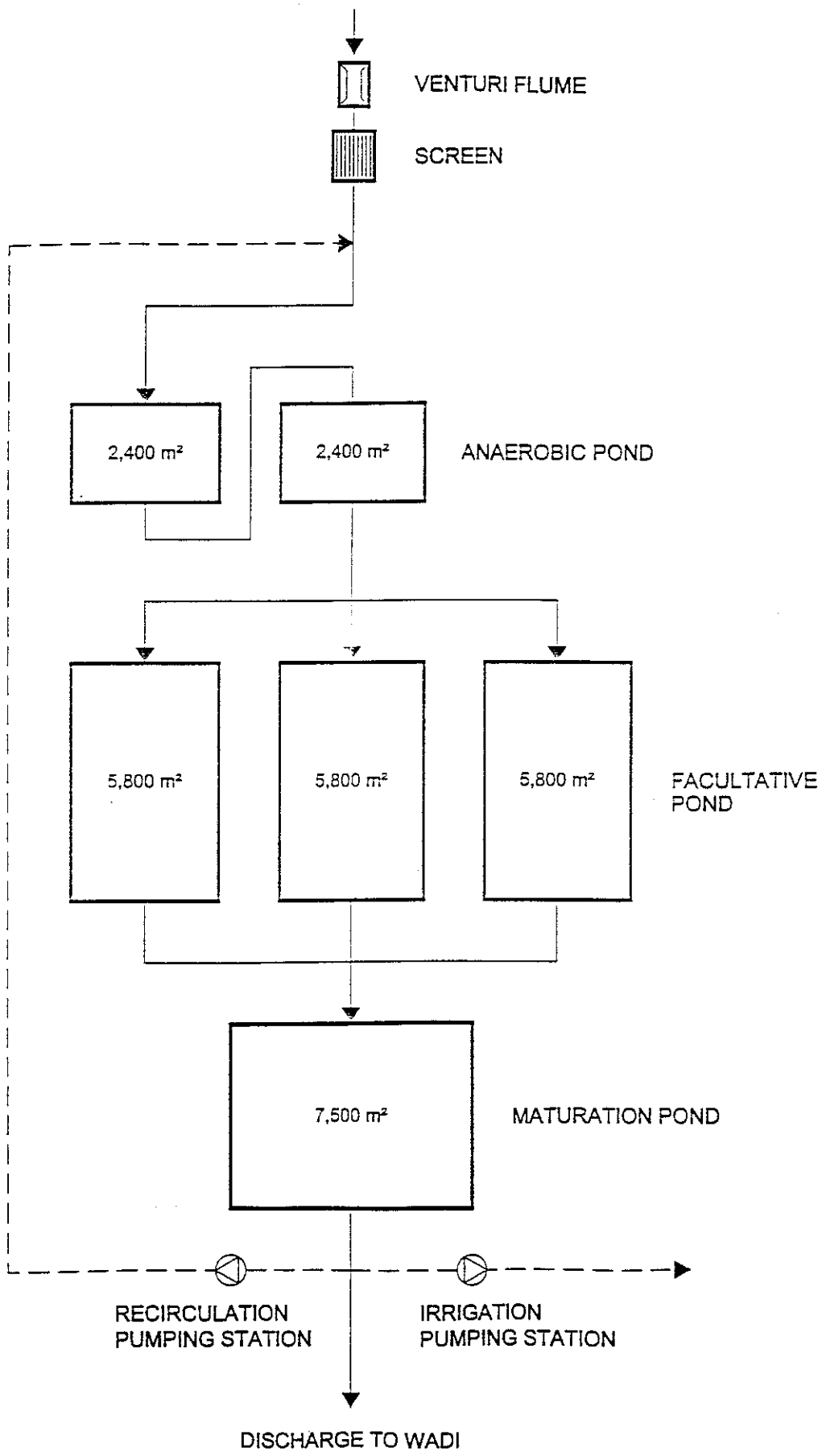


FIGURE 10: Schematic Layout of Wastewater Existing Treatment Plant - MA'AN

BASIC DATA OF TREATMENT PLANT: Ma'an

(Data of 1999, if not another year indicated) 10

Town:	Ma'an
Governorate:	Ma'an
Treatment plant:	Ma'an
Date of visit:	3.4.2000
Responsible engineer:	Haidar Ali Raswashdeh
Contacted person:	Mohammed Mefleh Qtieshat
Telephone:	none

Population			
	Tot.population living in towns with sewerage:	inhabitants	27.200
	Population growth	%	3,6
Wastewater disposal			
	Public system	%	54
	Cesspools	%	46
	Others	%	0
Wastewater collection			
	Towns/villages connected (the most important)	-	Ma'an
	Population connected (as coverage treatment)	c	14.700
	Coverage	%	54
	Important industries	-	no important water polluting industries connected
	Number of stormwater overflows works	no.	none
	Length of sewers	km	52,8
	Length per connected capita	m/c	3,6
	House connections	h.c.	871
	Capita per house connection	c/h.c.	16,9
	Return factor (acc. to Design Report)	-	0,85
	Monthly peak factor	-	1,25
	Employees for wastewater collection	E	4
	Factor: Sewer length per connected capita/coverage		6,6

BASIC DATA OF TREATMENT PLANT: Ma'an

10

Wastewater treatment

Wastewater treatment technology		WSP
Wastewater treatment technology		Wastewater stabilisation ponds
In operation since		1989
Composed of treatment facilities		
Facility		Screen
Number of units	-	1 (manual)
Total dimension		-
Facility		Anaerobic ponds
Number of units	-	2
Total dimension		2 x 12,000 m3
Facility		Facultative ponds
Number of units	-	3
Total dimension		3 x 14,500 m3
Facility		Maturation ponds
Number of units	-	1
Total dimension		9,400 m3
Facility		Chlorination unit
Number of units	-	1 (not in operation)
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		Recirculation pump available between the maturation pond and the screen. The screen not operational. By-pass used.

Installed capacity	m^3/d	1.600
Population served (assuming 65 g/c/d)	c	14.700
Coverage (assuming 65 g/c/d)	%	54
Inflow treatment plant (average)	m^3/d	1.738
	MCM/a	0,634
Estimated losses by seepage/evaporation	%	25
Estimated effluent of the treatment plant	m^3/d	1.304
	MCM/a	0,476
BOD_5-load influent (according to WAJ data)	mg/l	549
	kg/d	954
	t/a	348
BOD_5-load effluent (according to WAJ data)	mg/l	118
	kg/d	154
	t/a	56
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	16 mio. in October 1999
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	118
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	945
Sludge management		Desludging of anaerobic ponds once in in 11 years (1996) Sludge dried in ditches and covered by earth within the treatment plant area.

BASIC DATA OF TREATMENT PLANT: Ma'an

10

Cost of wastewater treatment		
Operation and maintenance cost	JD/a	46.350
Operation/maintenance cost related to influent	JD/m^3	0,073
Performance of wastewater collection		
Employees for wastewater collection	E	4
Number of employees per 1,000 house conn.	E/1000 h.c.	4,6
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	0,8
Average number of complaints per month	1/month	85
Average number of complaints per km sewer	1/month/km	1,6
Performance of wastewater treatment		
Treatment efficiency (BOD_5 acc.to WAJ data)	%	79
Expected efficiency (acc.to experience)	%	80 - 90
Used treatment capacity (hydraulic)	%	109
Odor problems	-	minor (particularly in summer)
Specific treatment problems		no laboratory available at plant
Power-cuts		1 per month (1-2 h), no generator available
Operation/maintenance arrangement available		none
Employees for wastewater treatment	E	15
Recommended number of employees (WWTP)	E	5
Environmental impacts of effluent		
Discharge of effluent into		Wadi Al Hamam
Requirements acc. to JS 893/1995 (according to WAJ data)		not respected
Reuse of effluent for agricultural irrigation		
Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		in summer: 500 m3/d, in winter 200 m3/d
Practice of unrestricted irrigation		no
Irrigation near treatment plant	donums	120

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds

11. MADABA TREATMENT PLANT

The treatment plant of Madaba receives the wastewater of the city of Madaba only. The wastewater stabilization pond system of the treatment plant of Madaba comprises the following facilities: screens, two trains of anaerobic ponds, facultative ponds and maturation ponds (see Figure 11). Disinfection of the effluent is possible by a chlorination plant.

The 1989 completed plant is meanwhile overloaded by almost 100 %. The BOD_5-strength was estimated at design stage to be about 800 mg/l. Indeed the actual (measured) BOD_5-concentration is in the order of 1,200 to 1,300 mg/l. The design capacity of the treatment plant (2,000 m^3/d) was already reached in 1993 and increases continuously (3,600 m^3/d in 1999). It seems that meanwhile even the "maturation ponds" operate under anaerobic conditions.

The BOD_5-concentration in the effluent reaches values of more than 400 mg/l and exceeds by far the relevant Jordanian Standards 893/1995 for discharge into wadis and catchment areas. The natural receiving water of the effluent is the Wadi Al Habis a tributary of Wadi Walah. Resources (several springs) along Wadi Walah would be polluted by the poorly treated wastewater of the Madaba plant. It was decided to avoid the discharge of the effluent into the Wadi Al Habis.

Therefore, in summertime the poorly treated wastewater is totally used for agricultural irrigation within the treatment plant area (about 200 donums) and outside (about 500 donums). In wintertime the effluent is stored in several ponds at the plant site for infiltration and evaporation as well as for agricultural use in summer. However, the quality of the effluent is quite unsatisfactory (280 mg BOD_5/l) and does not meet the biological requirements for the unrestricted reuse of treated wastewater for agricultural irrigation. The fecal coliform counts reach values between 10,000 and 20,000 per 100 ml. Due to the poorly treated wastewater having still high contents of organic compounds it is not advisable to use the existing chlorination plant for reduction of the bacterial pollution (fecal coliform count).

In 1996 Korean Engineering Company Hyundai has prepared a new design for the treatment plant of Madaba. The project was tendered and 6 construction companies have sent their bid to WAJ (March 2000). Implementation of the new plant shall be based on turnkey arrangement. It is intended to finance the project by a Korean and/or a Danish loan.

According to the new design the existing anaerobic ponds shall be used as stormwater overflow tanks (equalizing tank) to receive excess stormwater during rainfalls. Wastewater shall be pretreated by screens and 2 grease removal chambers. Biological treatment shall be based on an activated sludge process (extended aeration) comprising activated sludge tanks and secondary settling tanks. Additional treatment shall be provided by maturation (polishing) ponds using the existing facultative ponds. The existing maturation ponds shall be modified to provide further tertiary treatment (rock filtration). A chlorination unit shall provide the possibility of disinfection of the effluent, if required. Excess sludge shall be treated by sludge thickeners. The thickened sludge shall be dried by sludge drying beds. Dried sludge shall be disposed at a sanitary landfill.

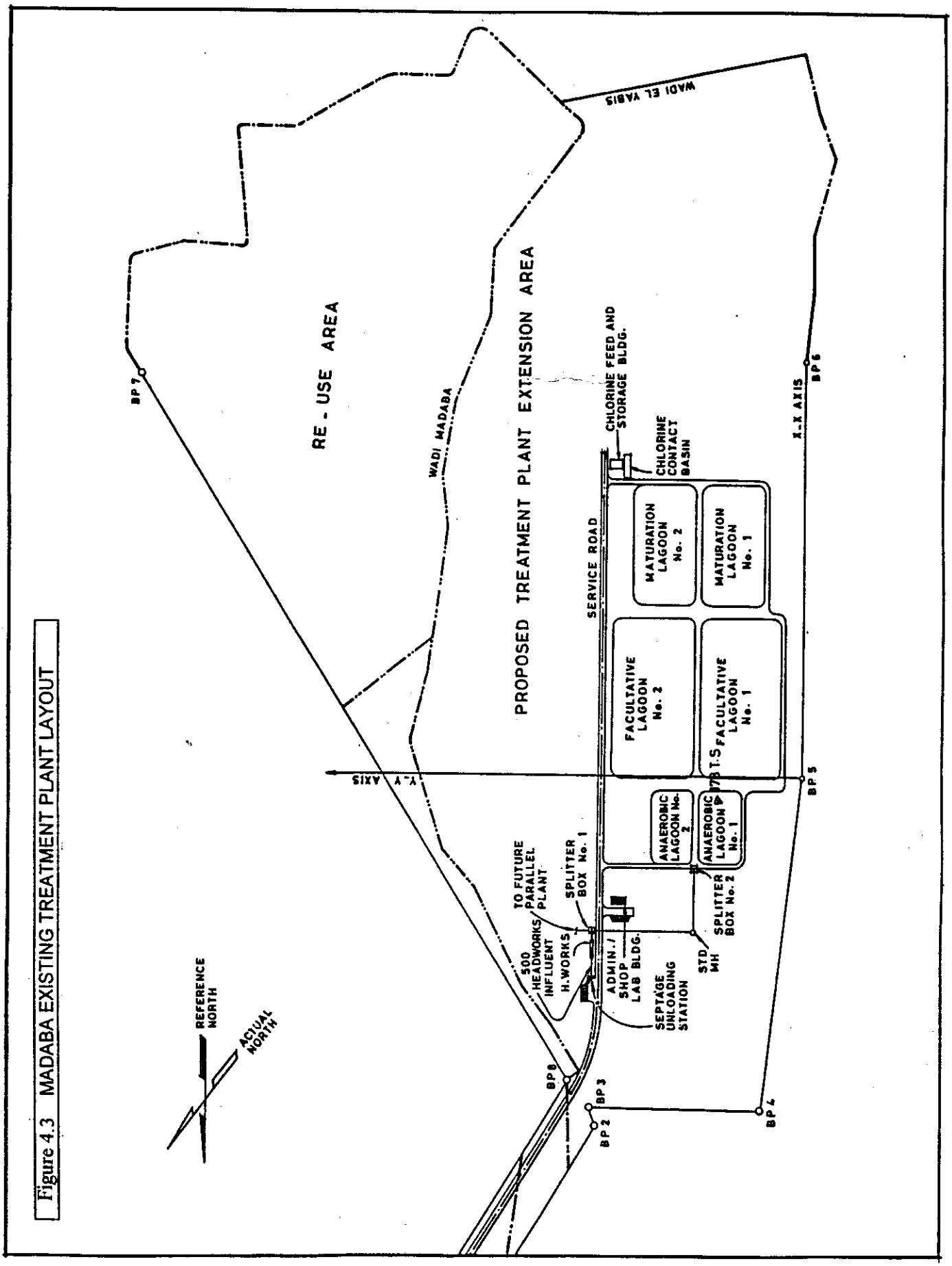


FIGURE 11: Schematic Layout of Existing Wastewater Treatment Plant - MADABA

BASIC DATA OF TREATMENT PLANT:

Madaba
11

(Data of 1999, if not another year indicated)

Town:	Madaba
Governorate:	Madaba
Treatment plant:	Madaba
Date of visit:	23.3.2000
Responsible engineer:	Imad Jammalieh
Contacted person:	Imad Jammalieh
Telephone:	05/544729

Population		
Tot.population living in towns with sewerage:	inhabitants	65.900
Population growth	%	3,6
Wastewater disposal		
Public system	%	77
Cesspools	%	23
Others	%	0
Wastewater collection		
Towns/villages connected (the most important)	-	Madaba Town only
Population connected (as coverage treatment)	c	51.000
Coverage	%	77
Important industries	-	assembling machineries, Coca-Cola
Number of stormwater overflows works	no.	1 (at the treatment plant)
Length of sewers	km	93,9
Length per connected capita	m/c	1,8
House connections	h.c.	3.771
Capita per house connection	c/h.c.	13,5
Return factor (acc. to Design Report)	-	0,8
Monthly peak factor	-	1,10
Employees for wastewater collection	E	9
Factor: Sewer length per connected capita/coverage		2,4

BASIC DATA OF TREATMENT PLANT:

Madaba
11

Wastewater treatment

Wastewater treatment technology		WSP
Wastewater treatment technology		Wastewater stabilisation ponds
In operation since		1989
Composed of treatment facilities		
Facility		Screen
Number of units	-	1 (manual)
Total dimension		-
Facility		Anaerobic ponds
Number of units	-	2
Total dimension		(2 x 5,700) m3
Facility		Facultative ponds
Number of units	-	2
Total dimension		(2 x 17,800) m3
Facility		Maturation ponds
Number of units	-	2
Total dimension		(2 x 7,300) m3
Facility		Chlorination unit
Number of units	-	1
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Facility		-
Number of units	-	-
Total dimension		-
Remarks:		-
		-

Installed capacity	m^3/d	2.000
Population served (assuming 65 g/c/d)	c	51.000
Coverage (assuming 65 g/c/d)	%	77
Inflow treatment plant (average)	m^3/d	3.609
	MCM/a	1,317
Estimated losses by seepage/evaporation	%	25
Estimated effluent of the treatment plant	m^3/d	2.707
	MCM/a	0,988
BOD_5-load influent (according to WAJ data)	mg/l	918
	kg/d	3.313
	t/a	1.209
BOD_5-load effluent (according to WAJ data)	mg/l	282
	kg/d	763
	t/a	279
		Influent BOD5 is of 1998 (1999 value 1,382 is too high)
Fecal coliforms at effluent (acc.to WAJ data)	1/100 ml	>15,000
Helminth eggs	eggs/l	0
Spec.wastewater generation	l/c/d	71
Spec.BOD_5-load	g/c/d	65
Total dissolved solids (TDS) at effluent	mg/l	1.439
Sludge management		Desludging of anaerobic ponds once in in 11 years (1996)

BASIC DATA OF TREATMENT PLANT:

Madaba 11

Cost of wastewater treatment

Operation and maintenance cost	JD/a	56.792
Operation/maintenance cost related to influent	JD/m^3	0,043

Performance of wastewater collection

Employees for wastewater collection	E	9
Number of employees per 1,000 house conn.	E/1000 h.c.	2,4
Recommended number of employees	E/1000 h.c.	2 - 4
Number of employees per km sewer	E/10km	1,0
Average number of complaints per month	1/month	60
Average number of complaints per km sewer	1/month/km	0,6

Performance of wastewater treatment

Treatment efficiency (BOD_5 acc.to WAJ data)	%	69
Expected efficiency (acc.to experience)	%	80 - 90
Used treatment capacity (hydraulic)	%	180
Odor problems	-	extremly (particularly in summer)
Specific treatment problems		biological overloading of plant
Power-cuts		no problem
Operation/maintenance arrangement available		?
Employees for wastewater treatment	E	10
Recommended number of employees (WWTP)	E	16

Environmental impacts of effluent

Discharge of effluent into	hydrographically Wadi Al Habis
Requirements acc. to JS 893/1995	not respected
(according to WAJ data)	(practically all effluent is stored/infitrated in winter and reused for irrigation in summer)

Reuse of effluent for agricultural irrigation

Possible reuse (acc. to JS 893/1995)		restricted irrigation only
Practice of restricted irrigation		in summer: entire effluent is reused for restricted irrigation
Practice of unrestricted irrigation		irrigation: inside/outside of plant: 200/500 donum
Irrigation near treatment plant	donums	630

Evaporation/infiltration losses of treatment plants:

Wastewater stabilization ponds	WSP
Activated sludge process/Trickling filters	AS/TF
Act.sludge proc./Trickl.filters incl.maturation pond	AS/TF+MP
Aerated ponds incl. maturation ponds	Aer.ponds