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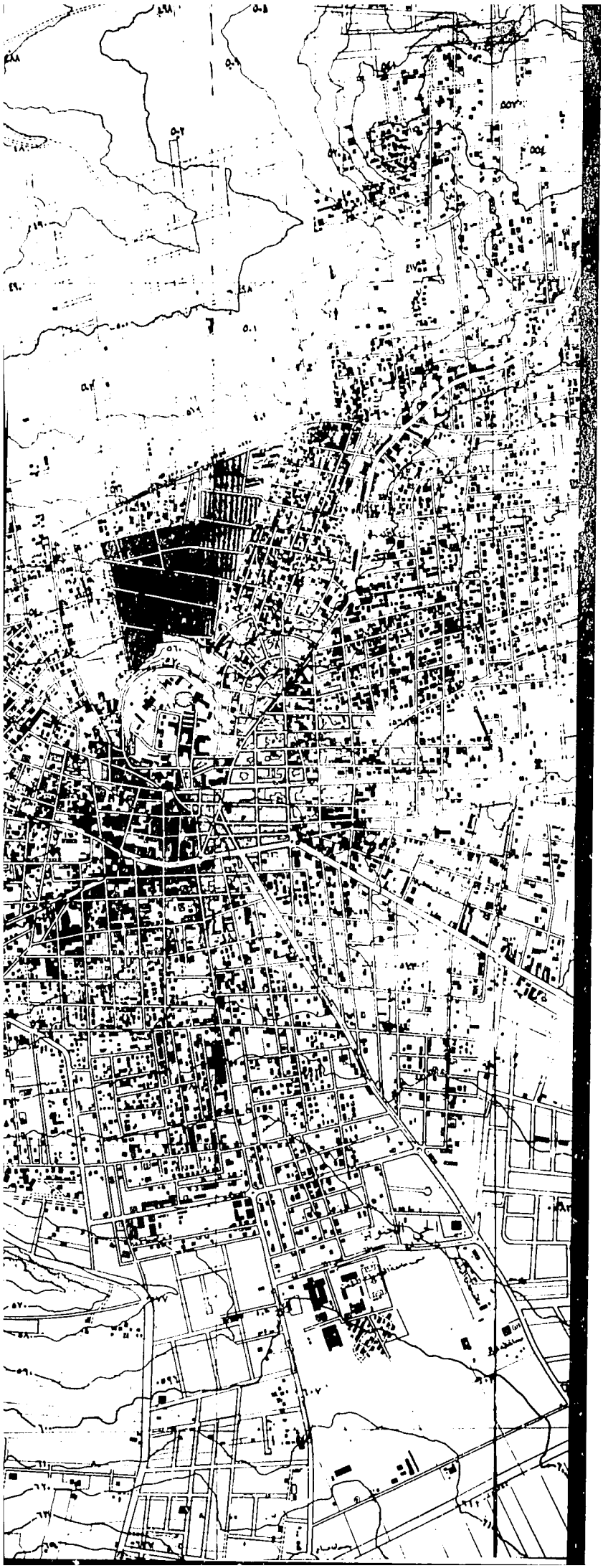

FEASIBILITY REPORT
AND PRELIMINARY
ENGINEERING STUDIES

IRBID MUNICIPAL WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

SUBMITTED THRU

MINISTRY OF MUNICIPAL, RURAL AND ENVIRONMENTAL AFFAIRS - EXECUTING AGENCY

TO THE

NATIONAL PLANNING COUNCIL - THE HASHEMITE KINGDOM OF JORDAN

March 1980

By
WESTON INTERNATIONAL, INC.

in association with
STANLEY CONSULTANTS, INC.
SIGMA-CONSULTING ENGINEERS
MRM-CONSULTING ENGINEERS
CO., LTD.

Feasibility Report and Preliminary
Engineering Studies

IRBID MUNICIPAL WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

Submitted Through
Ministry of Municipal, Rural and
Environmental Affairs --
Executing Agency

To The
National Planning Council
The Hashemite Kingdom of Jordan

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CHAPTER 1

FINAL REPORT SUMMARY

1.1 INTRODUCTION

On 1 May 1979, authority was given to proceed with the Feasibility and Preliminary Engineering Studies Project Phase of the subject project by the Ministry of Municipal and Rural Affairs (MMRA), acting as executing agency for the National Planning Council (NPC). The consultant group selected by NPC to provide engineering and design services was Weston International, Inc., with its subcontractors Stanley Consultants, Inc,; SIGMA-Consulting Engineers, and MRM Consulting Engineers Co., Ltd.

Weston's Project Director and Resident Project Manager arrived in Amman to begin work on 17 May 1979. A project office, located near the University of Jordan, was opened shortly thereafter to provide working space for all members of the Weston association. Using both American and Jordanian engineers, planners, and economists, the feasibility study was performed and submitted in draft form to NPC/MMRA on 25 October 1979.

Weston was delayed over 70 days by late delivery of mapping supplied by the National Geographic Center. The feasibility report was submitted 40 days late which means that Weston was able to make up 30 days by working in the evening and on weekends.

1.2 SCOPE

The objective of the feasibility study was to investigate the technical and economic feasibility of constructing four types of municipal services for the Irbid town plan area. They are:

1. A water distribution system.
2. A sewage collection, treatment, and disposal system.
3. A limited stormwater drainage system.
4. A solid waste collection and disposal system.

In addition, preliminary engineering studies were to be performed to the extent necessary to demonstrate technical feasibility, and to provide a basis for cost estimating.

The results of these studies are summarized in the following sections in items of the major findings and recommendations forwarded to NPC/MMRA as part of this feasibility report.

1.3 SOCIOECONOMIC STUDIES

Estimates of the present and future population, land use, and industrial development characteristics of the project area (defined as the Irbid town plan area) were made, based upon the best data available at the time the study was conducted. These estimates were prepared from census data, prior and concurrent planning studies prepared by others, and information supplied by the Municipality of Irbid. The 1978 Irbid population was estimated to be 146,000, and project growth rates of 4.5 percent through 1985, and 4.0 percent for the remaining period 1986 to the year 2000 were projected. The population projected for Irbid is as follows:

Year	Population
1975	128,000
1978 (Present)	146,000
1990	242,200
2000	353,400

Concurrent projections of land use were made for residential, commercial, mixed commercial/industrial, and industrial uses.

Subsequent to the completion of the study (January 1980), preliminary results of a new national census of population became available. The census was taken in November 1979, and lists the population of Irbid as 113,000. This reduced population will have little effect on the design of the proposed facilities, but it will have an effect on user charges that may be imposed to finance the project. These rates are evaluated in Chapter 9.

1.4 STUDY CRITERIA

Various criteria were developed by the consultant to provide uniform guidelines for the feasibility studies. Included were development of factors for water use rates, sewerage generation rates, rainfall intensity/duration criteria, and solid waste generation factors. In addition, cost data and prototypical facilities designs were developed. These criteria were discussed with various governmental agencies, local engineers and contractors, and other interested individuals, and modified as necessary to insure that the criteria applied to this study are representative of the conditions present in Jordan in general, and in Irbid in particular.

1.5 WATER DISTRIBUTION STUDIES

The Municipality of Irbid presently receives most of its water from the Water Supply Corporation (WSC), and distributes it to a limited number of customers through a small-diameter distribution system. Because of this system's hydraulic deficiencies and unmet water demands, an analysis of the existing system was not carried out, as it has no long-range usability.

At the present time, sufficient supplies of water are not available to meet the demand for water in Irbid. Present water use rates are less than 30 liters/capita/day, and a substantial percentage of demand is unmet.

As water availability is improved by the north Jordan water supply project and/or improvements in the WSC supply system, the demand for water will increase to normal use rates for Jordan which are estimated to be as follows:

	1980	1990	2000
Domestic (liters/capita/day)	75	85	95
Total (liters/capita/day)	126	144	160

The difference between domestic and total water use rates is caused by commercial/industrial use, unmetered illegal connections, and system leakage.

Various alternative methods of providing improved water service to Irbid were studied. The recommended plan calls for a four-zone distribution system that will be fed through a single connection to the (proposed) JVA transmission pipeline. The location of this connection allows water to enter the distribution system before it has to be pumped up to the JVA reservoir at Natifa. Once the water enters the system, it can be distributed by gravity without the need for pumping or elevated/ground storage reservoirs. Pressure-reducing stations are needed between distribution zones to maintain reasonable distribution pressures. All alternatives were analyzed using computer techniques.

The system is sized to deliver sufficient water to meet an average daily demand of 55,600 cu m/day by the year 2000. Service pressures in all parts of the City will be within a range of 210-620 kPa (30-90 psi). Nearly 75 km of new water mains are proposed, ranging in size from 10 cm (4 in.) to 80 cm (32 in.). Operation, maintenance, and training programs have been proposed.

1.6 WASTEWATER SYSTEM

The existing sewer system in Irbid consists of three short lengths of 50 cm (20 in.) pipe having a total length of about 600 m. Wastewater from these sewers is discharged untreated into a stormwater box culvert located in the Wadi Tariq Saum. All other domestic and commercial sewage is collected and disposed of in cesspools or septic tanks. Septic tank solids that are collected are trucked to Wadi el Hamam and discharged untreated.

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Alternative methods of providing sewage collection service to Irbid were formulated and analyzed. The results of the 1971 Czechoslovakian report were used as input to these studies. Based on this analysis, an optimum sewer routing scheme was developed that minimizes the need for pumping and lift stations. It also reduced the number of major interceptors (three) recommended in the Czechoslovakian report to two.

A total of 10.5 km of interceptor sewers is recommended for the master plan system, and over 340 km of trunk sewers and laterals, staged as follows:

	Stage I	Stage II
Interceptors, trunk sewers, and laterals	188.3 km	162.0 km
Pumping stations	3	3

It was estimated that the water use/wastewater generation factor applicable to Irbid is 80 percent, and the sewers were designed accordingly. The collection system is designed to serve 87 percent of the projected 1990 population, and the entire projected population by the year 2000. Included in the areas to be served in the first phase are low-income areas identified as having potential health problems.

Several alternatives were formulated and analyzed regarding appropriate methods of treatment and disposal of wastewater from Irbid, including:

1. Direct land application of wastewater.
2. Waste stabilization ponds (various types).
3. Biological treatment systems (various types).

A type of biological treatment system, called the extended aeration process, has been recommended for several reasons, including its ability to meet recommended discharge standards, cost-effectiveness, and other technical, socioeconomic, environmental, reliability, and safety considerations.

1.7 STORMWATER DRAINAGE SYSTEM

Two major drainage basins receive stormwater runoff from Irbid: Wadi Tariq Saum and Wadi el Hamam. Both of these basins contain existing stormwater drainage facilities that:

1. Are hydraulically constrained due to the location of inlets.

2. Have sediment accumulation and structural damage.

3. Carry sanitary wastewater flows.

4. Have flooding problems due to inadequate design capacity.

Major drainage problem areas were identified in both basins. Meteorological and hydrological studies were made to determine the statistical characteristics of rainfall intensity and duration patterns for the Irbid region. Based on the results of these studies, alternative methods of managing stormwater runnoff were investigated. The recommended system derived from this optimizing process includes limited use of existing facilities and construction of new facilities to relieve flooding problem areas.

In Wadi el Hamam, a new major collector network will be routed along the natural drainage course. An extension of this line, running southwest along Heckma Street, will relieve a flood problem area to the east of the refugee camp.

In Wadi Tariq Saum, a new storm drain line is also recommended to intercept the runoff from the large southern area of the basin. It also will relieve the overloaded existing drain which will continue in service, but with a much smaller contributing area.

1.8 SOLID WASTE DISPOSAL SYSTEM

The Municipality of Irbid presently provides solid waste collection and disposal service to its residents. Currently, waste material is placed in plastic or burlap bags, and stored in vacant lots until it is picked up by a collection truck. Pick-up schedules are irregular.

Studies show that solid waste is presently generated at the rate of about 0.55 kg/capita/day (1.2 lbs/capita/day) which is less than one-half European or United States generation rates. The rates are expected to increase slowly throughout the study period as the standard-of-living in Irbid continues to improve.

Several solid waste disposal alternatives were studied, including energy recovery, landfilling, and composting. Landfilling was selected mostly on the basis of economic cost-effectiveness. The recommended plan calls for the construction of a sanitary landfill on a 22-hectare (54.6 acres) site with simultaneous construction of a 10-ton/day pilot composting facility. The latter facility is recommended to provide data and demonstrate to area residents the use of composted wastes for agricultural purposes.

Improvements to the collection system have also been recommended in terms of scheduled collection and improved containers.

1.9 ENVIRONMENTAL ASSESSMENT

An assessment of the environmental impacts of each major alternative for the major systems was made.

The major long-term effect of the project will be to improve public health in Irbid by decreasing water contamination and increasing sanitation. Adverse impacts of the project include a slight decrease in water quality in the Wadi Arab drainage system, and short-term effects on air quality, noise levels, and community surroundings during construction. The adverse impacts are small compared to the potential health benefits to be derived from construction of these facilities.

1.10 ECONOMIC AND FINANCIAL FEASIBILITY ANALYSIS

The total estimated Phase 1 project capital costs are 17,891,000 JD (in constant 1979 JD). These include water distribution system costs of 5,909,000 JD, wastewater and collection system costs of 8,020,000 JD, stormwater drainage system costs of 2,974,000 JD, and solid waste disposal system costs of 988,000 JD. The estimated Phase 2 capital costs are 12,161,000 JD. (See Table 1-1, Capital Cost Summary.)

The Phase 1 capital costs are to be expended during the entire 10-year period as indicated in the construction funding schedule presented in Table 1-2. An annual capital cost inflation rate of 10 percent has been assumed for the project.

Table 1-3 presents the inflated capital costs estimated for the Phase 1 period. The total inflated costs for the project, financed in accordance with the schedule presented in Tables 1-2 and 1-3, is 24,137,000 JD.

A computerized cash flow analysis model was developed and used to project annual revenues, project costs for proposed facilities, integrate costs with existing system expenses, and compare projected costs and revenues for each element of the project. User charges and connection fees were manipulated in the model to produce positive accumulated surpluses on the income and expenditure statement as close to zero as possible.

Output from the model was used to produce cash flow statements, balance sheets, and income/expenditure statements which were checked for viability. Where outputs from these statements were unsatisfactory, user charges and connection fees were adjusted to produce new income/expenditure statements.

The cash flow model was then used to evaluate the sensitivity of the proposed facility to various factors, including inflation, water use rates, user charges, capital costs, and user population. The user

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Table 1-1

Capital Cost Summary
(Costs - JD x 1,000)

Major Work Element	Phase I Local	Phase I Foreign	Phase I Total	Phase II Local	Phase II Foreign	Phase II Total	Total Project Local	Total Project Foreign	Total Project Total
Water Supply System									
Probable construction cost[1]	2,279	2,264	4,543	1,978	1,799	3,777	4,257	4,063	8,320
Contingencies	341	342	683	295	272	567	636	614	1,250
Engineering and administration	228	455	683	189	378	567	417	833	1,250
Subtotal	2,848	3,061	5,909	2,462	2,449	4,911	5,310	5,510	10,820
Wastewater System									
Probable construction cost[1]	4,170	1,910	6,080	3,025	1,367	4,392	7,195	3,277	10,472
Contingencies	625	345	970	454	205	659	1,079	550	1,629
Engineering and administration	625	345	970	454	205	659	1,079	550	1,629
Subtotal	5,420	2,600	8,020	3,933	1,777	5,710	9,353	4,377	13,730
Storm Drainage System									
Probable construction cost[1]	2,289	123	2,412	928	14	942	3,217	137	3,354
Contingencies	272	18	290	139	2	141	411	20	431
Engineering and administration	91	181	272	47	94	141	138	275	413
Subtotal	2,652	322	2,974	1,114	110	1,224	3,766	432	4,198
Solid Waste System									
Probable construction cost[1]	449	438	937	--	316	316	449	754	1,253
Contingencies	26	--	26	--	--	--	26	--	26
Engineering and administration	13	12	25	--	--	--	13	12	25
Subtotal	538	450	988	--	316	316	538	766	1,304
Total Project Costs	11,458	6,433	17,891	7,509	4,652	12,161	18,967	11,085	30,052
Equivalent U.S. $ Cost (U.S. $ = 0.300 JD)		59,637,000			40,537,000			100,174,000	

[1] Including right-of-way

Table 1-2

Phase 1 Construction Funding Schedule
(Costs - JD x 1,000)

Description	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Total Phase 1 Cost
Water Supply System											
Water supply system costs	927	2,782	--	--	--	440	440	440	440	440	5,909
Wastewater System											
Wastewater treatment	283	1,131	1,131	--	--	--	--	--	--	--	2,545
Sewer construction	--	2,372	3,103	--	--	--	--	--	--	--	5,475
Subtotal--Wastewater System Costs	283	3,503	4,234	--	--	--	--	--	--	--	8,020
Storm Drainage System											
Storm drainage system costs	991	1,983	--	--	--	--	--	--	--	--	2,974
Solid Waste System											
Landfill development	440	110	--	--	--	--	--	--	--	--	550
Equipment procurement	162	--	25	--	22	100	30	69	--	30	438
Subtotal--Solid Waste System	602	110	25	--	22	100	30	69	--	30	988
Total Project Costs	2,803	8,378	4,259	--	22	540	470	509	440	470	17,891
Equivalent U.S. Dollar Cost (1.00 U.S. dollar = 0.300 JD)	9,343,000	27,927,000	14,197,000	--	72,000	1,800,000	1,567,000	1,697,000	1,467,000	1,567,000	59,637,000

Note: All costs in this table are constant 1979 costs.

Table 1-3

Phase 1 Construction Funding Schedule
Escalated Costs
(Costs - JD x 1,000)

Description	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Total Phase 1 Cost
Water Supply System											
Water supply system costs	1,019	3,366	--	--	--	779	857	943	1,037	1,141	9,142
Wastewater System											
Wastewater treatment	311	1,368	1,505	--	--	--	--	--	--	--	3,184
Sewer construction	--	2,870	4,130	--	--	--	--	--	--	--	7,000
Subtotal--Wastewater System Costs	311	4,238	5,635	--	--	--	--	--	--	--	1,018
Storm Drainage System											
Storm drainage system costs	1,090	2,399	--	--	--	--	--	--	--	--	3,489
Solid Waste System											
Landfill development	484	133	--	--	--	--	--	--	--	--	617
Equipment procurement	178	--	33	--	35	177	58	147	--	77	705
Subtotal--Solid Waste System	662	133	33		35	177	58	147	--	77	1,322
Total Project Costs	3,082	10,136	5,668	--	35	9[illegible]	915	1,090	1,037	1,218	24,137
Equivalent U.S. Dollar Cost (1.00 U.S. dollar = 0.300 JD)	10,273,000	33,787,000	18,893,000	--	117,000	3,187,000	3,050,000	3,633,000	3,457,000	4,060,000	80,457,000

Note: All costs in this table are escalated from 1979 costs.

Source: Tables 9-8, 9-11, and 9-14.

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charges were further analyzed, together with socioeconomic data, to determine the ability of low-income residents in the City of Irbid to pay for the proposed municipal utility services.

An internal rate of return evaluation was conducted to measure the viability of the proposed project.

These analyses indicate the project is affordable to the people of Irbid, and should be financed based upon the benefits that will accrue to the people of Irbid.

1.11 INSTITUTIONAL ARRANGEMENT AND PROJECT IMPLEMENTATION

Unless the institutional needs necessary to ensure proper installation, operation, and maintenance of the proposed facilities plans are satisfied, the facilities plans will not provide the level of service intended.

Basic implementation criteria covering three major categories, facility implementation, coordination with National Resources Authority Management policy, and regional and local development, have been developed.

Three alternative institutional arrangements are evaluated as follows:

1. Regional authority.
2. Regional planning/district authority.
3. Municipal departments.

It should be noted that all existing water department and solid waste department employees in the City of Irbid will be employed in each of the proposed alternatives.

Alternative 2 is recommended for implementation because:

1. The regional planning agency, water council, or regional department provides the necessary regional institution to provide separation between the national government and local municipalities.

2. The District operating authorities provide a dispersion of power to the municipalities while providing local economies of scale and improved efficiency.

The regional agency can administer the nation's policy on resources utilization, guide the development of the region, and assist in financing projects.

A recommended institutional plan is developed to implement alternative 2. The plan defines policy needs, institutional arrangements, and facility plan development. A recommended personnel training program is outlined. Qualified, adequately compensated personnel will be the key to a successful district utilities project in Irbid.

A proposed list of construction contracts and an initial construction schedule that meets the requirement to construct the initial project facilities by the end of 1981 is developed and presented in Figure 1-1. This schedule takes into account the mandate to serve the low income, public health problem areas first. The wastewater collection system contracts SAN 1 and SAN 2 include the Phase 1 interceptor sewers, as well as trunk and lateral sewers in the low-income areas. These contracts, together with the wastewater treatment plant contract, will produce a technically-viable sewerage project, however, the revenues generated by this limited project will be much less than the estimated revenues for the base case presented in Chapter 9.

1.12 RECOMMENDATIONS AND REQUIRED POLICY DECISIONS

As stated previously, the analysis indicates the proposed project is affordable to the people of Irbid. This statement is based on the assumption that certain policy decisions will be implemented in a timely manner, namely:

1. An Irbid district authority will be created to manage the project as detailed in Chapter 10.

2. The recommended project elements will be financed and work initiated as soon as possible, since projected inflation factors have a significant effect on overall project costs.

3. The existing water, sewer, and solid waste disposal user charge rates presently set by national policy are not adequate to finance even the initial years of the proposed project. The Irbid district authority should be given authorization to set and adjust user charge rates. The estimated rates required by the year 1985 for the water and wastewater systems are presented in Table 1-4.

4. The district authority must have the ability to adjust user charges. The sensitivity analysis indicates that the systems are sensitive to inflation rates, user population, and water use rates. Drops in revenues related to these parameters can only be recovered through upward adjustment of user charges.

5. The analysis assumes a reduced reconnection charge for existing residents presently served by the existing water distribution system, and who will be reconnected to the new system. The assumed charge is set equal to the estimated actual cost of the reconnection.

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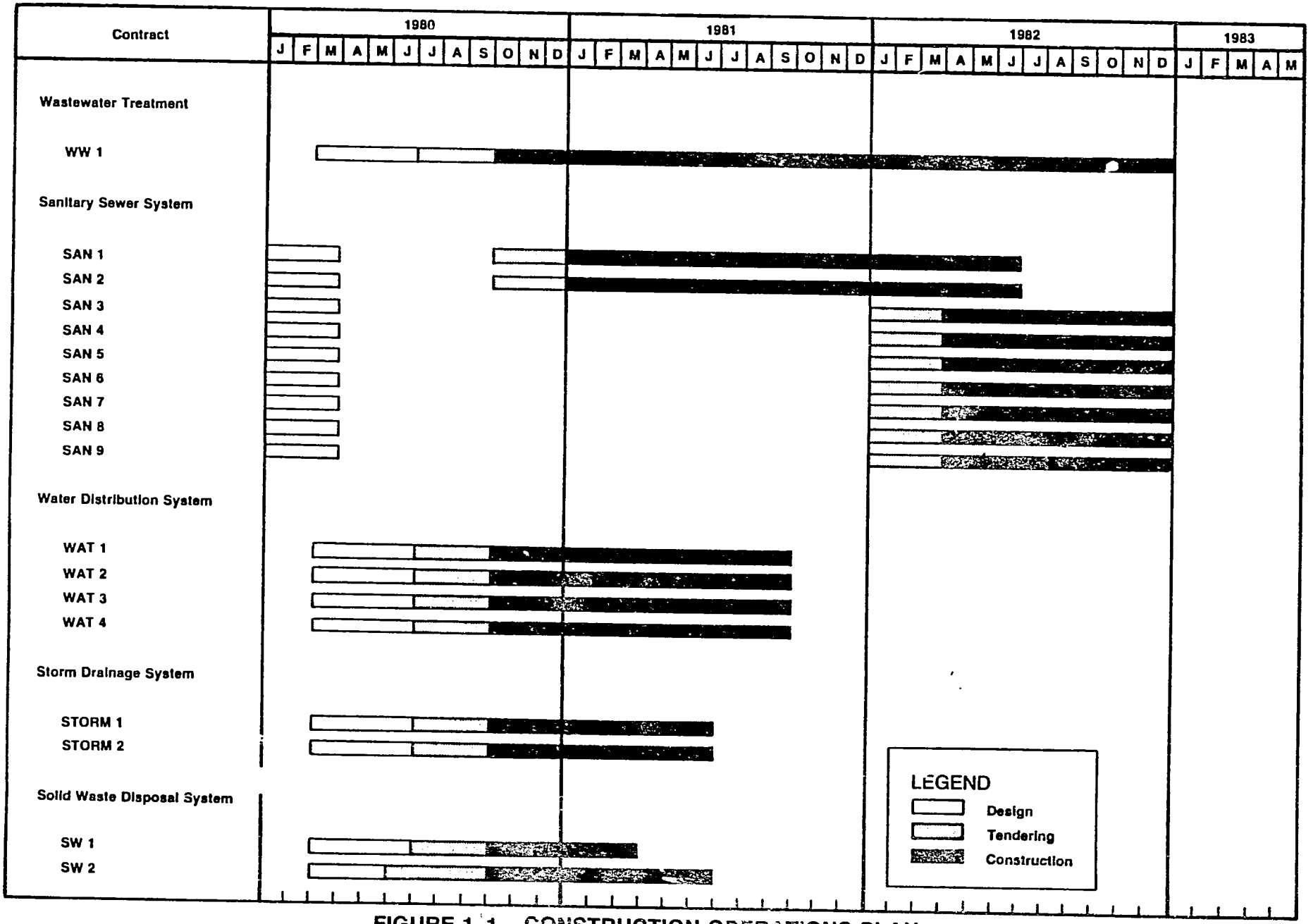

FIGURE 1-1 CONSTRUCTION OPERATIONS PLAN

IRBID WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

Table 1-4

Monthly User Charge (1985) Water and Wastewater
By Water Use Consumption Group

Water Use Consumption Group (cu m/month)	Water Charge: Unit[1] Charge (JD/cu m)	Water Charge: Monthly Charge (JD)	Wastewater Charge: Unit Charge (JD/cu m)	Wastewater Charge: Monthly Charge (JD)	Combined Water[1] and Wastewater Charge (JD)
0 to 15	0.330	3.200	0.047	0.368	3.570
16 to 25	0.418	10.500	0.060	1.205	11.700
More than 25	0.458	17.400	0.066	2.007	19.400

[1] Water charge includes estimated wholesale water cost, 250 fils/cu m.

[2] Costs based on medium inflation rates.

6. The cost of connection to the sanitary sewer system, normally a cost borne by the home owner, exceeds the ability to pay of the low-income group. The estimated connection cost represents over 25 percent of the annual income of this group. It is recommended that grants be made available to the low-income groups to facilitate these connections. It is estimated that 409,000 JD will be required in 1983 and an additional 1,227,000 JD in 1984. An ongoing grant propgram will probably be required throughout the project.

7. This study has assumed that the wholesale cost of water will rise to 250 fils/cu m when the north Jordan water supply project is implemented. This rate is the estimated cost of supplying water to Irbid from this project. The rate is almost quadruple the existing national wholesale water rate of 65 fils/cu m. The analyses in Chapter 9 indicate that the project is affordable at the higher wholesale water rate; however, the burden on the people of Irbid will be reduced if the wholesale water rate is set at some point between 65 and 250 fils/cu m.

CHAPTER 2

SOCIOECONOMIC STUDIES

2.1 PRIOR STUDIES

Previously published socioeconomic studies which pertain to the Irbid Governorate and Municipality have relied primarily on the most recent national census,[1] taken in 1961, together with an agricultural census[2] and labor census,[3] both taken in 1975. The synthesis and analysis of these raw data have chiefly been limited to the region and not to the City of Irbid itself. The following sections examine the north Jordan regional studies, national studies, and Irbid planning studies with a view to extracting the information pertaining to residential, commercial, and industrial growth in the City of Irbid.

2.1.1 North Jordan Regional Plans

Two previous regional plans devoted to water resources and economic planning in north Jordan, with specific emphasis on the Irbid Governorate and Municipality have been reviewed.

2.1.1.1 Integrated Regional Development Study of the Northern Jordan.

This study, conducted by the Japan International Cooperative Agency (JICA), provided extensive sociological, demographic, and economic statistics for Irbid. This report emphasized that north Jordan has been and will continue to be a focus for population growth, as well as commercial and industrial development. The JICA report provides comprehensive demographic data which are reviewed in subsection 2.2.1. These data reveal that north Jordan is expected to grow rapidly during the study period (1979-2000), and that Irbid will have a proportionately high share of this growth.

According to the JICA report, agriculture was and will continue to be an important facet of the north Jordan economy, with the Irbid vicinity enjoying a more diverse than average agricultural base. The main economic activity in Irbid itself is commerce. Irbid serves as the shopping center for 29 surrounding communities of 3,000 persons or more each.

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[1] The First Census of Population and Housing, Department of Statistics, 1961.

[2] General Results of the Agricultural Census, Department of Statistics, 1975.

[3] Results of the Labor Force Census, Department of Statistics, 1975.

Yarmouk University will be moved during the study period from inside the Irbid City limits to a suburban location 15 km to the east. Yarmouk University is expected to approach Jordan University in size during the study period. This will make Irbid a center of technology and knowledge-oriented industry and commerce. Commensurate with Irbid's high growth rate, the housing industry and associated labor market will enjoy rapid expansion during this period. Presently, industry in Irbid is limited compared to Amman, but the industrial estate within the City limits will expand to 115 hectares from its present 14 hectares by the year 2000 (see subsection 2.4.2).

2.1.1.2 Water Use Strategy in North Jordan.

This study, conducted by Howard Humphreys and Sons in 1978, provides a good analysis of north Jordan demographic data. It offers a comparative analysis of the population statistics considered in the report (see subsection 2.4.1). This report emphasizes the effect of Yarmouk University and the Jordanian-Syrian Free Trade Zone on the north Jordan economy. By 1987-1988, the new Yarmouk University will have over 20,000 students and 2,000 staff members, many of whom will live in Irbid and surrounding communities. The report indicates that the primary socioeconomic effect of the new Yarmouk University will be its contributions to technology and knowledge-based industry and commerce. They further argue:

> "The University will not result in a major in-migration of population, certainly not on a scale sufficient to modify the population growth rates projected for the area...The rate of development of the University may be a slower one than envisaged, for the programme of development is a very ambitious one." (vol. 3, p.30).

This analysis appears to be valid, but the growth of the University, while it will not affect the overall population projection for Irbid, will influence the rate of growth of certain portions of the Municipality of Irbid. Income and education levels in parts of Irbid will also be affected (see subsection 2.4.3).

2.1.2 Other Related Regional and National Plans

2.1.2.1 National Water Master Plan of Jordan.

The master plan, which was written by the German Agency for Technical Cooperation in 1977, accomplishes the following:

1. Reviews the socioeconomic data base for north Jordan.

2. Establishes national and regional growth rates.

3. Describes the population projection method most reasonable for projecting the growth rate of the Kingdom and disaggregating it by Governorate.

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4. Cites reasons for the proportionately high rate of growth of the Municipality of Irbid.

The primary sources of socioeconomic data used in the master plan are:

1. 1961 census.

2. 1975 agricultural census.

3. 1976 5-year plan.

4. Talks with officials of the Ministry for Municipal and Rural Affairs.

5. Unpublished computerized forecasts received from Dr. Hanna Rizk, U.N. demographer to the Department of Statistics.

While national, regional, and local growth rates can be inferred from these data sources, the authors concluded that the data base is poor from a population standpoint:

> "The data base in Jordan was found to be very poor. Therefore, forecasts as a balance between births and deaths and internal migration, both regarded separately, cannot be done. Useful data on internal migration are presently not available. (Growth) rates serve only as crude initial material". (vol. 7, p. 11).

The National Water Master Plan accepts 3.5 percent annually as a nationwide growth rate for projections up to the year 1985, noting that it could be affected by currently unforeseen political events.

Because the standard population projection method was unworkable, the master plan adopted a technique of estimation of autonomous regional growth rates, shaped by past development trends and local planning policy. These rates are constrained by a fixed national growth rate (vol. 7, p. 13). The major regional rates for 1979-1985 derived from iterative applications of this technique (vol. 7, p. 20) are:

1. 5.0 percent for the Municipality of Amman.
2. 4.5 percent for the Municipality of Irbid.
3. 4.0 percent for the Municipality of Zarqa.
4. 7.0 percent for Jordan Valley.

These high rates of growth in urban centers were matched by low growth rates in rural areas, reflecting migration from associated hinterlands.

According to the master plan, Irbid should experience a high growth rate because of the following factors (vol. 7, p. 16) :

1. The opening of Yarmouk University.

2. The improved water supply.

3. The Jordanian-Syrian Industrial Free Zone.

4. Influx of Palestinians from Lebanon due to political disruption.

The government policy for giving tax incentives to industries outside Amman should also contribute to a high growth rate in Irbid.

2.1.2.2 Jordan National Water Carrier.

This study was prepared by the Harza Overseas Engineering Company in 1979, and is basically an engineering analysis of proposed pipelines throughout the Kingdom. The population statistics are broken down only by "areas" defined using hydrologic criteria. The Harza report accepts the national growth rate established by the water master plan and applies it to the "northern area" (which includes Irbid) with the following result:

Year	Population of Northern Area
1977	463,000
1982	573,000
2002	786,000

These results are confusing to the extent that they reflect a 2.1 percent per annum growth rate for the entire period, considerably below the national average. This contradicts the previously-mentioned results which show both the Irbid Governorate and Municipality as population "push" areas.

2.1.2.3 Assessing Basic Needs in Rural Jordan.

This survey was authored by Jarir S. Dajani and Muneera S. Murdook in 1978. Factors such as data needs, public service priorities, income, public health, and education were examined with respect to planning goals and public policy. This is the only study which assesses village-by-village living conditions in the light of future development and governmental action. Some of the major conclusions of this study are:

1. The development of a potable water supply must be given highest priority.

2. Traditional farming and herding occupations are becoming less attractive, driving population out of the hinterlands into the major population centers.

3. There is a severe public health problem in rural Jordan not related to the water supply problem.

4. Socioeconomic planning is vital to the future well-being of towns and villages in rural Jordan.

The study develops a measure of system performance which amalgamates various socioeconomic indicators, and quantifies them in such a way as to evaluate the overall quality of life.

The provision of services and the effects of planning policy can be evaluated with respect to their contribution to the system performance measure.

This study goes on to evaluate the availability of services by sub-governorate. Irbid's performance is well above average with respect to schools, post offices, child-feeding centers, and electricity (Table 6, p. 29). On the whole, surrounding towns and villages do not show such high performance. Performance measures can be used to predict population migration and future settlement patterns, as well as to direct planning policy.

2.1.3 Irbid Planning Studies

Several plans relate exclusively to Irbid Municipality or Governorate.

2.1.3.1 Irbid Town Plan.

The Irbid town plan is a basic working document consisting of a collection of maps. The plan is subject to day-to-day decisions by Irbid municipal engineers and political leaders. The most important features of the town plan are the zoning boundaries, permitted zoning densities (subsection 2.2.4), future commercial areas, major road construction, expansion of the industrial estate within the City limits, water and sewer lines, stormwater drainage, and institutional planning. Basically, the town plan acts as a guideline for growth, but does not represent a cohesive planning policy. All of the mentioned features of the plan are incorporated in the population and land use projections discussed in this report.

2.1.3.2 Irbid Sewerage and Drainage Scheme.

This study was prepared by the Polytechna Praha, Hydroconsultant, Czechoslavakia in 1969. It contains only a cursory socioeconomic analysis, grossly understating the projected population growth for Irbid (see subsection 2.2.1.1).

2.1.3.3 Yarmouk River Development, Irbid Water Supply Feasibility Study.

This study was conducted by the Crown Agents in conjunction with the Water Supply Corporation in 1977. It focused primarily on the existing water supply, groundwater resources, surface-water resources, water demand, and proposed water supply schemes in Irbid and north Jordan in general. The socioeconomic discussion is limited to a population projection which is discussed in subsection 2.4.1.

2.1.4 Summary of Prior Studies

The basic socioeconomic data discussed pertained to present population and water use, as well as projected population and water demand. These data and findings have been reviewed alone and will be analyzed in Sections 2.2 and 2.4. The JICA report is the only one which emphasizes business and commerce in Irbid and other north Jordan communities. This information is quite substantive, and is further reviewed in Appendix F.

2.2 PRESENT POPULATION AND LAND USE CHARACTERISTICS

This section reviews population, income and land use characteristics; develops the criteria for establishing service areas; and examines historical population trends for the City of Irbid.

2.2.1 Population Characteristics

2.2.1.1 Historical.

The basis for all of the population estimates, current and projected, is the 1961 census supplemented by information gathered in the 1975 agricultural and labor censuses. Table 2-1 presents the historical population data for the Municipality. The historical statistics are in general agreement that the population of Irbid increased from approximately 23,000 in 1952, to 128,000 in 1975, implying an overall growth rate of 7.75 percent per year. The JICA study sets the 1967 population at 62,500, yielding an overall growth rate of 9.37 percent/year for the period 1967 to 1975. The Yarmouk River study yields a slightly lower growth rate for the same period. A major reason for these apparently high growth rates has been the major population shifts since 1961, resulting from the regional political situation. The figure of 60,000 for the 1969 Irbid population offered by the Irbid Sewerage and Drainage Scheme is clearly inaccurate. The report did not offer any substantial support for the selection of this figure.

2.2.1.2 1975 Population Estimates.

The year 1975 has been chosen as the base year for "current" population levels for this and other studies because it was the year of the

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Table 2-1

Historical Population Statistics -- Irbid

Source	1952	1960	1961	1967	1969	1971	1975
JICA vol. 2, p.VIV-4, Table 4.2	23,157		44,685	62,563			128,000
Yarmouk River Development, Irbid Water Supply Feasibility Study, p. 58			44,685	65,920		116,000	128,000
Irbid Sewerage and Drainage Scheme, p. 11	23,000	26,000			60,000		

agricultural census conducted by the Department of Statistics. Consequently, the estimated 1975 Municipality of Irbid population is the most reliable because it has not been interpolated. The three most reliable estimates of current 1975 base year population available at this time are as follows:

Source	1975 Population Estimate
JICA Study	128,000
Water Use Study in North Jordan	119,000
Yarmouk River Study	128,000

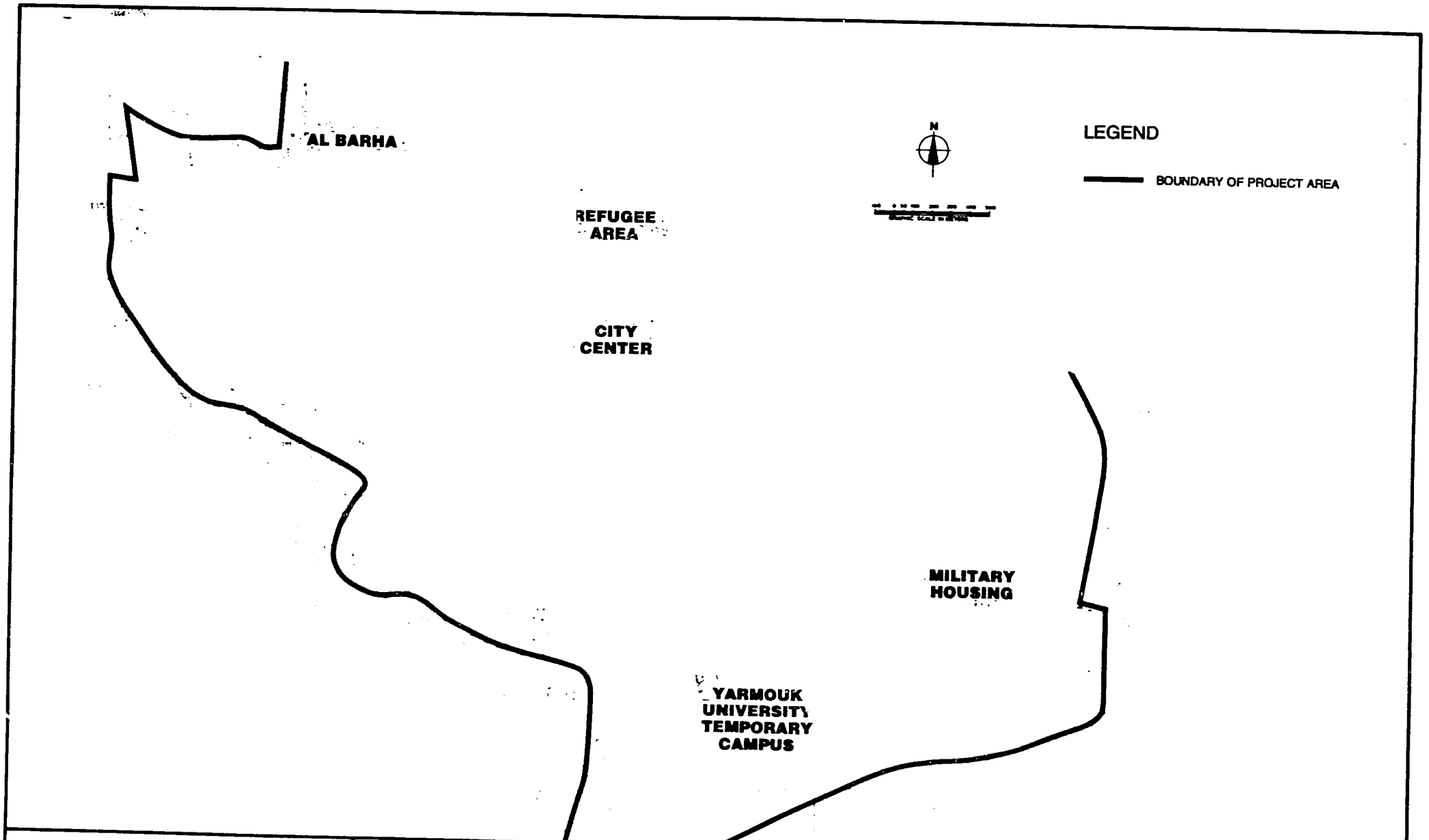
The three studies claim to be using the technique advocated by the Department of Statistics (i.e., correcting 1961 general census data with 1975 agricultural census data). It can be seen, however, that the Water Use Study in North Jordan estimate is lower by 7.0 percent than both the JICA and Yarmouk River report estimates for 1975. This discrepancy is unaccountable, except to point out that the projected populations for Irbid are in closer agreement (see subsection 2.4.1). For the purposes of this study, 128,000 is accepted as the 1975 base year population estimate for the City of Irbid. The national water master plan did not make a population estimate for the Municipality of Irbid.

2.2.1.3 1978 Estimate.

Both the JICA study and the national water master plan recommended a 4.5 percent/year growth rate for the Municipality of Irbid for the period of 1975 to 1985 (see subsection 2.4.1 for details). Applying this growth rate to the 1975 population yields a population estimate of 146,000 for 1978, the "current" population estimate used for this study.

2.2.1.4 Disaggregation of 1975 and 1978 Population Estimates.

The disaggregation of 1975 and 1978 population estimates is based on the control total approach which distributes weighted shares of total City population to the subareas. A 1978 aerial map, Figure 2-1a and b, was examined and the total building coverage in square meters was calculated. The building coverage for each subarea was also calculated. This was multiplied by the persons per household of each subarea, scaled such that the highest scaled number of persons per household equaled 100.0 in zoning area D. Table 2-2 outlines this methodology.



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

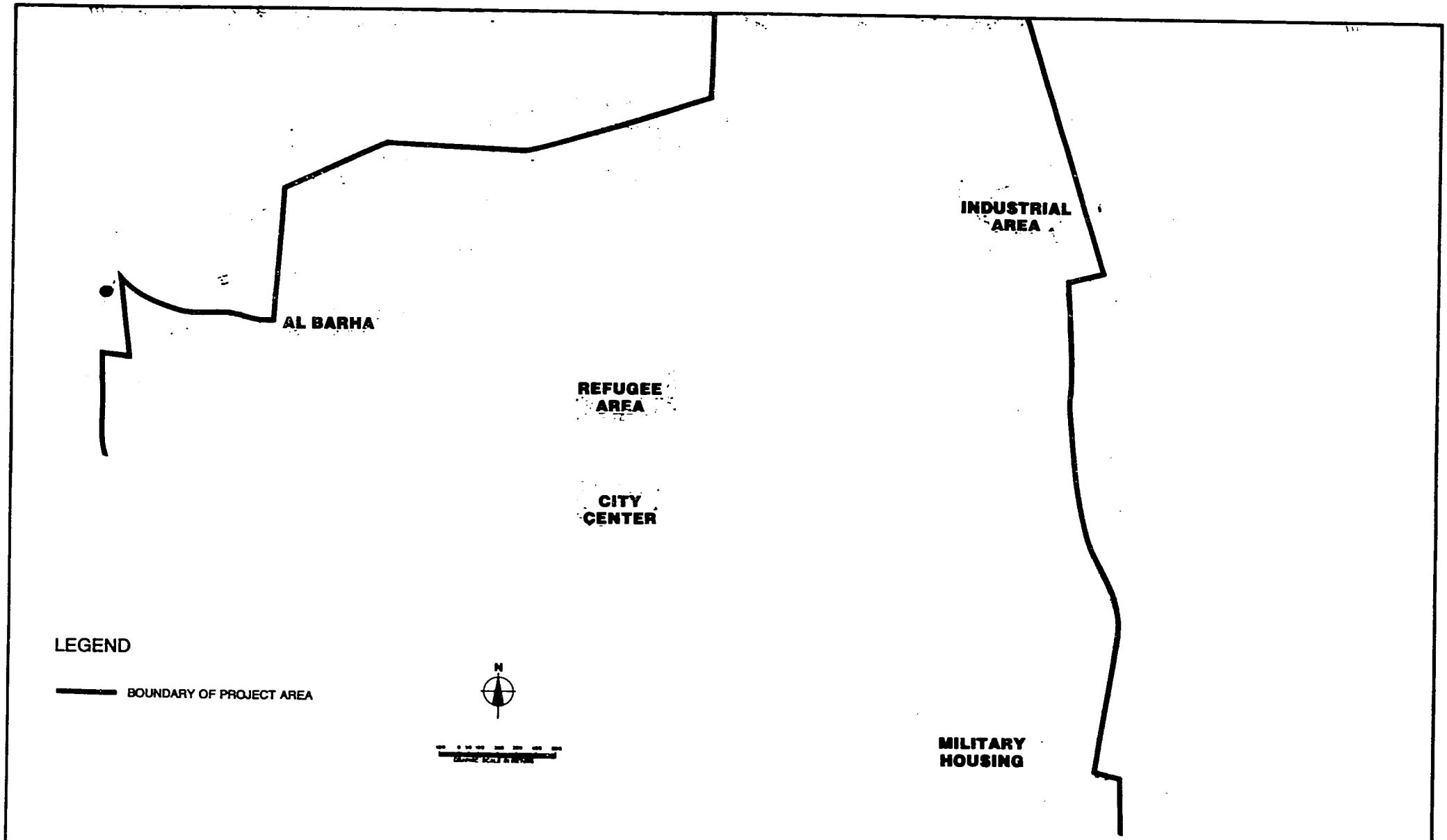
1978 BUILDING COVERAGE
PROJECT AREA BOUNDARIES

SHEET NO. FIGURE 2-1a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

1978 BUILDING COVERAGE
PROJECT AREA BOUNDARIES

SHEET NO. FIGURE 2-1b

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

Table 2-2

1975/1978 Disaggregated Population

Subarea[1]	(1) 1978 Building Coverage (sq m)	(2) Persons Per Household	(3) (2) Scaled to 100[2]	(4) Effective Population Cover (1) X (3)	(5) Decimal Shares (4) ÷ Total	(6) 1975 Population (5) X 112.0	(7) 1978 Population (5) X 130.0
A_1	74,000	7.6	67.8	5,040,000	.04	4.5	5.2
A_2	35,000	7.6	67.8	2,360,000	.02	2.2	2.6
B_1	139,000	8.0	71.8	9,960,000	.08	9.0	10.4
B_2	58,000	8.0	71.8	4,180,000	.03	3.4	3.9
B_3	40,000	8.0	71.8	2,890,000	.02	2.2	2.6
B_4	132,000	8.0	71.8	9,450,000	.08	9.0	10.4
C_1	150,000	8.2	73.2	11,080,000	.09	10.1	11.7
C_2	11,000	8.2	73.2	8,340,000	.01	1.1	1.3
C_3	240,000	8.2	73.2	17,500,000	.14	15.7	18.9
C_4	190,000	8.2	73.2	13,900,000	.11	12.3	14.3
C_5	80,000	8.2	73.2	5,800,000	.05	5.6	6.5
D[2]	140,000	11.2	100	14,400,000	.11	12.3[3]	14.3[3]
E	400,000	7.6	67.8	27,200,000	.22	24.6	28.6
Totals	1,700,000	-	-	132,100,000	1.00	112.0	130.0

[1] See Figure 2-3a and b for subarea illustration.

[2] Persons per household scaled such that area D = 100.

[3] Does not include 16,000 refugees.

In Table 2-2, column 2 lists the persons per household obtained from our socioeconomic survey (see subsection 2.2.2); columns 1 and 3 were multiplied to obtain the effective population "cover" for each area, column 4. Each entry in column 4 was divided by the column total to yield the weighted decimal shares listed in column 5. The decimal shares were multiplied by 112,000 and 130,000, the 1975 and 1978 population totals, respectively, minus 16,000 refugees who live in the refugee camp within the Irbid City limits.

2.2.1.5 1979 Census.

A new national population census was taken in November 1979 after this report was prepared. Preliminary results of this census, which became available in January 1980, list the population of the City of Irbid as 113,000. Final results of this census will not be available until after computer hardware is installed and programs are checked. These results are expected to be available in mid-1980.

2.2.2 Income Groups -- Socioeconomic Data

2.2.2.1 Field Collected Data.

As was pointed out earlier, employment in Irbid results mostly from commerce, Yarmouk University, and agriculture. Compared to surrounding areas, it is likely that Irbid is an affluent community. Table 2-3 presents the results of the socioeconomic survey. This was intended to be a cursory survey of some of the basic social and economic factors vital to our population estimates. Thirty-five residences, seven in each of the five zoning types A, B, C, D, and E were visited by field investigators accompanied by an official of the Municipality. (See subsection 2.2.4 for descriptions of the zoning types.) It was necessary to have an Irbid official along to insure that residents were comfortable answering relatively sensitive questions concerning their income, household size, etc. The necessarily small sample size was offset by a 100 percent cooperation rate which yielded more comprehensive data than would a survey with a sample two or three times as great, but unaccompanied by a familiar City official.

Questions pertaining to the following social and economic factors were asked:

1. Number of rooms in household.
2. Number of residents per household.
3. Yearly taxes (JD).
4. Number of workers per household.
5. Annual total household income (JD).

Per capita income was derived from these data.

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Table 2-3

Socioeconomic Survey Results --
Irbid

Zoning Area Designation	A		B		C		D		E	
	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Number of rooms in household	4.0	2-6	4.0	3-6	3.5	2-5	3.6	3-4	4.0	3-5
Number of residents per household	7.6	2-10	8.0	6-12	8.2	4-13	11.2	9-15	7.6	3-12
Yearly taxes (JD)	25	12-450	22	0-40	16	7-20	16	10-30	30	20-40
Number of workers per household	1.29	1-2	1.08	1-2	1.18	1-2	1.2	1-2	1.6	1-3
Annual income per household (JD)	2,640	1,000-4000	2,300	800-4,000	1,750	600-6,000	1,000	700-5,000	3,100	700-5,000
Per capita income (JD)	347		288		213		92		408	

The results of this survey served to verify some of our basic assumptions concerning the economic climate of Irbid as it pertains to the extant permitted zoning densities. Those parts of the Municipality of Irbid which prohibit high densities (areas A and B) had the highest per capita incomes, averaging 318 JD/year, as opposed to an average of 152 JD/capita/year in areas C and D where the highest densities were permitted. The number of residents per household was roughly the same for areas A, B, C, and E, but was approximately 40 percent higher for area D. Area E, the center of the City and a busy commercial area, is in many respects anomalous. Area E showed great variation in most of the social and economic factors examined in the survey. The high per capita income in area E reflects the fact that it is a commercial zone, and many merchants live nearby or above their shops.

Because some of the results of the socioeconomic survey were different from published figures, the survey was repeated incorporating another 26 randomly-chosen homes in all of the subareas. This raised the total sample size to 61 homes. The results of the repeat survey as compared to the original survey are as follows:

Item	Original Data	Repeat Data	Overall Average
Household size	8.5	9.2	8.7
Household income (JD)	2,313	2,322	2,318
Per capita income (JD)	273	252	265

It seems that 8.5 persons per household represents an average statistic for Irbid that can be used with reasonable accuracy.

2.2.2.2 Other Socioeconomic Data Sources.

The data for household size, income, and taxes for Jordan are sketchy and are mainly presented as estimates and defined levels rather than as field measured statistics. In particular, these data for the Municipality of Irbid were totally unavailable during the study period. The JICA report, the most recent comprehensive assessment of economic conditions in Jordan, puts forth defined income levels taken from other sources:

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Income Group	Income (JD/Household/Year)
Low	Under 600 JD
Middle	600 JD - 1,300 JD
Higher-limited	1,300 JD - 1,800 JD
High	More than 1,800 JD

These income levels were used in the SICA report (Vol. 2, p. VIII-3) to determine ability to pay for housing needs.

2.2.2.3 Evaluation.

According to these figures, a few Irbid families are low income, most are middle and higher-limited, and a surprising large portion are high income households. The higher results are attributed to the fact that all wages earned in a household were counted, and income was measured directly in the field, thereby increasing the chance that the figure will be supplemented by employment not inferable from tax records, company employment records, etc. Also, urban incomes are in general higher than those of rural areas, and Irbid is a bustling urban center. Overall the income data are satisfactory and reconcilable with national trends and estimates.

The JICA report gives a figure of six persons per household which is used as the 1980 nationwide estimate for the calculation of housing needs (Vol. 2, p. VIII-49). This number is not broken down by income levels or current housing conditions. Similarly, data from the 1976 Multipurpose Household Survey by the Department of Statistics show that the average household size for cities is 6.5 (p. 54).

Some of the factors which contribute to the higher average for Irbid are:

1. The proportionately high rate of population growth which causes a higher than average intensity housing shortage.

2. The large number of rooms per household.

3. The premium placed on living near the commercial center.

4. The added difficulty for young people to move away from home and establish a separate residence.

5. The fact that Irbid is a stable community with limited out-migration compared to rural areas, and limited in-migration to Amman; thus, the City contains a high proportion of larger and indigenous extended families.

No attempt was made to account for the difference between Irbid and the national average as the data gathered are field measured and are very reliable.

The preliminary 1979 national census reports an average of 7.0 persons per family in Irbid. The census has not distributed this figure yet to the various subdistricts existing in Irbid. The average of 7.0 persons per family or household is higher than the average figures reported for other cities in Jordan, but lower than the 8.5 persons per household determined in our limited field studies.

Household size is used to apportion population increments to the subareas within the City. The development densities used in this report reflect the projection that household size is estimated to diminish by 5 percent every five years during the project period. Projected average household sizes will range from 6.2 persons per household for A areas, to 9.2 persons per household for D areas in the year 2000. These factors are approximately 21 percent less than the present densities determined from our field studies. The projected factors are equivalent to the figures that would be obtained if the average family size obtained in the 1979 census was disaggregated to the five zoning areas in the proportions determined by our field survey.

In our study, population densities are used to size the water distribution and sewer collection systems described in Chapters 4 and 5. The water distribution system and sewer collection systems are designed based upon saturated development at projected year 2000 household sizes as indicated in Table 2-15 (subsection 2.4.3). If the average household size figures developed for Irbid, especially the low nationwide estimate, were applied uniformly to Irbid, under-design of water distribution and sewer collection facilities could result in the more dense low income D zoning areas.

Wastewater treatment and solid waste disposal facilities are sized based upon projected Citywide population estimates, through 1990 and 2000. If the population and population growth rate for Irbid indicated in the preliminary 1979 census results are confirmed, the Phase 1 wastewater treatment facilities proposed in this report and based on best previous population estimates, should serve Irbid beyond the year 1990. Useful life of the solid waste disposal facilities likewise would be extended beyond the design year, 2000. The population estimates do not affect the proposed stormwater drainage facilities.

2.2.3 Land Use Characteristics

This subsection describes the current land use in the Municipality of Irbid, as well as outlining land available for future residential, commercial, industrial, and institutional development.

2.2.3.1 1978 Land Use.

Figure 2-2a and b shows the current land use patterns in Irbid. It can be seen that the center of the City is comprised, to a large extent, of buildings with shops and commercial establishments located on the ground floor. Some of these buildings have residences on the first and second floors as well. The center of the City has the majority of institutional development.

Other commercial zones are located along major roads to the west, along Palestine Street to the northeast, along the road to Syria, and to the southeast along the road to Amman.

The principal residential areas include the neighborhoods peripheral to the commercial areas in the center of the City:

1. Turkomman West neighborhood (subareas C_3 and C_4).

2. Rapidly growing affluent areas directly to the east of the center of the City.

3. The refugee areas.

4. A high density neighborhood surrounding the refugee area.

5. El Bariha in the far northwest (formerly a separate village).

6. Another rapidly growing residential area to the west of the road to Syria.

The Irbid industrial estate is located to the northeast, along Deir Yassin Street. It now comprises a total of 14 hectares and includes a battery-making plant, an electric tube factory, and a ballpoint pen factory. Additional industrial development is located in scattered areas throughout the city.

Much of the land within Irbid's municipal boundaries is currently vacant. The largest vacant developable parcels of land are north of the refugee area and east of Abdel Kadir Al Husini Street and Rateb-Albattayna Streets. A small amount of vacant land in Irbid is undevelopable. This includes cemeteries and the slopes of wadis where construction is difficult, but not prohibited.

2.2.3.2 Land Available for Future Institutional Development.

There are approximately 100 schools (elementary, secondary, and trade) and 10 mosques currently located within the Irbid City limits. A sampling of the lot size for five mosques and three of the largest schools (which included playgrounds) yielded the following data:

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Lot Area in Square Meters

	Mosques	Schools
	2,500	10,000
	1,800	10,000
	2,500	10,000
	900	
	500	
Average	1,700	10,000

It is clear that mosques take up relatively little space. Planning for mosques in the future is difficult because as the population of Irbid increases, the currently established mosques may simply increase their patronage. There will be a need for new mosques in the future, however.

Very likely existing schools will be able to intensify their enrollments as well. The following data describe the enrollment distribution of schools in Irbid during 1979.

Number of Students	Number of Schools in Category
0-100	9
101-200	14
201-300	26
301-400	29
401-500	11
501-1,000	15
More than 1,000	3
Total	107

The average school has between 300 and 400 pupils.

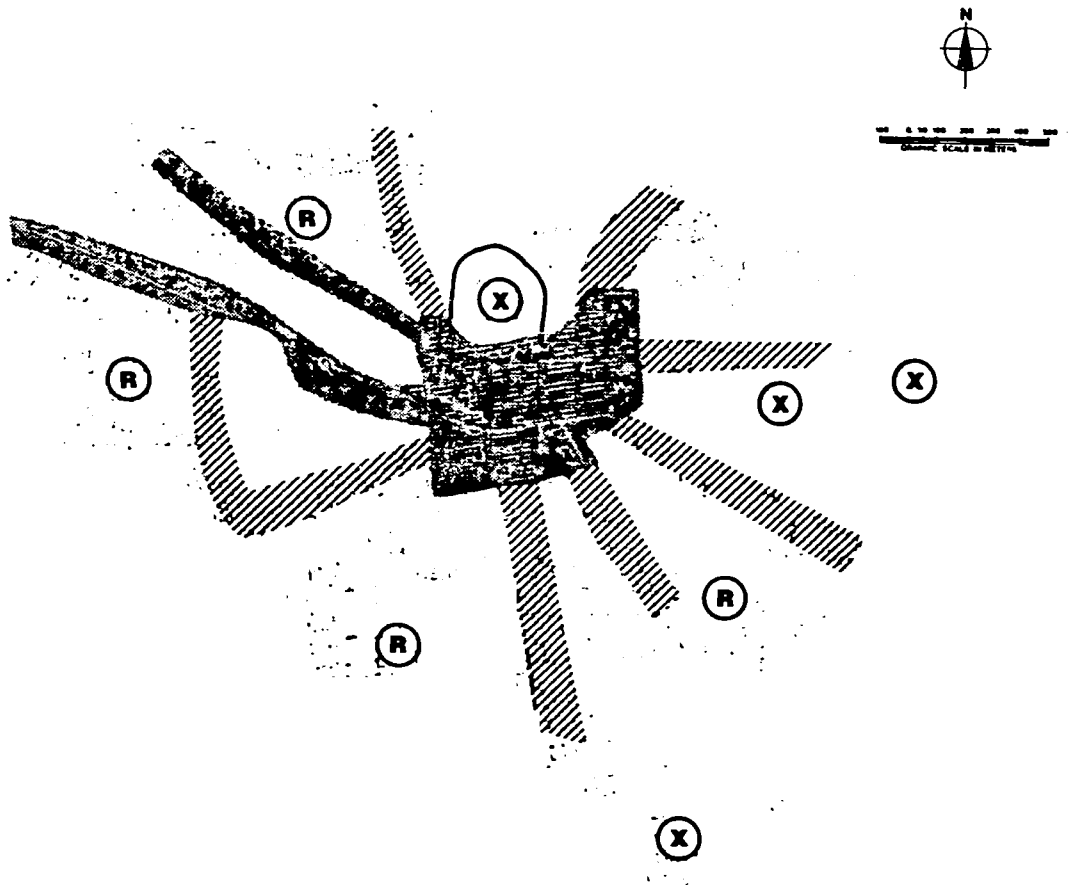
There is every indication from current planning policy discussed with Irbid municipal officials that future schools will be:

1. Larger in enrollment and land area.

2. Fewer in number on a per capita basis.

3. They will be constructed in planned locations, mostly in areas which are currently undeveloped.

We have allotted 2.2 percent of all currently undeveloped land for future school development, both public and private. This will, in our estimation, allow for a tripling of the current number of pupils



LEGEND

- MIXED COMMERCIAL/RESIDENTIAL ZONE
- COMMERCIAL ZONE
- (R) RESIDENTIAL ZONE
- (I) INDUSTRIAL ZONE
- (X) INSTITUTIONAL ZONE

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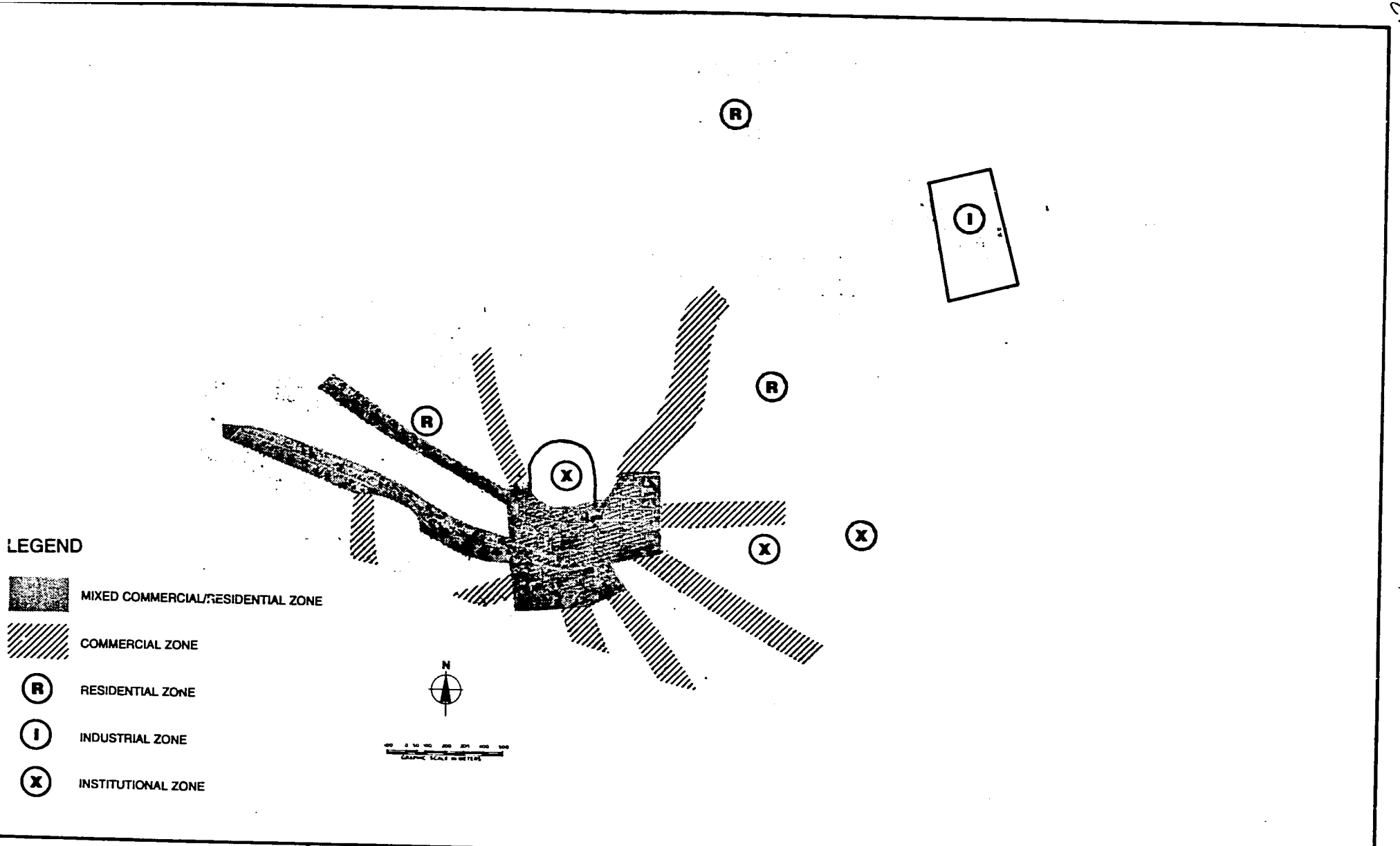

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1978 LAND USE MAP

SHEET NO. FIGURE 2-2b

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

(approximately 40,000) without overcrowding. We have also allowed for 0.3 percent of all undeveloped residential land for future mosques. This will permit 10 to 15 additional new mosques within the defined City limits. The total future institutional land is, therefore, 2.5 percent of available residential land.

2.2.3.3 Land Available for Industrial Development.

According to the Irbid town plan and local planning officials, future industrial growth from 1979 to 2000 will take place in the zoned. industrial area in the northeast portion of the City. By the year 2000 this industrial estate should comprise over 100 hectares (JICA report, Vol. 2, p. VIII-33).

We have been assured by planning officials that no further industrial development will be allowed outside the defined industrial area.

2.2.3.4 Land Available for Commercial Development.

Historically, the commercial areas in Irbid have been located in the center of the City. Recently, commercial development has taken place along the major streets leading to Palestine, Syria, and Amman. The Irbid town plan indicates that the only alternatives for future commercial growth are:

1. Intensification of current commercial business.

2. Establishment of business along strictly-defined business corridors, usually along major new highways.

This policy has been verified in discussions with local planning officials. Subsection 2.4.2 details the projection of future commercial land use.

Table 2-4 presents a breakdown of the commercial establishments operating in Irbid in 1969. Analysis of aerial maps indicates that by 1969 the commercial area in the center of the City was near full development. Consequently, these data reflect with some accuracy the representation of existing business types within the Irbid commercial establishment. It can be seen that business in Irbid is dominated by clothing shops, retail trade, production shops (sheet metal, machine, trade services), and markets. A windshield survey of the commercial area verifies these findings. There has perhaps been an additional emphasis on retail trade in electrical appliances since 1969. Most shops are highly specialized, verifying the obvious fact that Irbid serves as the center of commerce for a great many of the smaller surrounding communities.

Table 2-4

Commercial Establishments in Irbid -- 1969

Category	Number of Establishments
Pharmacy	15
Restaurants, bars	72
Clothing	311
Personal services	81
Production shops, trade services	187
Small dairies	9
Quarries	11
Markets, bakeries	455
Retail shops	239
Taxi	13
Gas and oil	57
Small factories	18
Banks, offices	13
Bamboo shops	27
Tent maker	4
Wood and coal	3
Poolrooms	2
Park	1
Car agencies	1
	1,519

2.2.3.5 Land Available for Residential Development.

Figure 1-1, in part, outlines the methodology for calculating the amount of land available for future residential development. This methodology involved the following steps:

1. Determine the total area of each service location.

2. Calculate the land available for present and future commercial use by subtracting 24.6 percent for streets and sidewalks.

3. Determine the current building coverage.

4. Multiply the building coverage by the lot to house size ratio (Table 2-5) for each subarea to determine total current residential coverage.

5. Withdraw areas set aside for future commercial and institutional development (no further industrial development will take place within Irbid municipal limits outside the defined industrial estate).

6. Subtract current use, and projected commercial and institutional use from total developable land to get area in square meters available for future residential development.

Table 2-6 shows the calculation of available residential land. The lot to house size ratio was calculated for A areas directly from permissible zoning densities because A areas are as yet only sparsely developed. For B and C areas, this ratio was calculated from selected fully-developed blocks. For D and E areas, which are almost fully developed, this ratio was conservatively approximated by 1.0.

The area withdrawn for future (1979-2000) commercial development was calculated by measuring the length of commercial streets and multiplying by 50 meters. This provides a 25-m setback on either side. Irbid planning officials have informed us that no residential development will be permitted on streets designated for commercial development. Institutional development has been mentioned in subsection 2.2.3.2.

2.2.4 Identification of Subareas

Existing information available in the Municipality of Irbid divides the City into several divisions based on:

Table 2-5

Lot to House Size Ratio
for B, C Developed Areas

Area of Selected Fully-Developed Lot (sq mm on a 1:10,000 map)	Area of Houses on Block (sq mm on 1:10,000 map)	Lot/ House Ratio
72	31	2.3
72	37	1.9
56	30	1.8
88	40	2.2
64	23	2.8
72	37	1.9
54	25	2.2
88	30	2.9
72	36	2.0
55	18	3.0
72	27	2.7
	Average	2.1

Table 2-6

Land Available for Future Residential Development -- 1978

(1) Subarea	(2) Total Area (sq km)	(3) Developable Land (sq km)	(4) Current Building Coverage (sq km)	(5) Lot/ Building Ratio	(6) Current Lot Coverage (sq km)	(7) Land Available For New Development (3) - (6) (sq km)	(8) Total Length Commercial Street (m)	(9) % Street Not Developed 1978	(10) Total Future Commerce Zone (8) x (9) (m)	(11) Area With-Drawn For Future Commerce (10) x 50 (sq m)	(12) New Insti-tutional Area (7) x 2.5 (sq m)	(13) Area Remaining For New Residential Lots (7)-(11)-(12) (sq km)
A_1	4.1	3.1	0.074	3.3	0.244	2.9	3,050	1.0	3,050	152,500	72,000	2.6
A_2	1.3	1.0	0.035	3.3	0.115	0.9	305	1.0	300	15,000	22,000	0.8
B_1	0.7	0.5	0.040	2.1	0.3	0.2	—	—	0	0	5.900	0.2
B_2	0.6	0.4	0.058	2.1	0.1	0.3	—	—	0	0	8,000	0.3
B_3	0.4	0.3	0.040	2.1	0.08	0.2	—	—	0	0	6,000	0.2
B_4	1.4	1.1	0.130	2.1	0.3	0.8	—	—	0	0	20,000	0.8
C_1	1.7	1.3	0.150	2.1	0.3	1.0	1,500	0.8	1,200	60,000	25,000	0.9
C_2	1.7	1.3	0.011	2.1	0.02	1.3	300	1.0	300	15,000	32,000	1.2
C_3	1.6	1.2	0.240	2.1	0.5	0.7	1,700	0.3	510	25,500	17,000	0.6
C_4	1.9	1.4	0.190	2.1	0.4	1.0	1,500	0.6	900	45,000	25,000	0.9
C_5	0.4	0.3	0.079	2.1	0.2	0.2	250	0	0	0	4,000	1.6
D	0.5	0.4	0.140	1	0.1	0.2	—	—	0	0	0	0.2
E	0.8	0.6	0.400	1	0.4	0.2	—	—	0	0	0	0.2
Total	17.5	13.2	—	—	3.1	10.1	—	—	—	303,000	—	9.3

Note: 25-m setback each side of commercial street.

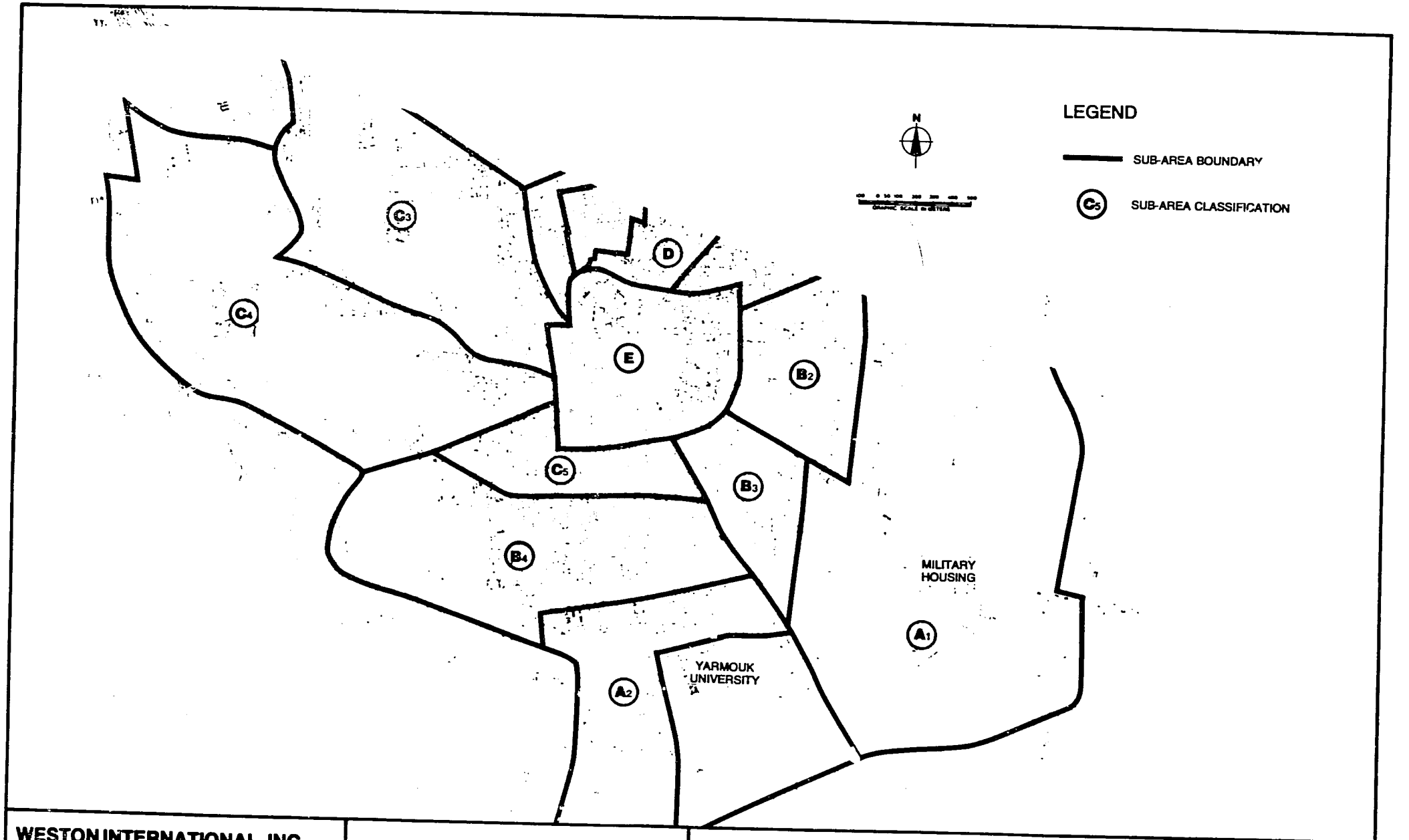
1. Zoning divisions.
2. Water distribution and billing divisions.
3. Building permit issuance areas.
4. Drainage basins.

Subareas have been selected for this study based primarily on socio-economic homogeneity. Figure 2-3a and b shows these existing subdivisions. The A, B, C, and D zoning subareas are homogeneous and distinct from each other with respect to income, and to some extent, household size (see Table 2-3). Future development within the major zoning areas (A, B, C, and D) will conform to established zoning criteria, thus adding to their homogeneity. Our subarea selection has all the advantages of the zoning division scheme. Zoning divisions A, B, and C were broken down even further because they were not internally homogeneous with respect to past development trends. For example in the C area, relatively high density, subareas C_1 and C_4 have developed recently and are growing fast. C_3 is a much older part of the City (including the village of El Bariha) and is not growing fast, while C_5 is close to the center of the City, and shares in its development trends. In the B area, B_1 and B_4 are currently experiencing a high growth rate. B_2 and B_3 permit the same density as B_1 and B_4, but are not currently growing as fast.

The homogeneity factors of the service areas can be summarized as follows:

1. Water use homogeneity (see subsection 4.3.1).
2. Zoning density homogeneity.
3. Homogeneity of past development trends.

The subareas do not overlap entirely with drainage basins. Because of this it has been necessary to reaggregate projected water demand for each wastewater drainage basin. The composite water demand is based on the densities of the selected subareas which make up a drainage basin.



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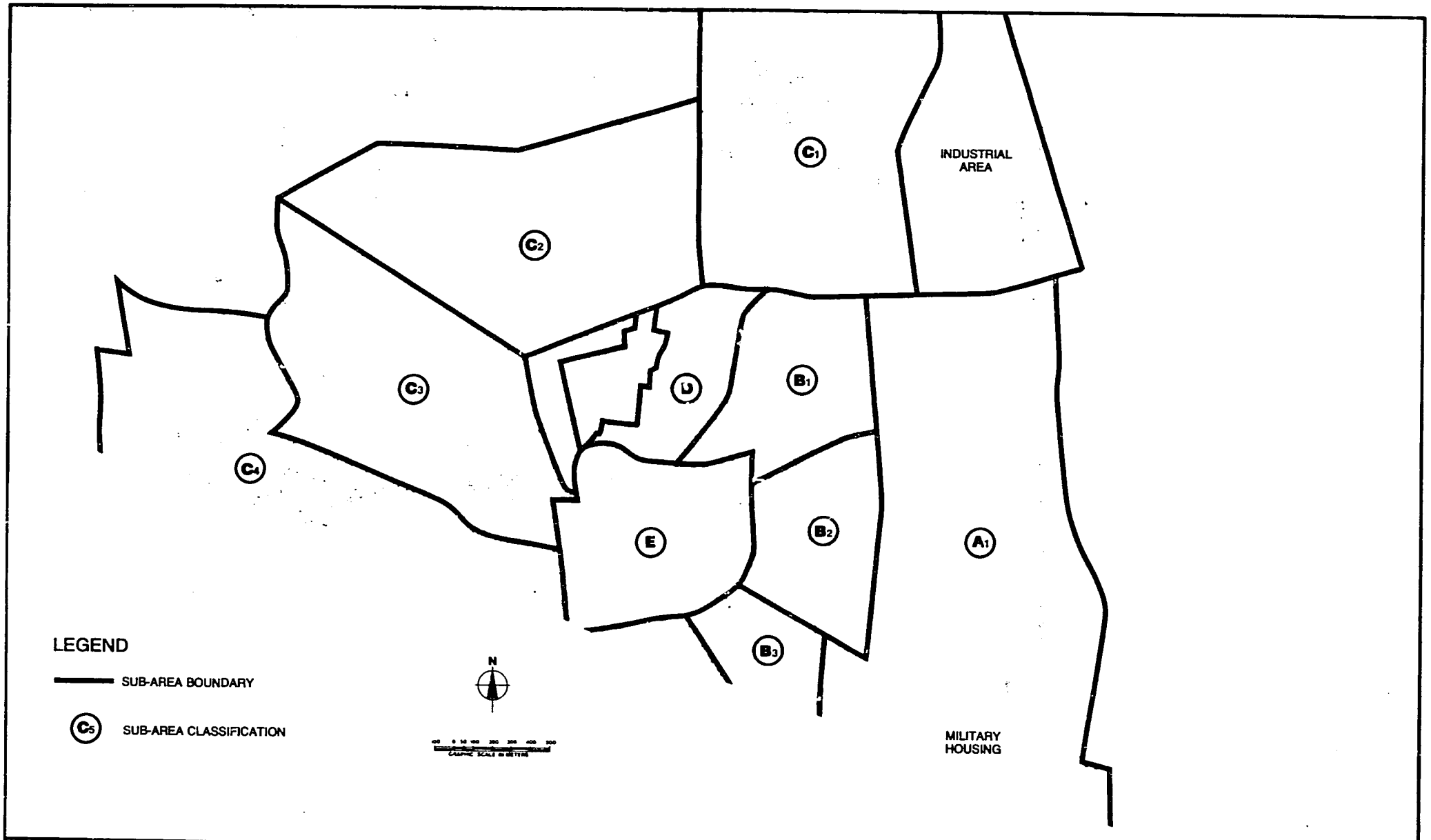
SUB-AREAS

SHEET NO. FIGURE 2-3a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	SUB-AREAS	SHEET NO. FIGURE 2-3b DATE: SEPT. 1979 BY: F. RAHHAL CHKD: HALVENSLEBEN

2.3 PRESENT PUBLIC HEALTH CHARACTERISTICS

The primary public health hazards concerning water supply and sewage disposal projects are water-related diseases. It is generally accepted that an adequate, clean water supply for drinking, sanitation, and personal hygiene, and a working waste collection and disposal system are essential to public health and well-being. A safe and convenient water supply and basic sanitation are essential to continued growth in a developing country. The City of Irbid has a relatively high incidence of water-related diseases because of poor water distribution, and inadequate wastewater collection and disposal systems. The goal of the proposed project and the justification of the outlay of large amounts of money is to improve the health of the citizens of Irbid.

Water-related diseases are relatively widespread and abundant in developing countries. The incidence of these diseases is affected by:

1. Climate.
2. Geography.
3. Culture.
4. Sanitary habits and facilities.
5. Population density.
6. Quantity and quality of available water.

All of these factors acting together, work to affect the incidence of water-related disease. Deficiencies caused by any of the listed factors can be compensated for through a program of capital expenditure for water supply and sanitation facilities, and public education.

The water-related diseases which are important for Irbid are cholera, typhoid, amoebiasis, bacillary dysentery, infectious hepatitis, other forms of gastroenteritis, and some skin infections. These diseases are either waterborne or water-washed. Waterborne diseases use water as a passive vehicle for transportation to potential victims, and are related to poor sanitation. Water-washed diseases are diseases which are encouraged by lack of water and personal hygiene. They are dependent on human waste as the transfer vehicle of infection.

The situation in Irbid promotes the spread of water-related disease because of several factors:

1. Quantity of water.
2. Quality of water.
3. Social habits.

Irbid, like all of Jordan, suffers from a chronically-short water supply. The problem has been exacerbated during the past few years because the extremely dry conditions have made water more scarce. If more water becomes available and steps are taken to insure its cleanliness, then sanitation-related problems can be alleviated.

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The quality of water in Irbid is consistently poor. There is a problem of contamination of water pipes. There is not enough water to supply pressure continuously to the entire Irbid system, therefore, water is supplied on a zonal basis. Different zones have water on different days of the week. During the time that there is no pressure in a particular zone, groundwater, including waste leaking from the many cesspools in the area, can flow into the water lines. When the zone is pressurized this contaminated water is mixed with potable water and transported to homes for domestic consumption.

The social habits of the citizens also can make the water-related disease problem worse. Food washing habits, and eating habits can cause diseases to be spread. If more sanitary procedures are followed, these problems could be alleviated.

Solid waste collection and disposal is another area that can contribute to the public health of a community. An open dump acts as a food source and place for harborage of disease vectors, including birds, insects, and rodents. An inefficient collection system provides the same problems in inhabited areas. At this time, Irbid has no identifiable solid waste-related disease in the area. Overall public health will be improved and maintained if a properly designed waste collection and disposal system is employed.

2.3.1 Available Health Statistics

There is a lack of accurate medical statistics for Jordan in general, and Irbid in particular. Medical information is collected on the basis of reported cases. This ignores the cases involving the poor who have a higher incidence of illness, but do not receive medical attention. Documentation of infectious diseases suffers the largest distortion because the poor have the most cases of infectious diseases.

Because of the lack of sound data, it is extremely difficult to quantify the improvement in public health related to increased water supply and sewerage. It is recognized that the impact will be a general improvement in public health. A reasonable indicator of improved general health is water consumption. Increased water supply should lead to increased consumption, which implies improved public health.

2.3.2 Assessment of Present Health Hazards

2.3.2.1 Water Supply Contamination.

Table 2-7 presents the results of analysis of Irbid municipal water samples. The samples were analyzed by the Central Laboratory of the Ministry of Health for coliform contamination using standard MPN methods. The data presented are for the period 1974 to 1978. During this period, 688 samples were analyzed, and 110 were found to be contaminated. This

Table 2-7

Coliform-Contaminated Sample
Analysis for Irbid Water Supply

Year	Number of Samples	Number Contaminated	Percent Contaminated
1974	113	20	17.7
1975	96	16	16.7
1976	180	34	18.9
1977	123	13	10.6
1978	176	27	15.3
Total	688	110	16.0

Source: Ministry of Health

yields an average contamination frequency of 16.0 percent for the period. In general, the contamination frequency has remained constant between 1974 and 1978. This is direct evidence that contamination of Irbid's current municipal water supply is a clear and present danger to public health.

2.3.2.2 Trends in Disease Frequency.

Reported cases of waterborne diseases for Irbid from 1971 to 1978 were compiled, and per capita rates calculated. It is apparent from Figure 2-4 that the total per capita number of reported incidents of water-related diseases increased dramatically. The rate of increase is approximately 0.09 cases per 1,000 persons per year for this period. These data, plotted on Figure 2-4, indicate that the state of public health in Irbid is deteriorating as population densities increase.

2.3.3 Socioeconomic Distribution

Some of the socioeconomic factors which influence susceptibility to waterborne disease include:

1. Income level.
2. Education.
3. Social and eating habits.
4. Housing type.
5. Location in the community.

2.3.3.1 Income Level.

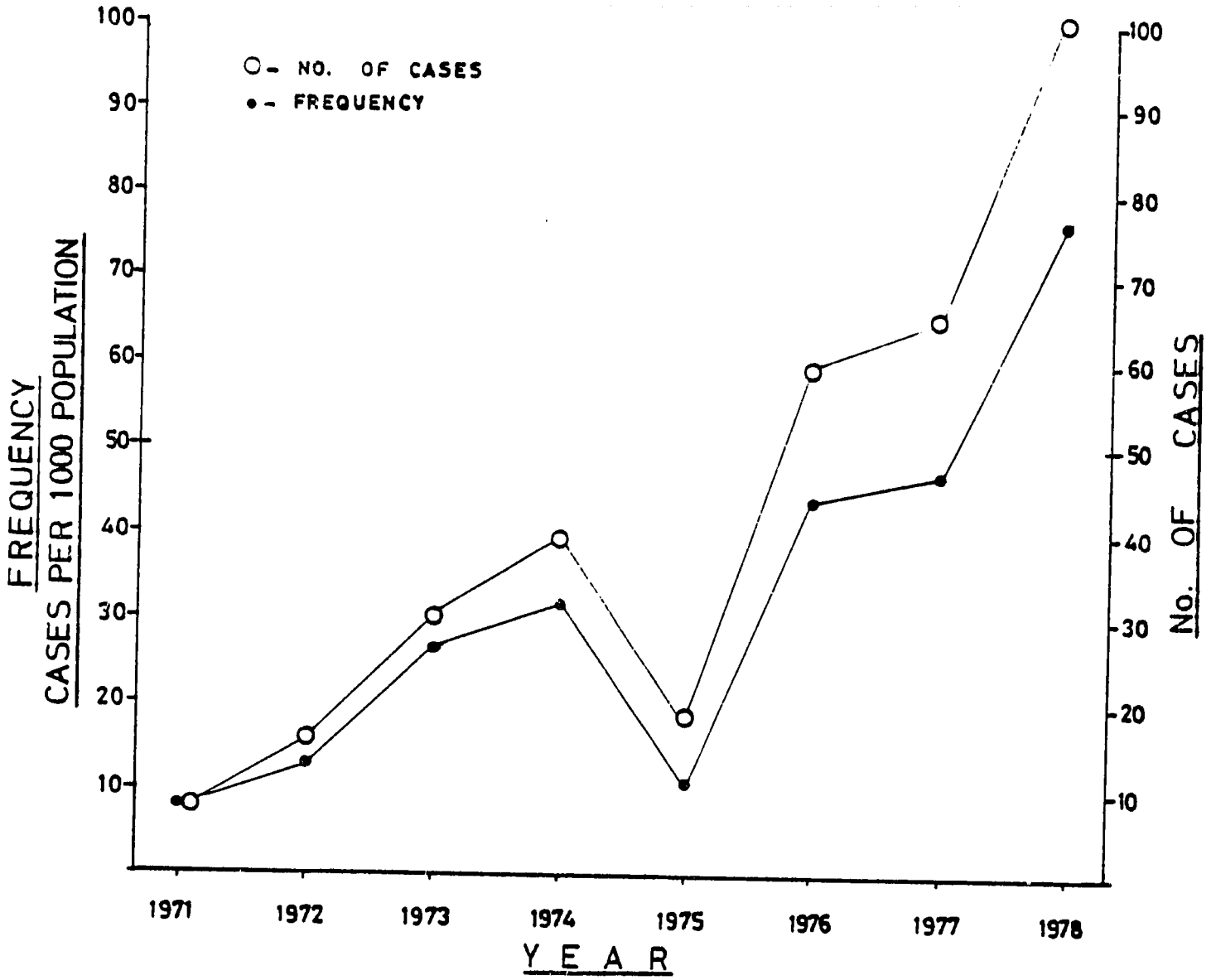
There is a strong correlation between income level and susceptibility to public health hazards, such as water-related disease. This is especially true for developing countries. There are no precise data indicating which socioeconomic groups in Irbid experience the greatest health problems and the highest rates of incidence of waterborne disease. In an interview, however, the Director of the Irbid Public Health Department indicated that the least affluent people were most likely to contract waterborne diseases. Some reasons for this include:

1. Poor sanitary facilities.
2. Inability to purchase bottled water for consumption.

Most of the other factors influencing susceptibility to public health hazards are themselves related to income.

2.3.3.2 Education.

While no data are available on education as it pertains to income among Irbid residents, it is not unreasonable to assume that education level and income are correlated. Education level alone, however, can affect public health to the extent that increased awareness of public health hazards and knowledge of how to combat them may decrease susceptibility to disease. This can act independently of a homeowner's ability to pay for better hygiene.



NUMBER OF CASES AND FREQUENCY OF WATER BORNE DISEASES - IRBID 1971 - 1978

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 2-4
	DATE: SEPT. 1979	BY: A. TAYEH
		CHECKED: P. J. H.

2.3.3.3 Hygiene and Eating Habits.

Hygienic practices are important with respect to public health hazards for two reasons:

1. They directly affect chances of contracting water-related diseases.

2. They can deter improvements in the general public health, even after water distribution and sanitary facilities are upgraded, regardless of ability to pay for such hygienic items as flush toilets.

Unhygienic practices can preclude the potential public health improvements that sanitary facilities could bring about. Even after the installation of water distribution and sewage collection systems, the retention of former habits would slow the improvement of public health conditions.

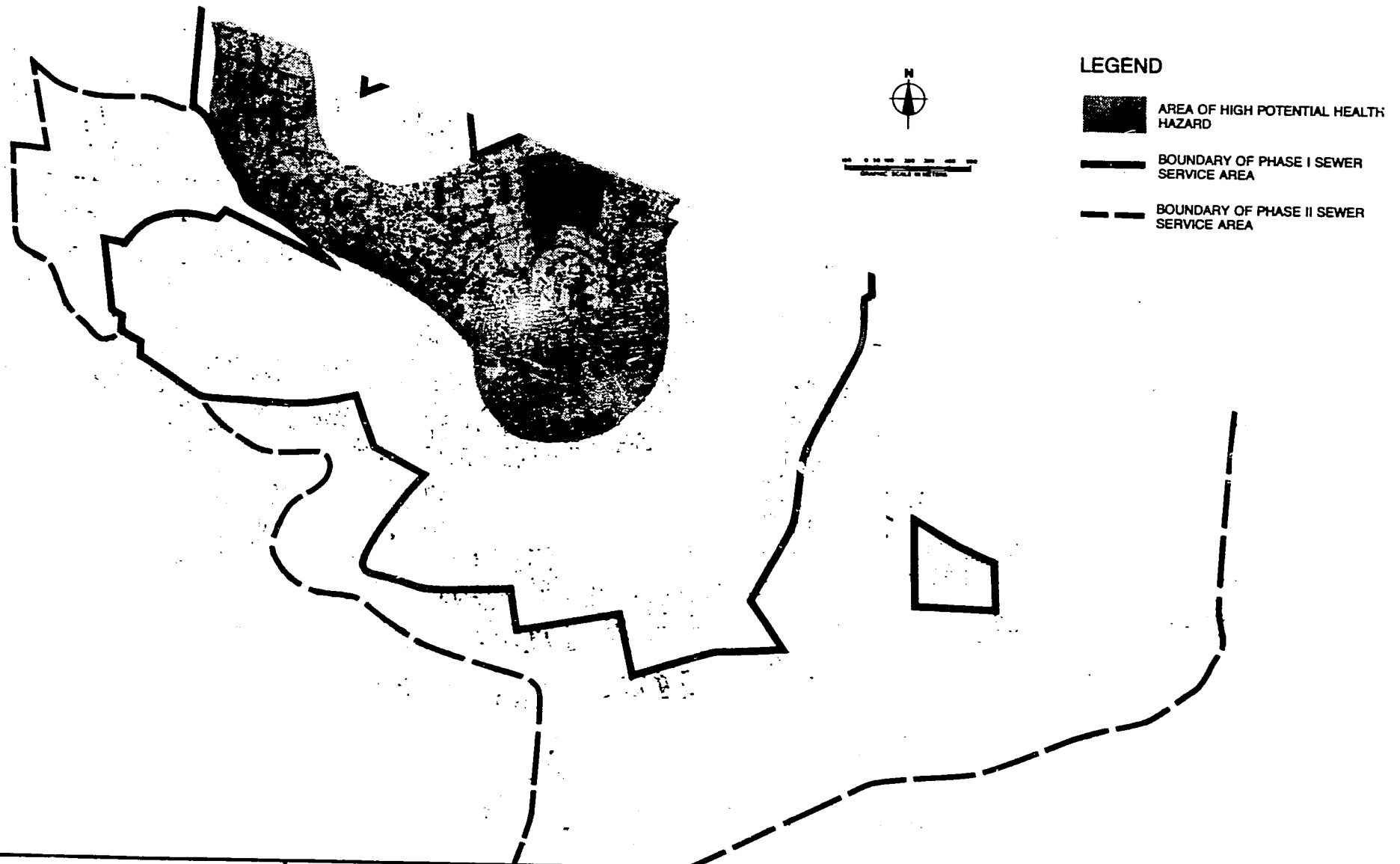
2.3.3.4 Housing Type.

The type of housing (size, construction, etc.) can affect susceptibility to public health hazards to the extent that certain structures may not be suitable for upgraded plumbing and hygiene-related items such as flush toilets and sanitary cooking facilities. This condition, however, is so closely related to income and location in the City that it does not warrant consideration. High population densities can contribute to the fast spread of disease.

2.3.3.5 Location.

Although income is the best indicator of public health hazard, location in the community will be considered the primary determinant of susceptibility to water-related diseases. Section 2.2 presents evidence that certain subareas in Irbid are the poorest (C and D). While it is true that poor people live in all the subareas, C and D are predominantly poor.

The proposed project will serve the areas of Irbid which are identified as low income areas during the initial phase of the project as shown in Figure 2-5a and b. These areas are correlated with higher incidence of water-related disease. Therefore, the areas most in need of improved health will be among the first groups served. This priority phasing of the project should return the greatest health benefits in the shortest amount of time.



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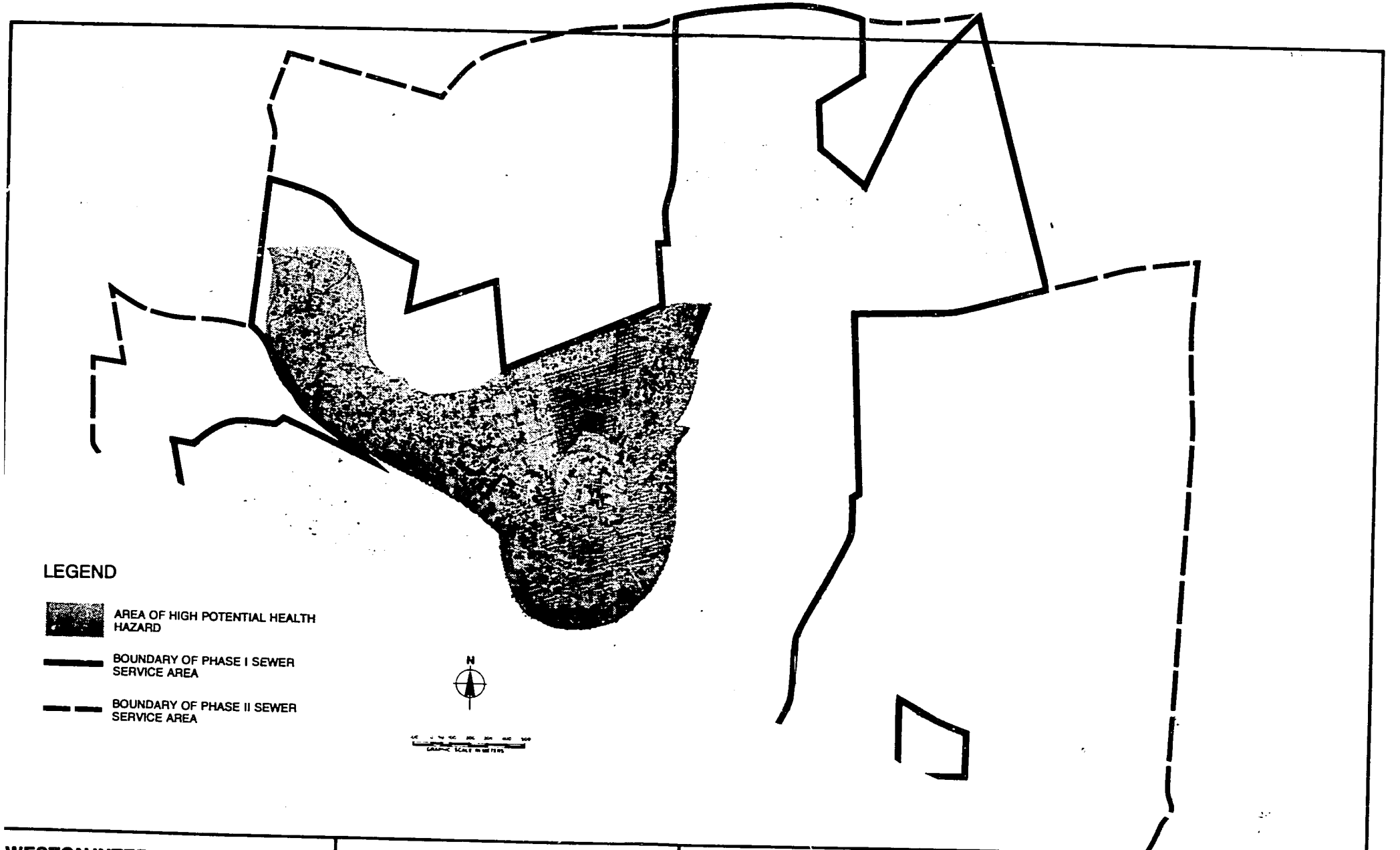
SEWER & WATER SUPPLY PHASING RELATIVE TO AREA OF HIGHEST PUBLIC HEALTH HAZARD

SHEET NO. FIGURE 2-5a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



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SEWER & WATER SUPPLY PHASING RELATIVE TO AREA OF HIGHEST PUBLIC HEALTH HAZARD

SHEET NO. FIGURE 2-5b

DATE: SEPT. 1979

BY: F. RAHHAL

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2.3.4 Effects of Proposed Project

The proposed project should benefit public health because of the following reasons:

1. The increased water supply will promote increased water consumption, and increased water use is a necessity for better hygiene.

2. A fully pressurized water supply system will reduce contamination of potable water.

3. A continuous water supply will eliminate the need for the rooftop and/or in-house storage systems, thus eliminating a potential source of contamination.

4. The sewerage system will eliminate the use of cesspools, which will reduce the potential water supply contamination.

2.4 POPULATION AND LAND USE FORECASTS

Both the Irbid Governorate and Municipality are growing rapidly with respect to the Kingdom as a whole. Estimates of Kingdomwide growth rates range from 3.2 percent to 3.7 percent/annum. Growth rates for Irbid range from 3.5 to 4.5 percent/year.

Irbid's relatively high growth rate is a result of a large per capita excess of births over deaths, as well as a substantial in-migration from surrounding hinterlands. Age structure data derived from the 1961 census indicate that while north Jordan as a whole has a large number of under 15 and 16 to 20 year olds, the Irbid Governorate and Municipality have proportionately more children than does the region. (JICA report, vol. 2, p. IV-19.) The JICA report also indicates that the rate of internal migration is high in north Jordan, and that Irbid, which is within easy travel distance of 30 communities with 3,000 or more persons each, will continue to experience a large share of in-migration. (Vol. 2, p. IV-4, IV-25, IV-26.)

2.4.1 Population Estimates

The four major reports which offer population and/or growth rate estimates for the Municipality of Irbid are:

1. "Integrated Regional Development Study of the Northern Jordan," by the Japan International Cooperative Agency, 1978.

2. "Water Use Strategy, North Jordan," by Howard Humphreys, 1978.

3. "National Water Master Plan of Jordan."

4. "Yarmouk River Development, Irbid Water Supply Feasibility Study," by Crown Agents, 1977, for the Water Supply Corporation.

Table 2-8 presents the growth rates and/or population projections established by these four studies. The JICA report, the water use strategy report, and the master plan calculate rates and population for the Municipality of Irbid, taking all factors (Yarmouk University expansion, the Free Trade Zone, and the expansion of the Irbid industrial estate) together in one estimate. The Yarmouk River study calculates the projected population increments attributable to these three factors separately as follows:

Factor	Population Increment by 1981	
Yarmouk University	14,160	(p. 66)
Irbid Industrial Estate	3,000	(p. 72)
Free Trade Zone	18,450	(p. 73)

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Table 2-8

Comparison of Available Projections

		1975		1980		1985		1990		2000		2010	
		Growth Rate (%)	Population (thousands)	Rate	Population	Rate	Population	Rate	Population	Rate	Population	Rate	Population
Integrated Regional Development Study of the Northern Jordan (Japan International Cooperative Agency) (p. IV-27)		7.8 p. IV-4	128			4.5 p. IV-25	199		248	4.0 p. IV-25	360		
Water Use Strategy North Jordan, Howard Humphreys & Sons, 1978 (Vol. 3, Appendix C, p. C1.)		3.5 p. 9	119			4.5	194	4.0		4.0	349		
National Water Master Plan of Jordan, 1977 (Vol. VII, Annex 1, Table 1)		NC	NC			4.5	NC	4.5	NC	4.0	NC		
Yarmouk River Development, Irbid Water Supply, Feasibility Study, Crown Agents/ Water Supply Corporation, 1977.	High	3.3*	128	3.4*	168	3.5*	197	3.5*	230	3.5*	317	3.5*	439
	Med.	3.3*	128	3.2*	168	3.1*	194	3.0*	223	2.8*	291	2.7*	276
	Low	3.3*	128	3.1*	167	2.9*	193	2.7*	220	2.3*	277	2.1*	339

*Does not include rate for industrial areas and University; total population does include industrial areas and University.

NC - not calculated by study.

This study does not disaggregate these separately-calculated population increments to individual municipalities, making the total population projection for the Municipality of Irbid incalculable from their data.

As is stated in subsection 2.2.1, the population statistics as compiled by the JICA report have been accepted as the official statistics for the purpose of this study. An examination of Table 2-8 reveals close agreement between the year 2000 projections of the JICA report and the water use strategy report. The Yarmouk River study projections for the year 2000 do not reflect growth due to the new Yarmouk University, Irbid industrial estate, and the Free Trade Zone. The difference between the Yarmouk River study medium estimate for the year 2000 (291,000 persons) and the figure adopted for this study is 79,000 persons. It is not unreasonable to assume that the three projects mentioned could generate a population increase in Irbid of this magnitude by the year 2000. The water use strategy report analyzes the assumptions behind the Yarmouk River study, finding many reasons to question its credibility, not the least of which is the fact that it did not have the 1975 agricultural census results available to approximate levels of internal migration.

2.4.1.1 Parameters of Population Projections.

The following is a summary of the assumptions behind the population projections taken from available socioeconomic studies:

1. Yarmouk River Study (p. 63 - 4).

   a. Improved agricultural methods and standards of living in rural areas near Irbid will stimulate commence, and consequently, population growth within the City limits.

   b. Irbid will benefit with respect to population and commerce from being the main road link between Jordan, Syria, Saudi Arabia, and Iraq. (Note: although Irbid is not directly on the road link, it will benefit because of increased trade through the area.)

   c. Enhanced electric power and water supply from the Yarmouk River will attract population.

   d. Yarmouk University will attract new residents.

   e. New residents from all these sources will require goods and services which will further increase employment opportunities and population.

2. JICA Report (p. IV-26).

   a. As yet undeveloped nonagricultural opportunities will stimulate future employment in Irbid and contribute to population growth.

b. Amenities for living to attract people as compared to the Amman Governorate will contribute to the immigration to Irbid.

3. Master Plan (Vol. VII, p. 16-17).

a. The opening of Yarmouk University in 1983 will attract 20,000 people to provide services, in addition to a final capacity of 22,500 students.

b. The Yarmouk River water supply source will improve the quality of life in Irbid and attract new residents.

c. The joint Jordanian-Syrian Free Trade Zone will be a strong source of employment for the entire region. Many of these people will settle in or near Irbid.

d. Due to the political disorders in Lebanon, an influx of more than 15,000 persons into Irbid can be expected during the period 1976 to 1986. (Note: this influx has not developed as projected for Irbid.)

4. Water Use Strategy Report (p. 30-31).

In general, this report accepts the rationale of the master plan. They concur that the Free Trade Zone, the improved water supply, and the expansion of Yarmouk University will contribute to the 4.5 percent growth rate for 1978 to 1985.

It is not yet clear exactly how Yarmouk University expansion, the Free Trade Zone, in-migration, and enhanced electric power will individually contribute and influence Irbid's growth. The JICA report, master plan, and water use strategy all agree that taken together these factors will influence growth in Irbid significantly.

It is also certain that the development of increased water supply, and the commensurate enhancement of sewerage facilities and water quality influences population growth.

2.4.1.2 Other Data Sources.

Due to the strength of the arguments put forth by the master plan, JICA study, and water use strategy report, a complete field verification of growth rates and base population was not undertaken. We have obtained verification, however, of growth rates by analyzing building census data made available by Irbid city planning officials:

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Year	1971	1972	1973
Number of single family homes	11,580	12,130	12,625

Source: Municipality of Irbid by Number.

From this we have inferred the following "growth rates" of single family homes in Irbid.

Period	1971-1972	1972-1973	1971-1973
Growth rate (present)	4.8	4.1	4.4

These rates are in general agreement with those accepted for this study.

2.4.1.3 Irbid Subdistrict Projections.

The Irbid subdistrict is an administrative subunit including the Municipality of Irbid and rural Irbid as defined by the 1961 census, excluding Taiyaba, Samma, and Mazar enumeration subdistricts (JICA report, p. IV-6). The Irbid subdistrict contains one-third of the population of the Irbid Governorate.

A very rough estimate for projected Irbid subdistrict population was obtained by multiplying the municipal projection by 1.7, the ratio between the 1975 subdistrict and municipal projections. The approximate population data are as follows:

1990	2000
422,000	627,000

Although primarily a census unit, the subdistrict has been chosen as the service area for septage dumping from 1982 to 2000 (see Chapter 5).

2.4.2 Land Use Estimates

Land use estimates for 1990 and 2000 are critically dependent on the Irbid town plan projected land use, and the calculation of land available for development.

2.4.2.1 Commercial Development.

We have assumed that commercial development resulting from increased population will take three forms:

1. Intensification of business in the commercial zone in the center of the City.

85

2. New development of streets designated as future commercial areas.

3. Incidental commercial development (small shops) incorporated into new residences.

The data of Table 2-4 indicate that in 1969 there were 1,519 shops. Table 2-1 indicates that the 1967 municipal population was approximately 62,500. This yields approximately 0.024 commercial shops/capita. The effective number of commercial shops projected for 1978, 1990, and 2000 are:

Year	Total Number of Shop Equivalents
1978	3,504
1990	5,952
2000	8,640
Total increase 1978 to 2000	5,136

From Table 2-9, the total undeveloped land devoted exclusively to commerce is 313,000 sq m (see Figure 2-6a and b). Assuming that a commercial shop has 5-m frontage and 25-m setback, i.e., 125 sq m/shop, a total of 2,500 new shops can be established in these zones.

Because of the rapid rate of development of residential areas during the period 1978 to 1990, we assume that 75 percent of all new commercial development in these designated zones will take place by 1990. This amounts to 1,875 shops by 1990, and an additional 625 shops by the year 2000. All other commercial development is assumed to become established as either incidental commercial development in new residential areas, or intensification of existing commercial business. The following tabulation shows the breakdown of all projected commercial development:

Year	Number of New Shops in Designated Areas	Number of New Shops Incidental of Intensification	Total Number of New Shops
1990	1,875	573	2,448
2000	625	2,063	2,688
Total increase, 1978 to 2000	2,500	2,636	5,136

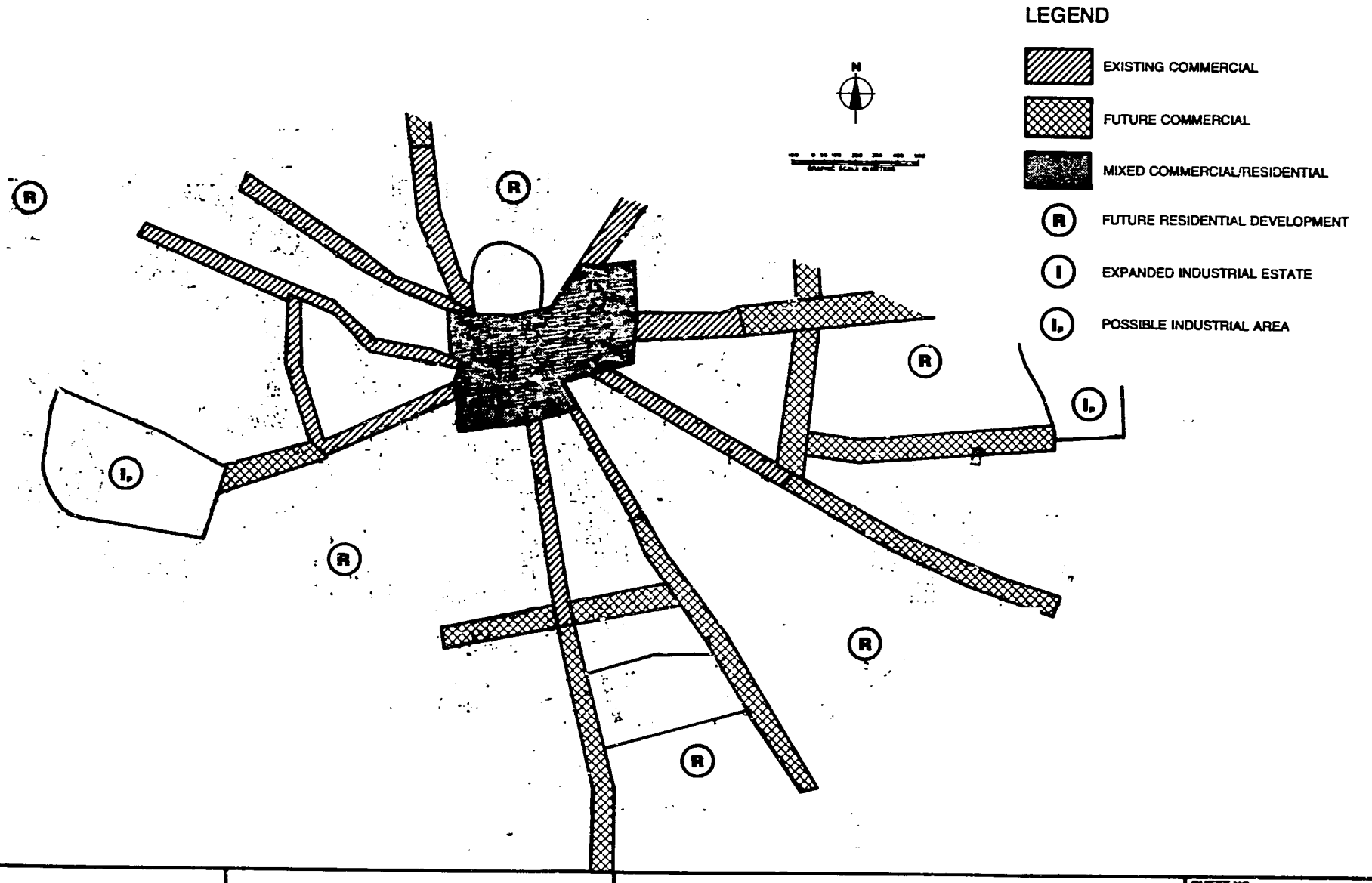
2.4.2.2 Industrial Land Use.

As previously stated, all future industry will be required to locate in the industrial park. This park is projected to expand to over 100 hectares by year 2000.

Table 2-9

1963 Building Coverage

(1) Subarea	(2) 1:10,000 Building Coverage (sq m)	(3) % Share of 1963 Population (2) ÷ total	(4) 1963 Population
A_1	26	0.00	0
A_2	56	0.01	363
B_1	504	0.06	2,178
B_2	195	0.02	726
B_3	86	0.01	363
B_4	395	0.04	1,452
C_1	100	0.01	363
C_2	16	0.06	0
C_3	2,077	0.24	8,712
C_4	505	0.06	2,178
C_5	674	0.08	2,904
D	1,197	0.14	5,082
E	2,853	0.33	11,979
Total	8,684	1.00	36,300



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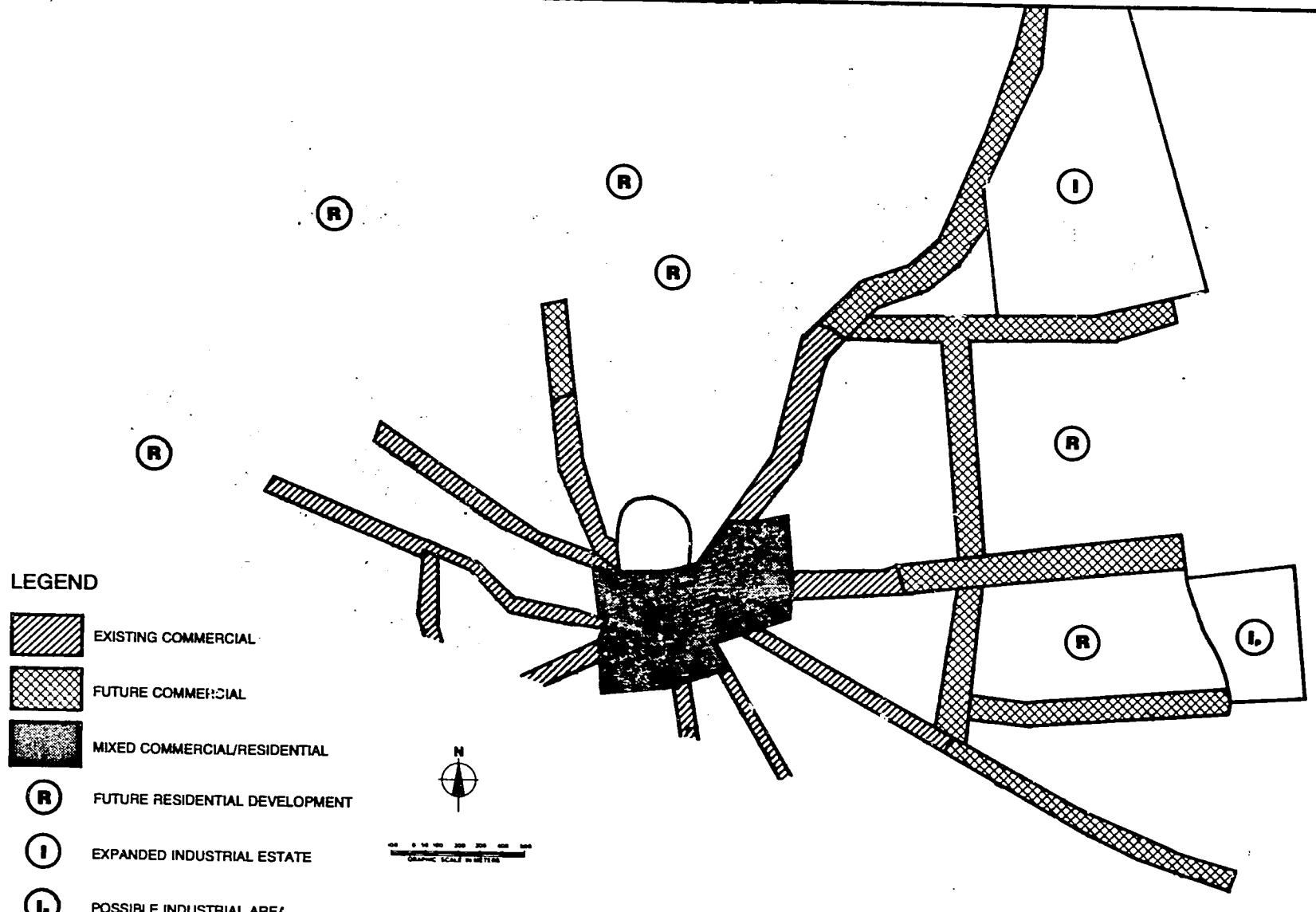
PROJECTED COMMERCIAL LAND USE

SHEET NO. FIGURE 2-6a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEVEN



LEGEND

- EXISTING COMMERCIAL
- FUTURE COMMERCIAL
- MIXED COMMERCIAL/RESIDENTIAL
- (R) FUTURE RESIDENTIAL DEVELOPMENT
- (I) EXPANDED INDUSTRIAL ESTATE
- (Ip) POSSIBLE INDUSTRIAL AREA

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2.4.2.3 Residential Land.

Figures 2-7a and b and 2-8a and b show the development of residential land projected for 1990 and 2000. It can be seen that the 1975 to 1990 projected development fills in the fast growing areas (B_1, B_2, B_3, B_4, C_1, C_3, C_5, and E) during this period. By the year 2000, all potential residential areas within the present Irbid City limits will have been covered with homes. Municipal policies providing stimulus for in-filling of undeveloped land will be helpful in achieving this goal.

2.4.3 Disaggregation of Population Increments

The purpose of this subsection is to outline the methodology for allocating population increments to the 13 subareas for the periods 1978 to 1990 and 1990 to 2000. As indicated in Table 1-1, the 16,000 persons living in the refugee area north of the center of the City are left out of the counts for 1978, 1990, and 2000. We assume for planning purposes that after the refugee area is no longer required, it will be developed as a D area at the maximum permitted density.

2.4.3.1 Disaggregation Methodology.

As indicated on Figure 1-1, the process of population disaggregation contains the following steps:

1. Review available information.

2. Establish Municipalitywide population projections.

3. Select service areas.

4. Project industrial, commercial, and institutional growth.

5. Calculate residential land available for future development.

6. Use population trajectories to project new residential land use.

7. Reallocate deficits to surplus areas.

8. Calculate final products:

   a. Land available for future residential use.
   b. Subarea population.
   c. Percent impervious surface.
   d. Population density.

2.4.3.2 Inputs.

This subsection explains in detail the inputs to the disaggregation methodology, and how the various subproducts and final products are calculated.

1. Incremental Shares of Population Growth.

Table 2-9 gives the results of an examination of a 1963 aerial map of Irbid. Figure 2-9a and b indicates the 1963 developed area. The 1963 building coverage was calculated for each subarea. This was compared to the 1978 building coverage in each subarea, and this 1963-1978 increase in building coverage area becomes the first input into the disaggregation process.

2. Additional Construction on Existing Buildings.

Almost all buildings in Irbid allow for the addition of up to three stories, the limit imposed by the zoning ordinance. Building permits in Irbid are issued for each additional story added to existing buildings, as well as for new construction. An examination of building permit data revealed the average ratio of upward growth to new construction was approximately 0.14. The ratio for the subareas varies from 0.20 for areas B_4 and C_5, down to 0.02 for areas A_1 and A_2. This ratio was multiplied by areal growth to determine upward growth for the period 1963 to 1978.

3. Effective Building Cover.

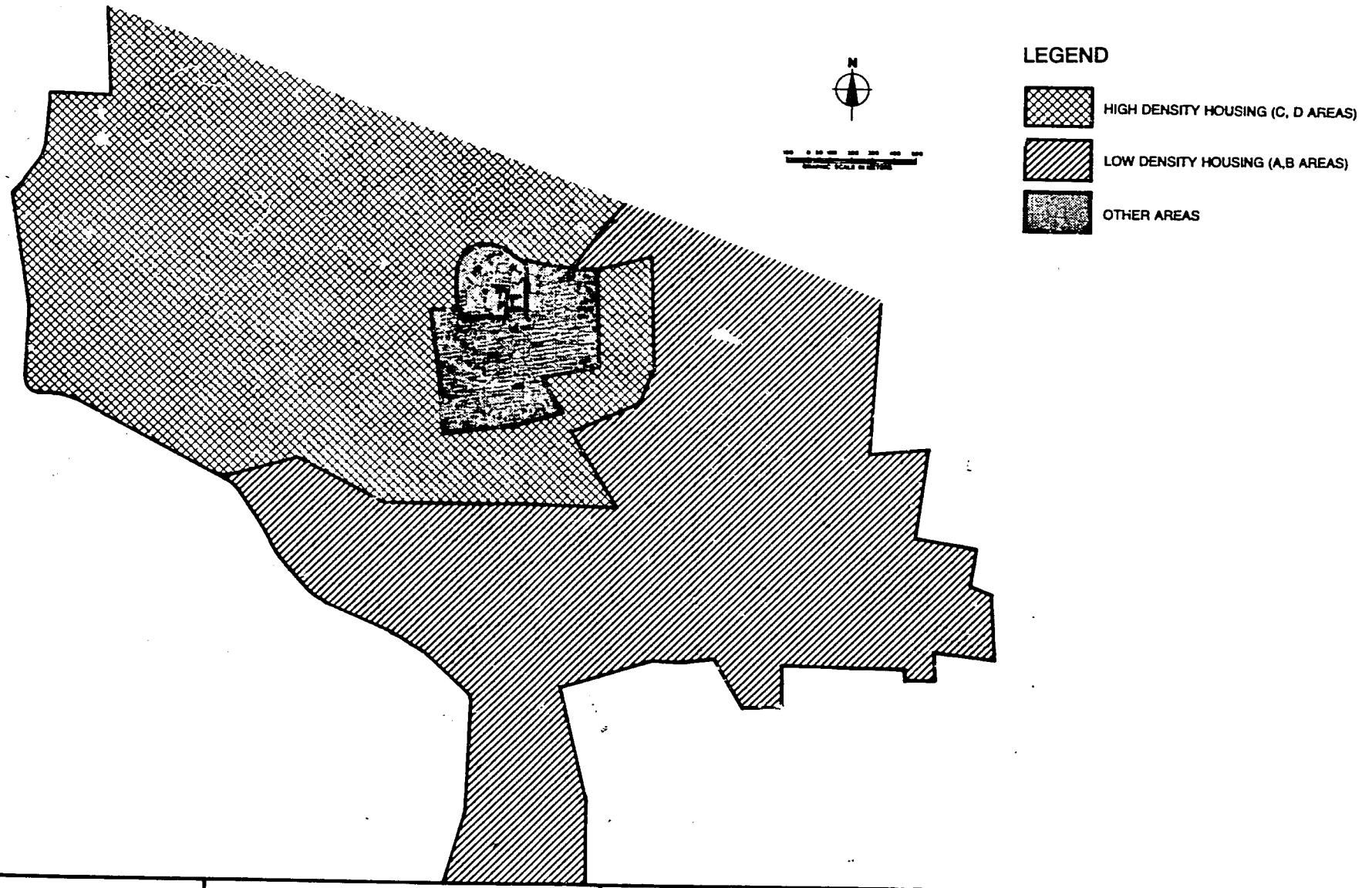
The areal and upward growth increases were corrected for persons per household using the 1978 population disaggregation developed in subsection 2.2.1, Table 2-2. From this, an effective share of the 1963 to 1978 growth in building cover was determined. This was converted into decimal shares by dividing the share for each subdistrict by the total.

4. Disaggregated Population.

The 1963 to 1978 corrected decimal shares were multiplied by the projected growth increments for the 1975 to 1990 population increment (120,000 persons, see Tables 2-10a and 2-10b) to yield disaggregated population increments.

5. Development Density.

As the next step, it was necessary to allocate land for residential development based on the projected population increment. This was done by dividing the population increment by the average number of persons per unit of developed land. Table 2-11 shows the calculation of development density. Development densities for 1990 and 2000 reflect the



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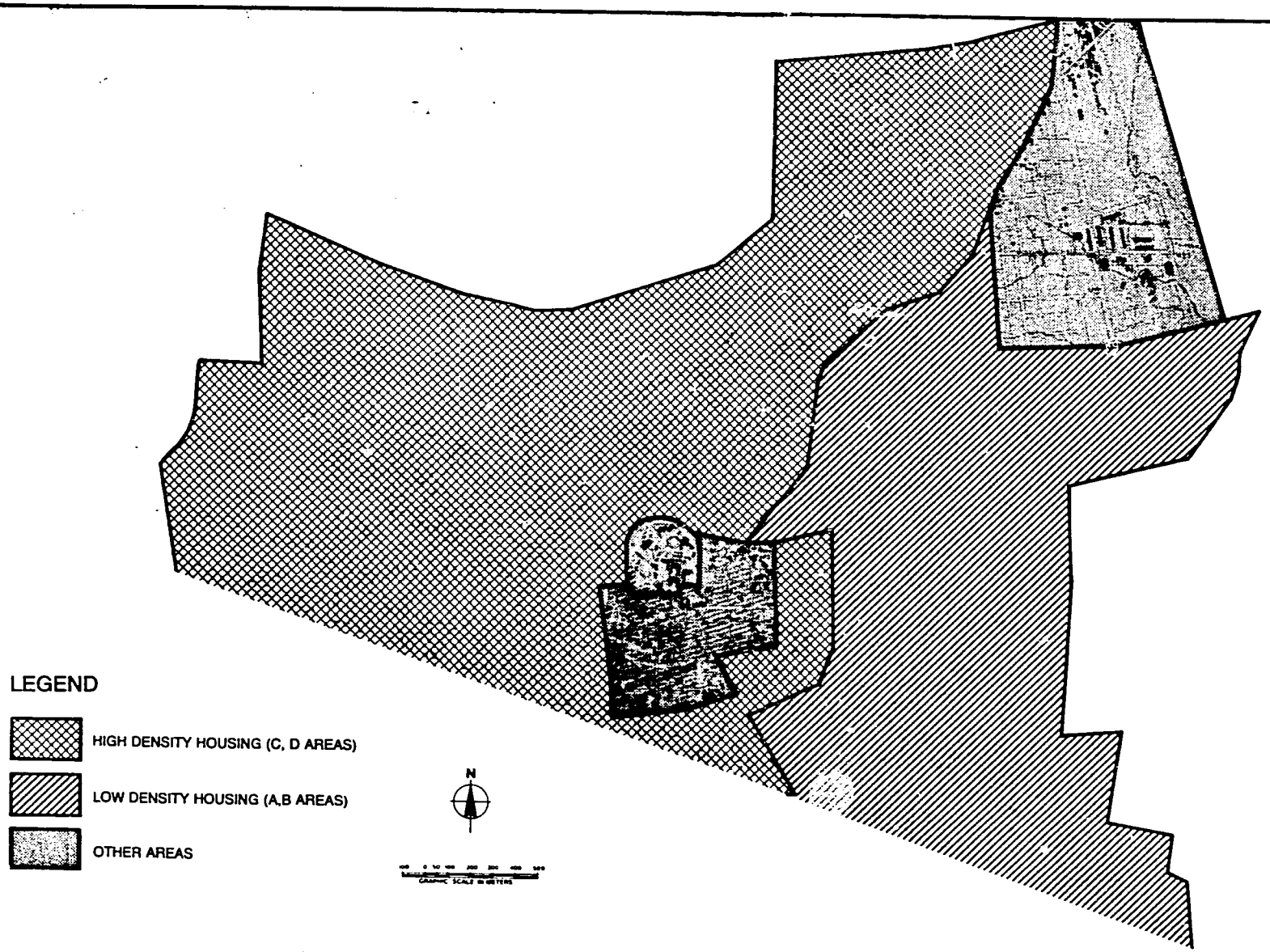
1990 RESIDENTIAL LAND USE

SHEET NO. FIGURE 2-7a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



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1990 RESIDENTIAL LAND USE

SHEET NO. FIGURE 2-7b

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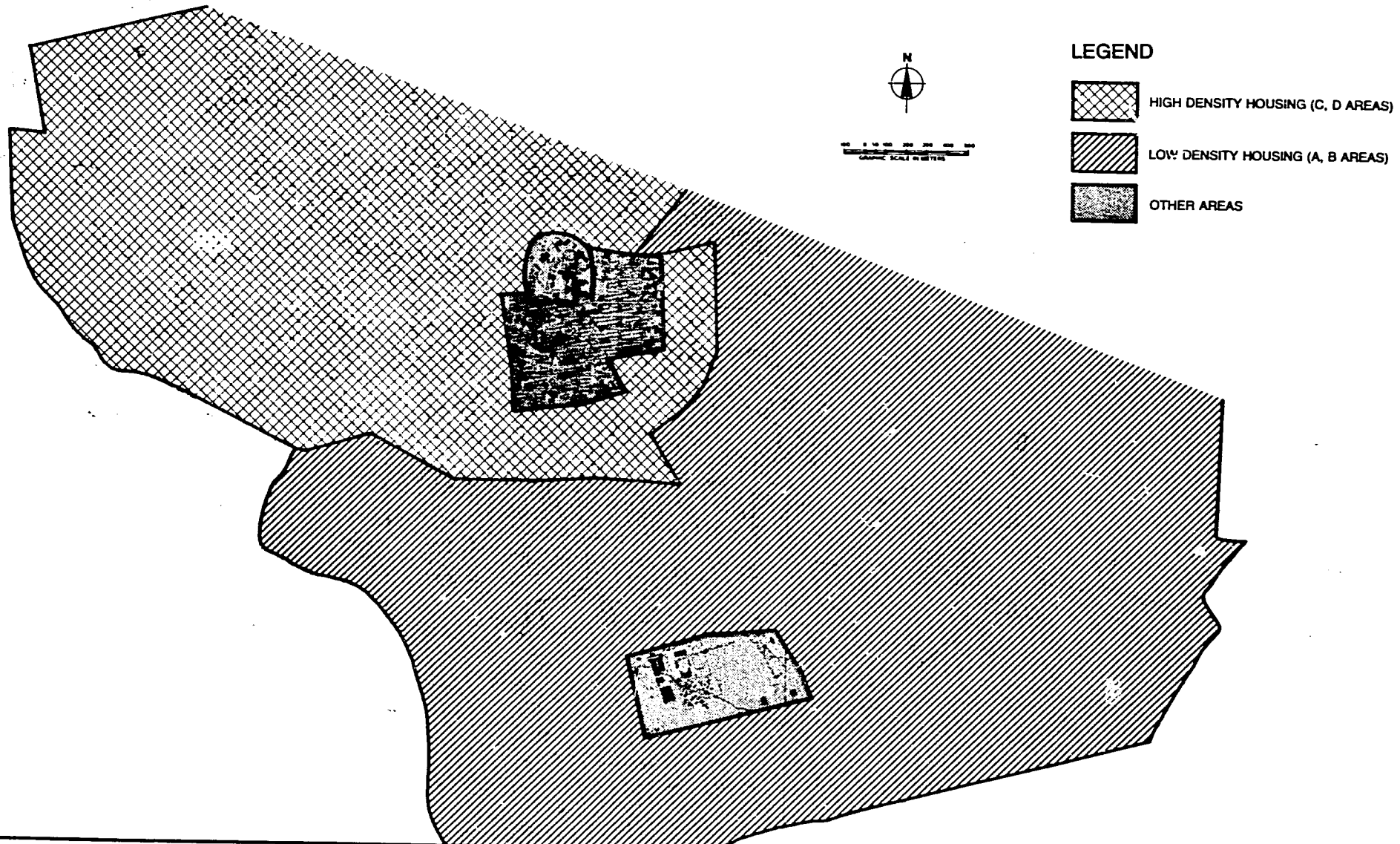

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2000 RESIDENTIAL LAND USE

SHEET NO. FIGURE 2-8a

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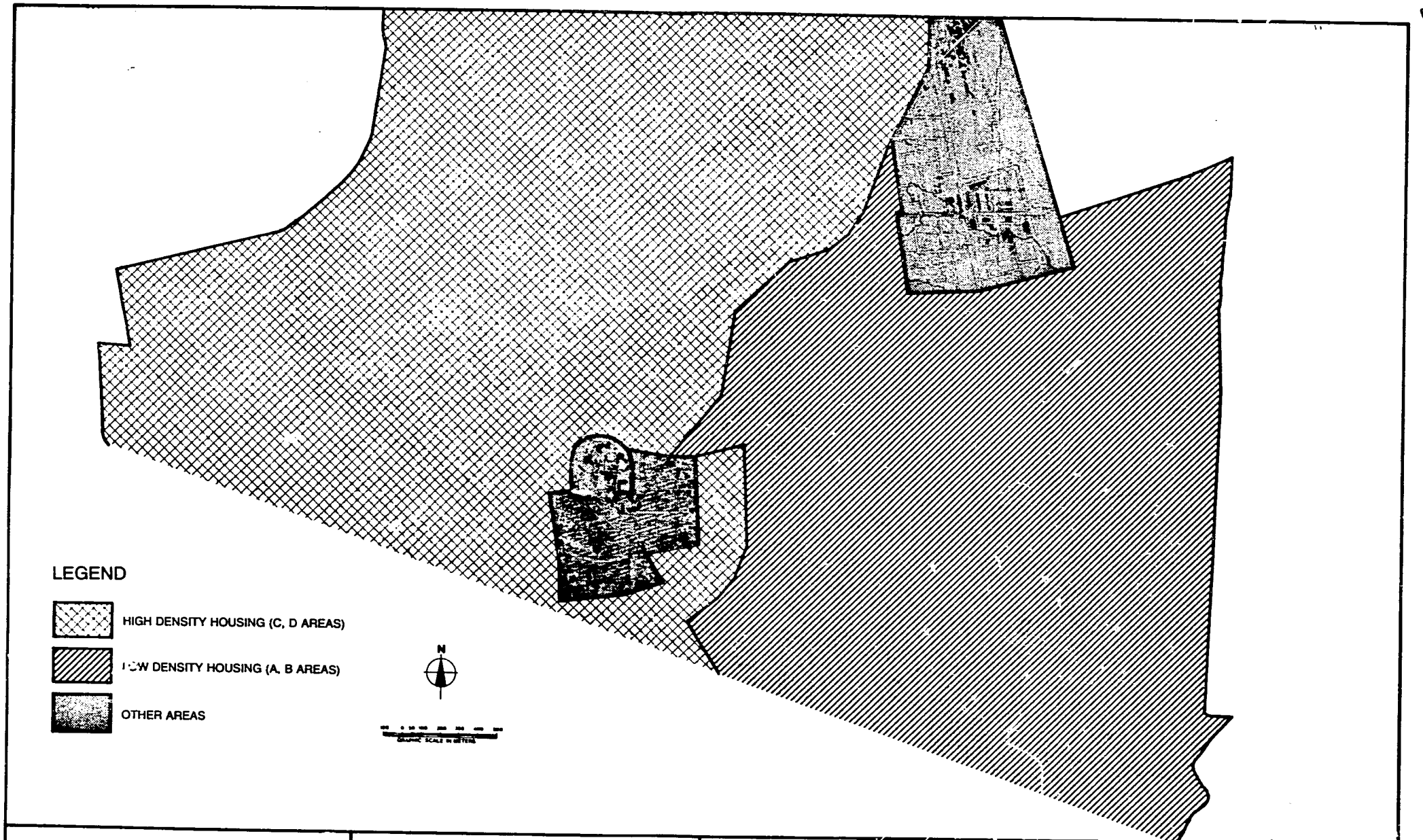

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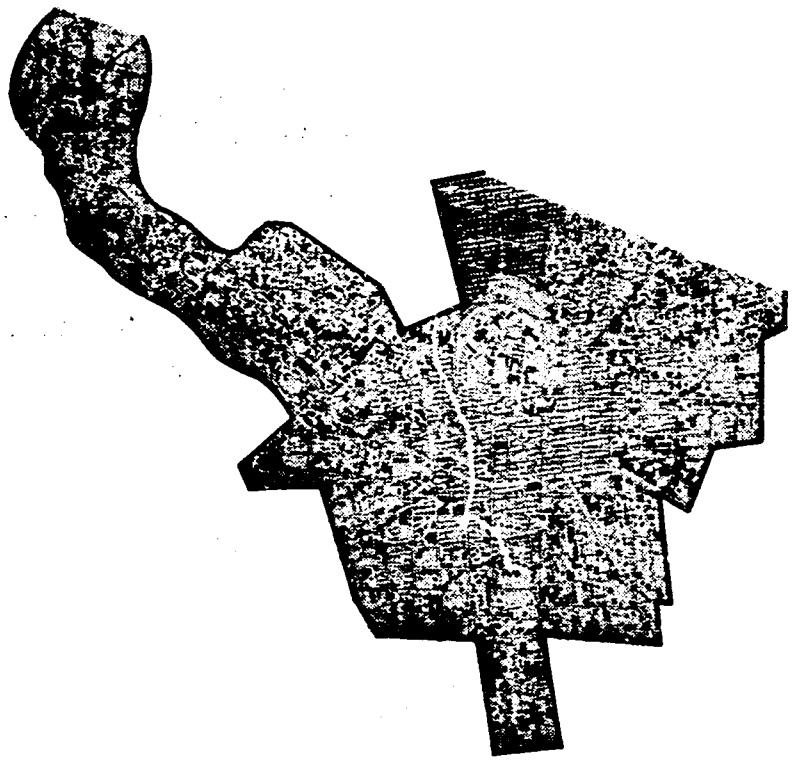
2000 RESIDENTIAL LAND USE

SHEET NO. FIGURE 2-8b

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



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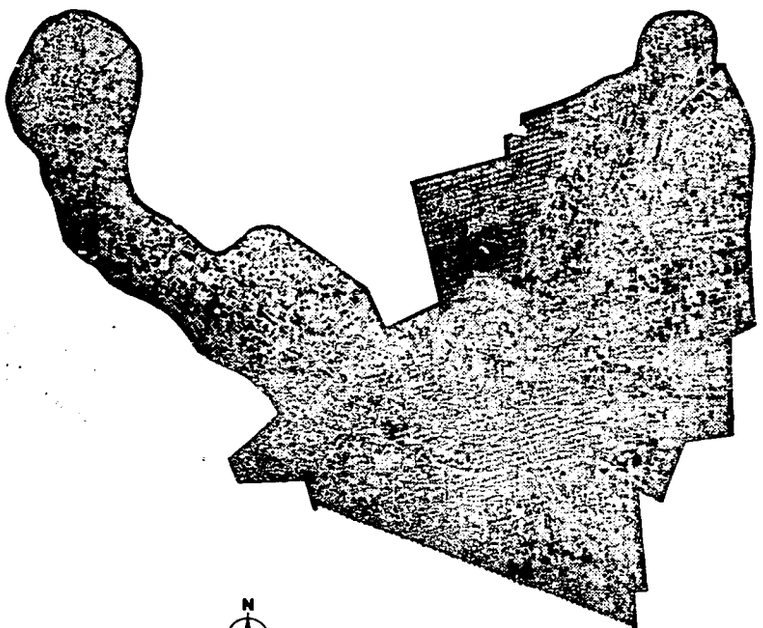
LEGEND

APPROXIMATE BOUNDARY OF 1963 BUILDING COVERAGE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	1963 BUILDING COVERAGE	SHEET NO. FIGURE 2-9a DATE: SEPT. 1979 BY: F. RAHHAL CHKD: HALVENSLEBEN



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APPROXIMATE BOUNDARY OF 1963 BUILDING COVERAGE

N

GRAPHIC SCALE IN METERS

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Table 2-10a

1990 Population Disaggregation
Part I

(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8a)	(8b)	(9a)	(9b)	(10)
	1963-1978 Area Increase (sq mm on 1:10,000 map)		Upward 1963-1978 Area Increase (sq mm on 1:10,000 map)			Effective Building Cover		Decimal Shares		1975-1990 Disaggregated Increments		
Subarea		Ratio of Upward to Outward Construction		Persons Per Household	Scaled to 100	Out	Up	Out	Up	Out	Up	Development Density
A_1	717	0.02	14	7.6	67.8	48,612	949	0.072	0.001	8.6	0.1	0.92
A_2	292	0.02	6	7.6	67.8	19,798	407	0.029	0.000	3.5	0.0	0.92
B_1	583	0.14	106	8	71.8	63,399	7,611	0.094	0.011	11.3	1.3	1.3
B_2	388	0.14	54	8	71.8	27,858	3,900	0.041	0.009	4.9	1.1	1.3
B_3	316	0.14	44	8	71.8	22,689	3,176	0.034	0.005	4.1	0.6	1.3
B_4	922	0.20	184	8	71.8	66,200	13,240	0.098	0.020	11.8	2.4	1.3
C_1	1,414	0.14	198	8.2	73.2	103,505	14,491	0.154	0.021	18.5	2.5	1.6
C_2	98	0.14	14	8.2	73.2	7,174	1,004	0.011	0.001	1.3	0.1	1.6
C_3	316	0.14	44	8.2	73.2	23,131	3,238	0.034	0.005	4.1	0.6	1.6
C_4	1,391	0.14	185	8.2	73.2	101,821	13,517	0.151	0.020	18.1	2.4	1.6
C_5	119	0.20	24	8.2	73.2	8,711	1,742	0.013	0.003	1.6	0.4	1.6
D	242	0.14	34	11.2	100	24,200	3,388	0.036	0.005	4.1	0.6	2.7
E	1,153	0.14	161	7.6	67.8	78,173	10,944	0.116	0.016	13.9	1.9	1.5
Totals	8,252	0.14	—	-	-	672,878		0.883	0.117	105.8	14.2	-
										120		

(4) = (2) x (3)
(7a) = (2) x (6)
(7b) = (4) x (6)
(8) = (7 total 7
(9) = (8) x total 9

Table 2-10b

1990 Population Disaggregation
Part II

(11) Subarea	(12) 1975-1990 Areal Increment (sq m)	(13) Area Available for Residential Development	(14) Incremental Area Deficit	(15) Incremental Area Surplus	(16a) Area	(16b) Reallocation Origination	(16c) Destination	(17) Actual Experienced Increment (sq m)	(18) Outward Population Increment	(19) Total Population Increment (Thousands)	(20) 1990 Population	(21) Residential Land Available for Future Development
A_1	935,000	2,654,000		1,835,000	590,000[1] (833,670)[1]	B_1, B_4		1,653,000	17,348	17.4	21.9	1,001,000
A_2	380,000	828,000		495,000				333,000	3,498	3.5	5.7	495,000
B_1	869,000	231,000	530,000		530,000		A_1	231,000	3,426	4.7	13.7	0
B_2	378,000	319,000	11,000		11,000		A_1	319,000	4,728	5.8	9.2	0
B_3	315,000	242,000	34,000		34,000		A_1	242,000	3,586	4.2	6.4	0
B_4	908,000	780,000	15,000		15,000		A_1	780,000	11,559	4.0	22.9	0
C_1	1,115,000	915,000	97,000[2]		97,000		C_2, C_3, C_5	915,000	16,700	19.2	29.3	0
C_2	81,000	1,250,000		1,178,000	378,000 111,000	E C_1, C_4		585,000	10,700	10.8	11.8	665,000
C_3	256,000	658,000		434,000	140,000 41,000	E C_1, C_4		410,000	7,500	8.1	23.8	248,000
C_4	113,000	930,000	61,000[2]		61,000		C_2, C_3, C_5	930,000	17,000	19.4	31.7	0
C_5	100,000	156,000		68,000	22,000 6,000	E C_1, C_4		117,000	2,100	2.5	8.0	39,000
D	152,000	225,000		92,000	30,000[1]	E		150,000	4,600	5.2	17.5	75,000
E	927,000	241,000	570,000[2]		570,000		C_2, C_3, C_5	241,000	4,100	6.0	30.6	0
									106,800	120.8	232.5	2,523,000

[1] Reallocated area scaled up because of density limitation.
[2] Deficits awarded to C_2, C_3, C_5 in proportion to surpluses.

Note: (12) = (9a) - (10) x 100
(13) = Column 13, Table 2-6

Table 2-11

Development Density

Subarea Type	Household Size (HS)	Required Lot Minimum	Current Development Density (DD)	1990		2000	
				HS	DD	HS	DD
A	7.6	750[1]	1.0	6.9	0.9	6.2	0.8
B	8.0	550[1]	1.4	7.2	1.3	6.6	1.2
C	8.2	450[1]	1.8	7.4	1.6	6.7	1.5
D	11.2	420[2]	2.7	10.2	2.4	9.2	2.2
E	7.6	500[2]	1.5	6.9	1.4	6.2	1.2

[1] Taken from zoning regulations.

[2] Taken from socioeconomic survey.

fact that household size is expected to diminish by 5 percent every five years during the project period. (JICA report, p. VIII-50 and our estimate.)

6. Deficits and Surpluses.

The allotted residential land was compared to the total available land. If available land exceeded allotted residential land, the surplus was calculated. If allotted residential land exceeded available land, the deficit was noted.

7. Reallocation.

In areas where a deficit occurred, the residential land was shifted to a neighboring subarea permitting the same zoning density. When all areas of the same density became filled, the deficit residential land to be reallocated was multiplied by the ratio of development density of the area having the deficit, and that of the receiving area.

8. Further Development.

The calculated increment was added to previously-developed residential land to yield total developed land. It was also converted back to population to obtain total subarea-calculated population increments. Available developed land, and 1975 to 1990 population trajectories were calculated, and the process was repeated for the period 1990 to 2000.

2.4.3.3 Irbid Municipal Projections.

The 1990 and 2000 projections followed the general scheme just outlined (see Table 2-12). By 2000, all available land within the planning area will have full residential and commercial development, at least to the ground floor. It is unlikely that Irbid could ever experience full residential development within the Municipality boundaries, i.e., all potential existing and future buildings with ground, first, and second stories.

1. Limits to Amman Growth.

Officials at the Amman Urban Regional Planning Group have informed us that during the study period, it is possible that the Municipality of Amman may restrict or prohibit further population influx. We can analyze the possible effects of this contingency upon Irbid's projected population in qualitative terms only. Under these conditions we would, of course, predict an increase in the already high population pressures on both the Irbid Municipality and Governorate. The ultimate growth for Irbid which would correspond to this eventuality could possibly involve the following:

Table 2-12

Year 2000 Disaggregation

(1) Subarea	(2a) Decimal Shares of 1990-2000 Growth: Out	(2b) Decimal Shares of 1990-2000 Growth: Up	(3) Disaggregate Upward Population Growth	(4) Residential Land Available (sq m)	(5) Residential Land Deficit (sq m)	(6) Year 2000 Areal Population Increment	(7) Total 2000 Population Increment	(8) Year 2000 City Limit Population	(9) Year 2000 Suburban Population
A_1	0.298	0.005	560	1,001,000	3,021,000	8,803	9,363	31.2	
A_1S	-	-	-	-	-	-	-	-	26.0
A_2	0.061	0.001	110	495,000	328,000	4,108	4,218	9.9	
Yarmouk University	-	-	-	-	-	-	-	2.5	
A_2S	-	-	-	-	-	-	-	-	5.2
B_1	-	0.006	670	0	-	0	670	14.3	
B_2	-	0.007	760	0	-	0	760	10.0	
B_3	-	0.006	670	0	-	0	670	7.1	
B_4	-	0.021	2,350	0	-	0	2,350	26.3	
C_1	0.228	0.031	3,470	0	1,824,000	0	3,470	28.8	
C_2	0.112	0.016	1,790	665,000	231,000	9,310	11,100	22.9	
C_3	0.099	0.014	1,570	248,000	544,000	3,472	5,070	28.9	
C_4	-	0.015	1,680	0	-	0	1,680	23.4	
C_5	0.024	0.005	560	39,000	153,000	546	1,100	9.1	
CS	-	-	-	-	-	-	-	-	39.0
O[1]	0.039	0.006	670	75,000	123,000	1,650	2,300	19.8	
E	-	0.006	670	0	-	0	670	31.3	
Total	0.861	0.139	-	2,523,000			27,069	279.5	64.2

[1] Does not include refugee area.

Note: (7) = (3) + (6)

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1. An increased inner City population perhaps exceeding 450,000 persons.

2. Increased suburban population higher than that currently predicted for the year 2000. This could bring the greater Irbid population to over 600,000.

3. The 30 surrounding towns having current populations in excess of 3,000 each will absorb population growth. This would be limited because these towns do not have the infrastructure to support the same standard of living as Irbid.

2. Restriction of Growth Beyond the Municipality of Irbid Limits.

This would represent a policy of decentralization of the Irbid Governorate population. The policy of decentralizing the major population centers of Amman, Irbid, Aqaba, and Zarqa is one that has been presented to the national government (see JICA report, Chapter 13). It must, of course, be pointed out that such a policy must be accompanied by comprehensive planning. The strong predicted influx into the major population centers must be taken into account. Were this policy to be implemented in Irbid without provision for the inevitable shift in population settlement patterns, the following results could be expected:

1. Densities within Irbid would increase approaching the saturation density put forth by Table 2-13.

2. There would be increased pressure for zoning ordinance variations, both with respect to height of buildings and density. This would, in turn, alter the population projections for the year 2000.

3. The decentralization of the Municipality of Irbid would increase population in outlying towns, and put pressure on them to upgrade water distribution and sewerage collection/treatment facilities.

These alternate futures are contrary to current planning policy, historical trends, and most likely future trends. If the possibility that they could occur should arise, then the effect on the proposed sewerage and water distribution scheme should be evaluated.

2.4.4 Implications and Assumptions of Forecasts

There are several assumptions critical to the socioeconomic study, and some implications which must be considered carefully.

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Table 2-13

Saturation Population

(1) Subarea	(2) 1978 Population	(3) Available Residential Land (sq km)	(4) Available Lots	(5) Year 2000 Household Size	(6) Household Size x 3	(7) Incremental Population	(8) Total Population
A_1	5.2	2.6	3,526	6.2	18.6	65.6	70.8
A_2	2.2	0.8	1,104	6.2	18.6	20.5	22.7
B_1	9.96	0.2	420	6.6	19.8	8.3	18.3
B_2	3.4	0.3	580	6.6	19.8	11.5	14.9
B_3	2.2	0.2	440	6.6	19.8	8.7	10.9
B_4	9.96	0.8	1,418	6.6	19.8	28.1	38.1
C_1	10.1	1.3	2,876	6.7	20.1	57.8	67.9
C_2	1.1	1.0	2,238	6.7	20.1	45.0	46.1
C_3	15.7	0.7	1,678	6.7	20.1	33.7	49.4
C_4	12.3	0.6	1,242	6.7	20.1	25.0	37.3
C_5	5.6	0.2	347	6.7	20.1	7.0	12.6
D	12.3	0.2	536	9.2	27.6	14.8	27.1
E	24.6	0.2	482	6.2	18.6	9.0	33.6
Total	114.62						449.7

2.4.4.1 Assumptions.

1. The road development within the defined municipal boundaries (as depicted by Figure 2-2) will be completed by 1990. (Irbid planning officials have assured us this will happen.)

2. The water supply and sewerage system will adequately serve major development expected by 1990, and will be able to take on new customers at approximately the rate of 10,000 persons per year between 1990 and 2000.

3. All current zoning regulations will remain enforced and unchanged.

4. Settlement beyond presently-defined City limits will not be restricted severely or prohibited.

5. Future commercial growth will be limited to commercial zones, except for incidental commercial development.

6. Policies will encourage in-filling of existing undeveloped land.

2.4.4.2 Implications.

1. Most of the 13 subareas will have extensive residential development by the year 2000.

2. Restriction of commercial development will put added pressure on the large commercial area in the center of the City.

3. The most homogeneously affluent areas will not be fully developed until the year 2000 or after.

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CHAPTER 3

STUDY CRITERIA

3.1 GOALS AND OBJECTIVES

The study goals are to establish an integrated framework for municipal water distribution, together with an adequate system of sewerage and stormwater drainage, as well as solid waste disposal in the City of Irbid planning area. The goals are to be accomplished in three stages:

1. Stage I -- Conduct socioeconomic and health studies, as well as technical investigations, preliminary engineering, and financial analysis. This report is the result of these studies and analyses.

2. Stage II -- Detailed design and preparation of tender documents for construction of the required facilities.

3. Stage III -- Construction of water distribution, sewerage, and stormwater drainage facilities, as well as acquisition of equipment and development of solid waste disposal facilities. Facilities required to serve the needs of the Municipality of Irbid through the year 1990 are to be constructed by the end of 1982.

The objectives set out to accomplish Stage I of the project, the socioeconomic and health study, and feasibility studies, are as follows:

1. Prepare a socioeconomic report for the Irbid town plan area using available data and identifying areas with low-income population; inadequate water and sewerage services; and having the highest incidence of water-borne diseases.

2. Prepare technical, economic, and financial feasibility studies and investment programs to provide the following:

   a. Water distribution within the Irbid town plan area.

   b. General scheme for wastewater disposal and treatment.

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c. Separate system of stormwater drainage structures within the project area.

d. Solid waste disposal system.

3. Develop a time-phased investment program reflecting the most urgent service needs in items of high densities, serious health problems, or the greatest inadequacies in present service.

4. Prepare suggestions as to water charges, house connection costs, and relevant municipal taxes, consistent with the government's policies and priorities. This includes an analysis of individual socioeconomic groups' ability to pay for various costs.

3.2 WATER SUPPLY SYSTEM CRITERIA

3.2.1 Water Demands

Due to the lack of an adequate water supply, measurement of water use in Irbid does not reflect the true demand. This makes an analysis of water demand difficult. Existing water uses have been used only as a guide to estimating water demands.

3.2.1.1 Residential Demand.

The present Irbid water use is estimated at 33 liters/capita/day. This estimate is based on an estimated present population of 146,000 persons, and the water use figures for 1978. Per capita water use in 1978 was greater than in previous years because a greater supply was available to the Municipality. Thus, the 1978 water use is closer to the actual demand. The total per capita use given is divided between residential and commercial uses. Lack of existing data make separation of residential and commercial/industrial uses impossible. In the water demands developed in the "North Jordan Water Use Strategy," by Howard Humphreys and Sons, commercial/industrial water use is estimated at 20 percent of the total demand.

The average daily water use in Amman is estimated as 100 liters/capita/day; this does not include losses. Here again, demand is restricted by available supply. The estimate of future Amman demand is 150 liters/capita/day in the year 2000, not including losses.

The analysis of projected water demand/use presented in Chapter 4 results in the following water demand/use figures (liters/capita/day):

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	1975	1980	1990	2000
Domestic	70	75	85	95
Total	118	126	144	160

The total demand includes an allowance of 20 percent for system losses. The residential demand is an average rate. Socioeconomic data were used to disaggregate this demand to the various areas of the City.

3.2.1.2 Commercial/Industrial Water Demand.

Other than major commercial users such as the hospital and University, there is no way to reliably measure current commercial demand. The dairy and the slaughterhouse are the only industrial facilities for which water use records are available. Besides these two industries, there are currently no other known industries using process water.

Because future commercial demand will be located over sizable areas of the Municipality, the per capita water demand, by area, includes a variable allowance for commercial use. Each socioeconomic area is assigned a per capita amount for commercial use.

Other than demands of the dairy and slaughterhouse, the industrial use is also assumed to be included in the per capita demand. Dairy water demands are estimated as 45 cu m/day in 1990, and 67 cu m/day in 2000. Slaughterhouse demands are estimated as 235 cu m/day in 1990, and 470 cu m/day in 2000.

3.2.2 Design Pressure

Maximum and minimum pressure levels for the distribution system ensure adequate water supplies to users at pressures which will not harm residential plumbing or contribute to system losses.

3.2.2.1 Operating Pressures.

A minimum pressure criterion is required so that the distribution system will supply water to all consumers. The lowest allowable pressure is one which will fill the roof storage facilities. In order to determine the minimum pressure, the length and type of building plumbing was taken into consideration. Based upon an estimate of building head loss, the minimum system pressure should be 210 kilopascals (kPa) (1 kg/sq cm = 98.1 kilopascals).

Maximum system pressure has been set as 620 kPa. This level maintains delivery pressures at the tap which do not harm building plumbing or contribute to wastage. Keeping the system pressure below 620 will help minimize leakage in existing mains. The existing mains have not been operating near 620 kPa, and pressures greater than current operating pressures will increase any existing leakage rates.

Filling the existing elevated water tank requires 150 kPa system pressure. Since this is below the minimum pressure, the tank will not be usable for storage unless pressures drop below the minimum criterion.

3.2.2.2 Pressure Zones.

The operating pressure range of 210 to 620 kPa encompasses an elevation difference of 40 m under static conditions. Since the planning area includes an elevation difference of approximately 155 m, the use of pressure zones will be necessary to avoid excessive pressures during low flow and static conditions.

Four pressure zones are required to cover the elevation difference within the system. The system will be supplied from the highest zone. The study area is downhill from the supply point so a higher zone can supply the next lower zone through a pressure-reducing station without the need for pumping.

3.2.3 Fire Fighting Requirements

Discussions were held with Irbid Civil Defense to determine whether water for fire fighting purposes would have to be accounted for in this study. Present fire fighting practices use tankers to supply water to fire fighting equipment. No changes in this practice are expected because most of the fires are in rural areas. The fire department will shortly have a new site which includes water storage for filling their tankers. It is apparent that no allowance for fire fighting is needed in design of the system, but it is suggested that tanker filling points be installed at strategic locations in commercial and industrial areas. Location and design of tanker filling points will be determined during the design phase.

3.2.4 Future System Characteristics

3.2.4.1 Impact of Water Quality on System Facilities.

Water quality of the existing supply is tabulated as follows. This table is developed from data obtained by the National Resources Authority in 1976 and 1977 for all of the wells supplying Irbid. The present water supply is characterized by moderately-high levels of total dissolved solids, and very high levels of nitrates. The World Health Organization limit for nitrates is 45 mg/L.

Existing Water Supply Quality

Water Qualiy Parameter	Range of Results
Total dissolved solids	280-1,000 mg/L
Chlorides	25-375 mg/L
Sulfates	0-350 mg/L
Hardness (calcium and magnesium)	40-135 mg/L
pH	7.00-8.42 pH units
Nitrate	10.19-42.97 mg/L

Source: Natural Resources Authority, Water Laboratories.

When the water supply comes from the Yarmouk River, water quality characteristics will change. The levels of total dissolved solids and sulfates will decrease, and the level of nitrates should drop significantly.

The change in water quality should have no effect on the operation or maintenance of the water system. There will probably be a notable change in the test of the water, however.

3.2.4.2 Pipe Material.

Asbestos cement, ductile iron, polyvinyl chloride (PVC), and steel were considered for the type of pipe to be used.

1. Asbestos Cement Pipe -- This pipe has good hydraulic characteristics, is free from corrosion problems, and is manufactured in Jordan. The maximum size manufactured locally is approximately 50 cm. Asbestos cement pipe also is characterized by being difficult to tap for services and requires extra care in handling and bedding. Extra granular bedding to a height of 30 cm over the main would be required, thus increasing pipe installation costs. Proposed mains larger than 50 cm would have to be of some other pipe material.

2. Ductile Iron Pipe -- The type of ductile iron pipe considered is cement-lined internally and has an external and internal bituminous coating. Ductile iron pipe has good strength characteristics, does not require extra care in handling and bedding, is readily tapped, and is available in all sizes required for this project. Ductile iron pipe is not manufactured in Jordan. Corrosion characteristics are moderately good when protective coatings as given are used. Service life of ductile iron pipe in Irbid should be greater than 50 years.

3. PVC Pipe -- This pipe has good hydraulic characteristics, is free from corrosion problems, and is manufactured in Jordan in sizes up to 20 cm. This type of pipe is not

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available in sizes larger than 30 cm. Proposed mains larger than 30 cm would have to be of some other pipe material. PVC pipe is more difficult to tap than ductile iron pipe. While PVC pipe has fewer handling problems than asbestos cement pipe, extra care in bedding is a necessity. Extra granular bedding over the pipe would also be required for PVC pipe.

4. Steel Pipe -- This pipe would be cement-lined and have an external bituminous coating. Steel pipe has excellent strength characteristics, can withstand normal handling, requires only normal care in bedding, is readily tapped, and is available in all sizes required for this project. Steel pipe is not manufactured in Jordan. Even with protective coatings corrosion is a problem, and the service life of steel pipe would probably be less than 50 years.

The existing system is comprised primarily of steel and galvanized iron pipe.

In choosing the pipe material, there are a number of important considerations in addition to cost:

1. Service Life -- The length of time before the pipe must be replaced.

2. Availability in All Sizes -- Unless all mains are of the same material, the Municipality must maintain tools and stock for different types of material.

3. Handling and Bedding -- Pipe which does not require special care will last longer and be easier to maintain and operate.

4. Tapping Characteristics -- Considerable tapping of the proposed system will be necessary. Ease of tapping will benefit operation of the system.

These considerations and costs are evaluated in the following table. Each material is ranked from 1 to 10 for each consideration, with 10 representing the best ranking. In addition, each consideration has been given a weighting factor. For cost, the weighting factor is 0.3; for service life, 0.3; for availability in all sizes, 0.1; for handling and bedding, 0.2; and for tapping characteristics, 0.1 The weighting factors total 1.0. The numbers in the following table are the product of the weighting factor and the ranking.

Pipe Material Characteristics

	Type of Pipe			
	Asbestos Cement	Ductile Iron	PVC	Steel
Cost	3.0	1.5	2.1	0.3
Service life	2.7	2.7	3.0	1.5
Availability in all sizes	1.0	1.0	0.6	1.0
Handling and bedding	0.6	1.8	1.2	1.8
Tapping characteristics	0.8	1.0	0.8	0.6
Total Points	8.1	8.0	7.7	5.2

There is a 5 percent difference in ranking between asbestos cement, ductile iron, and polyvinyl chloride (PVC) pipe materials. Other factors beside those given should be employed to determine which material to use. It is recommended that asbestos cement pipe be removed fron consideration because of difficulties in storing and handling of pipe. It is also more susceptible to breaking after installation when other underground work is done near it. There is also some uncertainty about potential health hazards from asbestos fibers with this type of pipe material. The use of PVC pipe would save about 1,500,000 JD in Phase 1 construction costs, but requires the use of two materials in the new construction because the maximum size of PVC pipe is 30 cm. With ductile iron pipe there will be only one pipe material, but the project cost is higher. The decision on which pipe material to use will depend upon the relative importance of a lower project cost versus the use of two different pipe materials with attendant problems.

3.2.4.3 System Valves.

Basically, three types of valves will be required: shut-off valves, automatic air release valves, and pressure-reducing valves. Existing valves are gate valves for shut-off valves and automatic air release valves.

1. Shut-off Valves.

Reliability, experience of municipal employees, and maintenance characteristics recommend continued use of gate valves in the distribution system. Nonrising stem, double disc-type gate valves are assumed for this study. The valves will be installed, buried with a valve box provided for valve operation. Valves will be installed at locations allowing the isolation of individual lines in segments no longer than 300 m. Gate valves will meet AWWA C500-71.

2. Air Release Valves.

Automatic air release valves are to be installed at significant high points within the distribution system to release entrained or trapped air. These valves will be installed within a concrete box which has

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a manhole access to the ground. These valves will have an inlet size of 1/2-inch (1.3 cm) when installed on 10-cm through 30-cm diameter mains; larger mains will have a valve with a 1-inch (2.5 cm) inlet. Maximum operating pressure of the 1/2-inch (1.3 cm) valve will be 1,035 kPa, and 2,070 kPa for the 1-inch (2.5 cm) valve.

3. Pressure-Reducing Valves.

This type of valve will be required on mains connecting pressure zones. The pressure-reducing valve causes a loss in pressure head through the valve, and maintains a constant pressure on the downstream side of the valve. Each installation will consist of two valves, each of which will be capable of handling the design flow in the main. The valves will be installed in a concrete underground structure, which has a manhole opening to the ground. Pressure-reducing valves will conform to ASTM A694-74.

3.2.4.4 Service Connections.

Cost of the project will include provision of individual service connections whenever the main is installed in or along an existing road or street. When the main is in an open area, no service connections will be provided. Service connections are provided to given equal access to the main from each side of the street or road. When the main is in the street, the service connection will be extended to a curb on each side of the street. When the main is along the street, the service connection will be extended to a curb stop only on the far side of the street. Details of these two conditions are shown on Figure 3-1.

All new and existing service connections should be made with a curb stop located between the main and the meter. This will allow removal of the meter without dewatering the main. Where existing service connections do not meet this standard, curb stops should be added whenever possible.

3.2.4.5 Storate Requirements.

The purpose of storage is to provide water to meet peak demands and emergencies. It is assumed that the supply source can deliver water at a rate equal to the Irbid maximum day demand. Peak hour demand is estimated as 125 percent of the maximum day rate.

Storage of 20 percent of the maximum day demand is the standard allowance for meeting peak demands. It is assumed that for proper operation under emergency conditions, at least one day's storage is required. Most power outages, or other causes of interruption of supply, should be able to be repaired in one day's time. The Municipality should also be able to restrict consumption under emergency conditions, so that one day's storage would actually last longer, if necessary.

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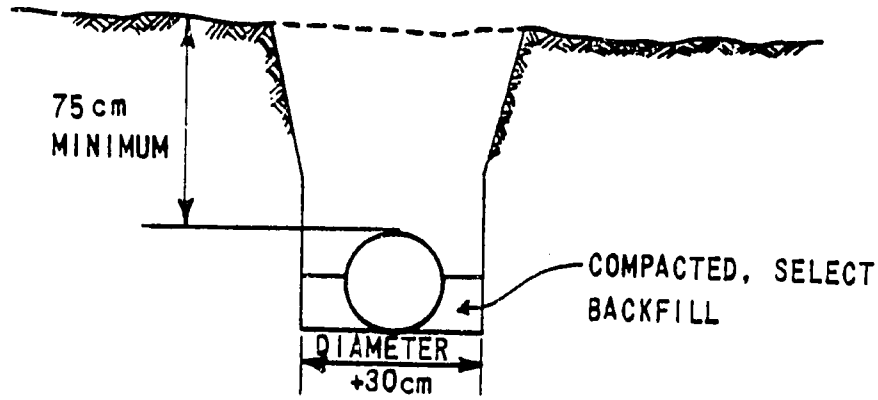
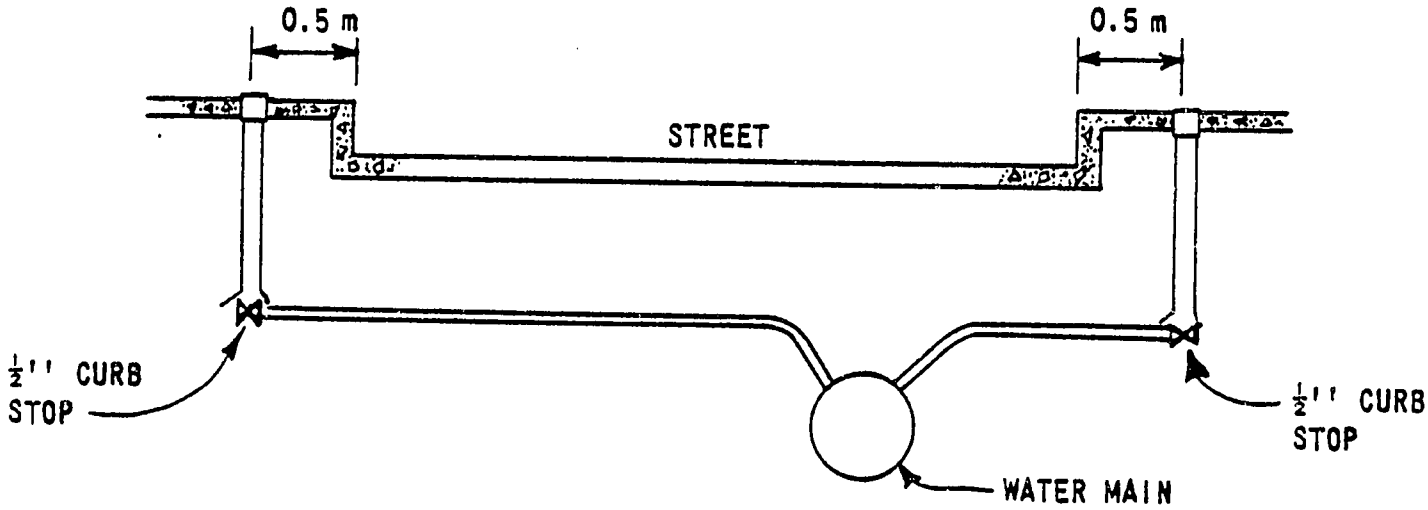
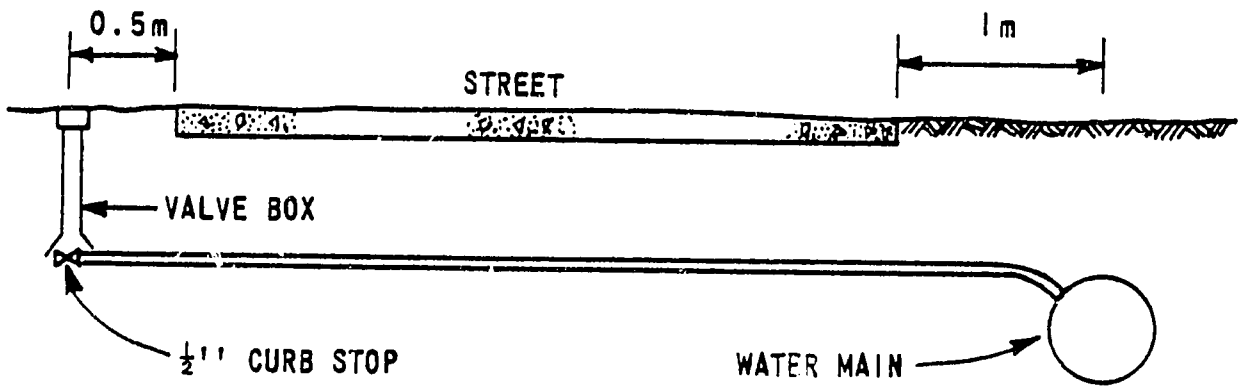


TYPICAL TRENCH DETAIL



SERVICE CONNECTIONS-MAIN IN STREET



SERVICE CONNECTIONS-MAIN BESIDE STREET

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co.Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 3- 1 DATE: SEPT. 1979 BY: CHECKED:

It is further assumed that these storage requirements will not be coincidental, and that the largest requirement will govern storage requirements.

3.2.4.6 System Reliability.

Internal system reliability will be accomplished by looping as much of the system as feasible. Deadend distribution mains will be avoided. To maintain reliability between pressure zones, several pressure-reducing stations will be placed connecting each zone.

Reliability of the supply source is not within the jurisdiction of this study.

3.3 SEWERAGE SYSTEM CRITERIA

The function of a sewerage system is to transport wastewater from the living and working environmental, and treat and dispose of it in the most hygienic and economical manner.

The City of Irbid is a rapidly growing urban community whose sewerage facilities have not grown at the same pace as the population, commerce, and industry. The geology of the area in and around the municipal limits of Irbid show a vast quantity of underlying limestone formations, both relatively hard and soft in nature, and mostly of factured structure. These materials occur as surface outcroppings, and as a subsurface material at varying depths from just below the surface to several meters below the surface.

This geology does not readily lend itself to a hygienic or economical disposal of the wastewater flows generated by a modern, urbanized population such as exists in Irbid. At the present time, the City of Irbid utilizes a system of cesspools, or collecting basins, and a limited number of septic systems. Tank pumper trucks remove liquid from systems that are unable to maintain adequate percolation into the ground. These types of facilities, coupled with a congested populace and rapid building program, contribute to a deteriorating public health environment. A properly engineered, constructed, and managed sewerage system will help to reverse this environmental deterioration and permit continued and expanded growth in the City of Irbid. These design criteria are based upon a combination of existing practices in Jordan, basic data established for this study, material developed during the study, and generally-accepted U.S. engineering practices.

These criteria were established specifically for the Irbid project area's proposed sewerage facilities, and they establish the values and parameters for sizing and selecting the sewerage system components.

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There are a number of terms which have special meanings in wastewater engineering and in this study. The following list defines some of the more important terms used in this study:

1. Interceptor -- A sewer that receives flow from a number of smaller trunk sewers, and transports it to the point of treatment.

2. Trunk sewer -- A sewer into which wastewater from two or more lateral sewers is discharged, and which subsequently discharges into an interceptor.

3. Lateral sewer -- A sewer into which wastewater from building sewers is discharged, and subsequently discharges into a trunk sewer.

4. Building sewer -- A sewer which is an extension of the building plumbing, and discharges into the public sewer (lateral sewer).

5. Common sewer -- A building sewer in which all owners of abutting properties have equal rights.

6. Bedding -- The earth or other materials on which a pipe or conduit is supported.

7. Infiltration -- The quantity of groundwater that leaks into a pipe through joints, porous walls, or breaks.

8. Crown -- The inside top of the arch in a sewer, covered channel, or conduit.

9. Invert -- The lowest portion of the internal cross-section of a sewer, covered channel, or conduit.

10. Manhole -- An opening in a sewer provided for the purpose of permitting a man to enter or leave the sewer.

11. Drop manhole -- A manhole installed in a sewer where the elevation of the incoming sewer considerably exceeds that of the outgoing sewer. A vertical waterway outside the manhole is provided to divert the wastewater from the upper to the lower level so that it does not fall freely into the manhole except at peak flow rates.

12. Slope -- The inclination of the invert of a conduit expressed as a decimal ratio of meters per meter of length.

3.3.1 Sewer Loading Criteria

3.3.1.1 Existing Flows and Disposal Methods.

The Municipality of Irbid has only a few sanitary sewers in operation. These are three short, separate lines with a total length of approximately 600 m. They all drain into a box culvert which is part of the existing storm sewer collection system, draining the central part of town.

Sanitary wastewater disposal presently is rudimentary. Each dwelling or building has a drain to an individual, or common cesspool (the latter being the case when more than one building is drained to one cesspool). At best, a cesspool can only provide a limited degree of wastewater treatment, and in some cases reduces wastewater volume by leaching through the cesspool walls and bottom, thus allowing polluted water to eventually seep downward to existing groundwater. The storage of this stagnating wastewater in the numerous locations throughout the urban community is a potential public health hazard.

If the leaching rate is low, and the cesspool fills up, the owner must call a public or private septage hauler to pump out the contents. The hauler then disposes of the tank contents at a dumping site on the Wadi el Hamam. Liquid septage presently flows into the wadi system causing potential public health hazards downstream.

The installation of a sanitary sewer collection system and a wastewater treatment plant would provide a great improvement in the public health of the residents of the Municipality of Irbid. The construction of these sanitary facilities will not only improve the present public health conditions, but will help to promote the steady growth of the Municipality.

3.3.1.2 Design Flows.

The design flow is an accumulation of several separate flow streams; domestic, commercial, institutional, and industrial flows with an allowance for infiltration/inflow plus a multiplying factor account for instantaneous flow variation. Domestic flows are the largest and most important flow stream for this project.

All interceptors and trunk sewers are sized for the projected tributary area saturation population sewage flows. The flow values and methods used to compute domestic, commercial, institutional, and industrial flows are discussed in the following paragraphs.

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1. Flow Variations.

Flow varies in accordance with individual consumer water use patterns. This variation is attenuated, to some extent, when the number of people contributing to the flow increases. That is, there is a greater variation between peak and average flows from smaller contributing populations. A sanitary sewer is designed to carry the peak flow without surcharging the system. This flow is determined by multiplying the average daily flow by an appropriate peaking factor. Various formulae have been developed to determine such factors. In the United States, estimates of this factor range from about 5.0 for a design population of one thousand to 1.5 to 2.0 for a design population of one million.

Inspection of the daily continuous flow records for the Amman, Ain Ghazal wastewater treatment plant, recorded between May 1978 and May 1979 indicates two points:

a. The dry weather average daily flows, which are primarily domestic wastewater flows, do not vary from one season to another, i.e., winter to summer. This observation is consistent with observations of domestic sewage flows (as opposed to potable water flows) for most communities in the United States.

b. The peaking factor or ratio between average daily flow and maximum hourly flow for dry days for the Ain Ghazal treatment plant was approximately 2.2 with a contributing population of approximately 150,000.

The water use characteristics and peaking factor observed at the Ain Ghazal treatment plant (not the water use rates) are in general agreement with similar characteristics and functions observed in the United States. Even though living patterns and water use rates are different in Jordan, this general agreement of wastewater peaking factor is not at all surprising since peaking factor is a ratio and is a function of population served rather than actual water consumption.

Many state regulatory agencies in the United States have set peaking factors of 4.0 for laterals and trunk lines, and 2.5 for interceptor sewers. Since there are no existing wastewater flows in Irbid to allow measurement of actual flows and peaking factors, we feel these values are reasonable and satisfactory for this project.

2. Water Consumed versus Sewage Flow.

Sewage consists primarily of used water, and the portion of water supplied that reaches the sewers must be estimated. Water used for watering lawns and gardens, washing cars, and flushing streets, etc., will not be discharged to the sewer. In Irbid, little water is presently used for lawn and garden irrigation. Individual car washing is not common since the water supply is limited.

It has been observed in Irbid that gray water (laundry and dishwashing wastewater) is dumped outside the home. This disposal method avoids overloading malfunctioning cesspools, reserving their capacity for sanitary flows. With the construction of a sewage collection system, this type of disposal will be reduced. All of this sewage flow is expected to enter the collection system.

We expect minimal water will still be used for nonessential needs, such as lawn sprinkling and car washing during the study period. We estimate that 80 to 85 percent of the water supplied to individual customers in Irbid will reach the sewers.

3. Infiltration/Inflow.

Wet weather infiltration and inflow contribute to the peak flow rates observed in sanitary sewers.

Infiltration is that portion of the rainfall which falls on the ground surface, percolates into the ground, and eventually finds its way into the sewers through leaking pipe joints and manhole walls. This flow contribution occurs usually some time after the rainfall has started, and continues for sometime after rainfall has ceased. Most infiltration occurs in the upper reaches of a sewer system; namely, the laterals and service connections, primarily because of the greater number of pipe joints, possibility of faulty materials, and chance of unsupervised construction methods during installation.

Inflow is that portion of the rainfall that drains overland and enters the sewer system through openings in manhole covers, cracks in manhole frames, and through seepage channels directly into broken pipe, pipe joints, and manhole openings. This type of flow occurs during a rainfall that is heavy enough to cause overland flow, and ceases when overland flow has stopped.

Many previous studies have shown a wide variation in values of infiltration and inflow factors applied to sewer design loadings. These variations result from the wide differences in geographic locations and rainfall patterns, surface conditions, construction methods and materials, and subsurface geology of areas studied. Larger values generally apply to older sewer systems, higher rainfall areas, and areas of highly permeable soils.

The conclusions drawn from previous studies are presented in graphic form in "Wastewater Engineering: Collection, Treatment and Disposal," Metcalf and Eddy, Inc., Figure 2-8, p. 43, 1972. These curves indicate for new sewers, a rate of infiltration (for design purposes) that varies from 9 cu m/hectare/day for areas less than 40 hectares, to 3.6 cu m/hectare/day for areas larger than 1,000 hectares.

We have evaluated data on the recorded sewage flow into the Amman wastewater treatment plant during the calendar year May 1978 through May 1979. During this period, increased flows were recorded during the rainy season between October 1978 and March 1979. The rainfall records maintained by the Natural Resources Authority for the Amman area were compared with the sewage flows. The total length of sewers in Amman, tributary to the wastewater treatment plant as of January 1979, was approximately 56 km. Sewer sizes range from 200-mm to 1,200-mm diameter. The plant flow records indicate an average increase of daily flow of 1,800 to 1,825 cu m/day during the winter months of 1978-1979. These flow rates indicate high infiltration and inflow rates are occurring in the Amman system. This indicates that during the rainy season in a semiarid climate with groundwater levels generally far below the sewer inverts, infiltration and inflow rates must be considered a major contribution to sewage flow. For this study, we have used the infiltration curve for new sewers referred to previously, and reproduced in Figure 3-2.

4. Industrial/Commercial/Institutional Flow.

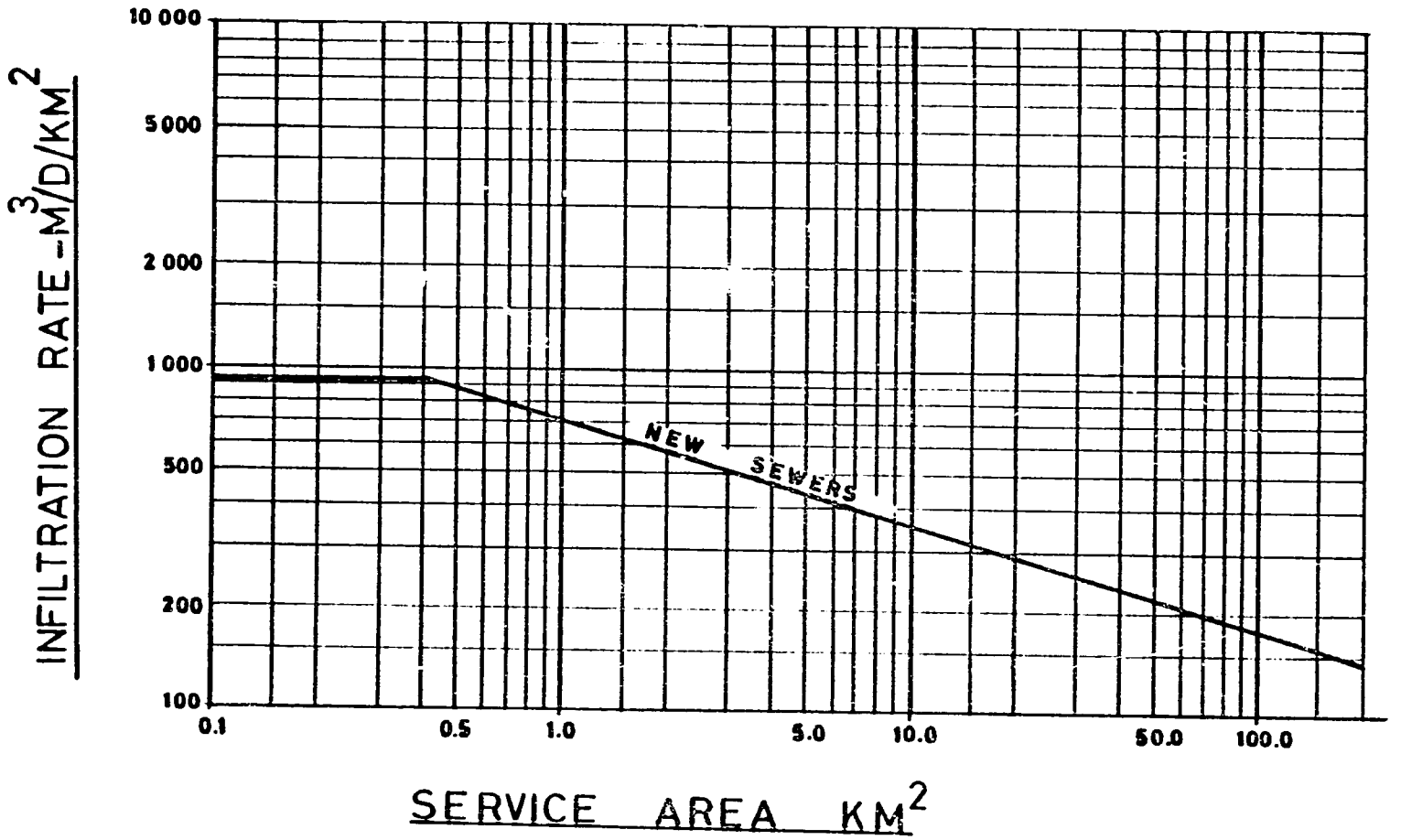
Industrial, commercial, and institutional wastewater flow rates are developed in subsection 3.3.3. Existing as well as potential large water users are identified in subsection 3.3.3.3. These water users, including the slaughterhouse, dairy products company, bottling plant, and industrial park have been located and their wastewater contribution is considered a point contribution into the sewer system.

An allowance has been made to account for dispersed industrial, commercial, and institutional wastewater flows. By the year 2000, the wastewater flows from these dispersed sources is expected to be approximately 6,075 cu m/day. For sewer design purposes, we have assumed this dispersed wastewater flow will develop in proportion to population. Consequently, our sewer design for Irbid includes an allowance of 17.2 liters/capita/day for dispersed industrial, commercial, and institutional wastewater flows. The per capita quantity of 17.2 liters/capita/day is a mathematically-derived value. This value was derived by assuming a reasonable total industrial, commercial, and institutional wastewater flow for the City of Irbid, subtracting values for known existing industrial and other point wasteloads and estimated values for the proposed industrial park, and dividing the remainder by the design population (i.e., 6,075 cu m/day ÷ 353,400 capita).

5. Total Flows.

The design flows used to size interceptors and trunk sewers are the accumulation of several factors.

Areas tributary to interceptor and trunk sewers are determined from the topographic maps.



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ADAPTED FROM : "WASTEWATER ENGINEERING", METCALF & EDDY, 1972, FIG. 2.8 PAGE 43

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE	INFILTRATION CHART	FIGURE 3-2 DATE: BY: A. TAYEH

The projected population in each area is determined from data developed from the population disaggregation portion of the socioeconomic studies described in Chapter 2.

The domestic wastewater flow (DF) is determined for each socioeconomic subarea tributary to the interceptors and trunk sewers based on the population projections and water consumption rates for the subareas.

The industrial, commercial, and institutional (ICI) wastewater flows tributary to each interceptor and trunk sewer have been determined. Infiltration/inflow flow rates are determined for each tributary area.

The total design flow (TDF) used to size each section of interceptor and trunk sewer is then determined by multiplying the domestic and industrial, commercial and institutional flows by a peaking factor (PF) and adding the infiltration/inflow. The equation for this computation is as follows:

$$(DF + ICI) \times PF + I/I = TDF$$

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3.3.2 Sewage Collection System Criteria

3.3.2.1 House Connections and Public Facilities.

The numerous house and building connections required for a sewer system must be affordable, and they must be installed in a manner that insures proper operation of the system.

The recommended minimum size for house or building connections is 150-mm inside diameter. Where existing building congestion or arrangement precludes separate connections, a common building sewer with two or more buildings connected to it may be constructed to the street lateral. This common sewer should not be less than 200-mm inside diameter. The individual house or building sewers entering a common building sewer may be 150-mm inside diameter.

Minimum slopes for house connections and common sewers shall be as follows:

- 150-mm inside diameter - 0.02 m/m
- 200-mm inside diameter - 0.01 m/m

The minimum sizes and slopes for building and common sewers are determined empirically based upon the minimum requirements necessary to avoid stoppages and permit easy maintenance.

Typical details for house or building connections are shown on Figure 3-3.

Public facilities are a system of convenience stations, usually located in areas of dense public activity such as the downtown business and marketing areas, for the use of shoppers, tourists, and travelers. They are installed and maintained by the governing municipality.

These facilities usually consist of multiple toilets and washbasins in an enclosure readily accessible to the public, yet unobtrusively located.

At present, the Municipality of Irbid has one convenience station. Maintenance of this facility is poor partly because the present system of cesspool sewage is not amenable to operation of public sanitary facilities.

Available data and experience in other towns nearby, namely Amman, that do have public sanitary facilities, indicate such facilities are not in the best interest of the community because:

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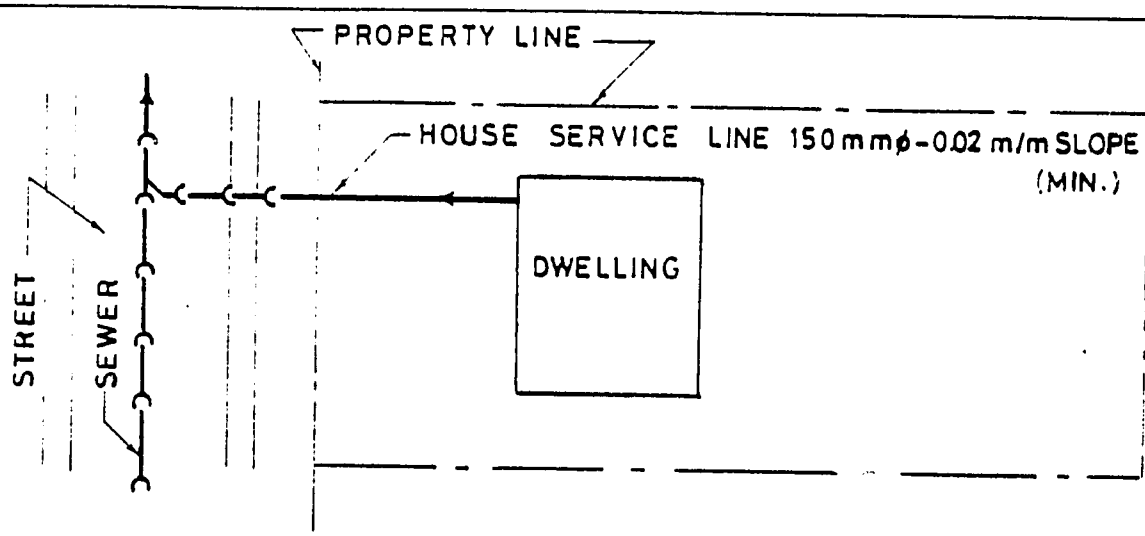
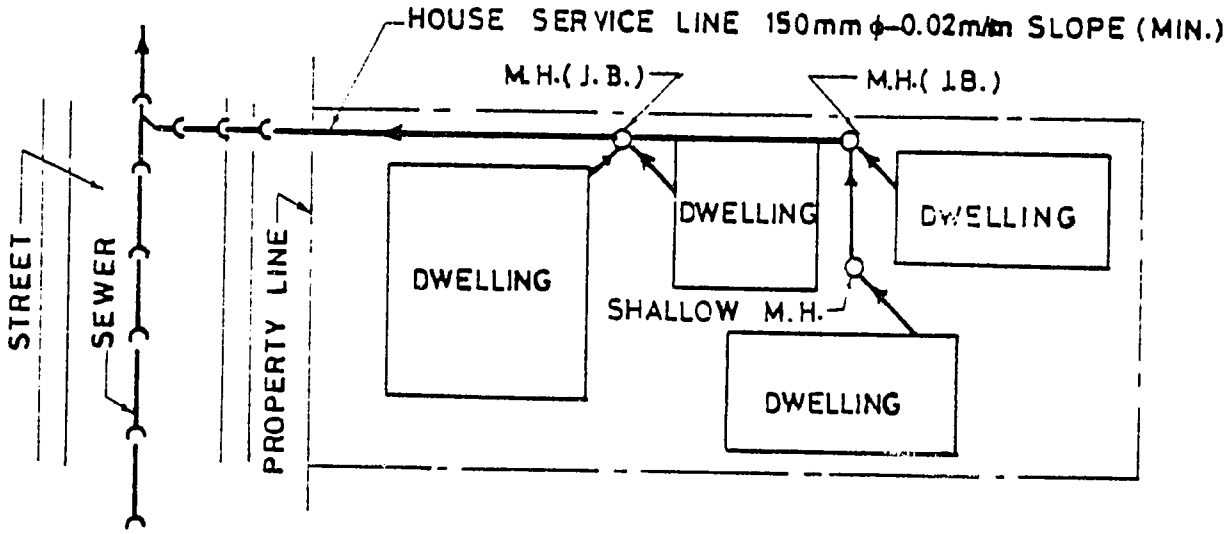
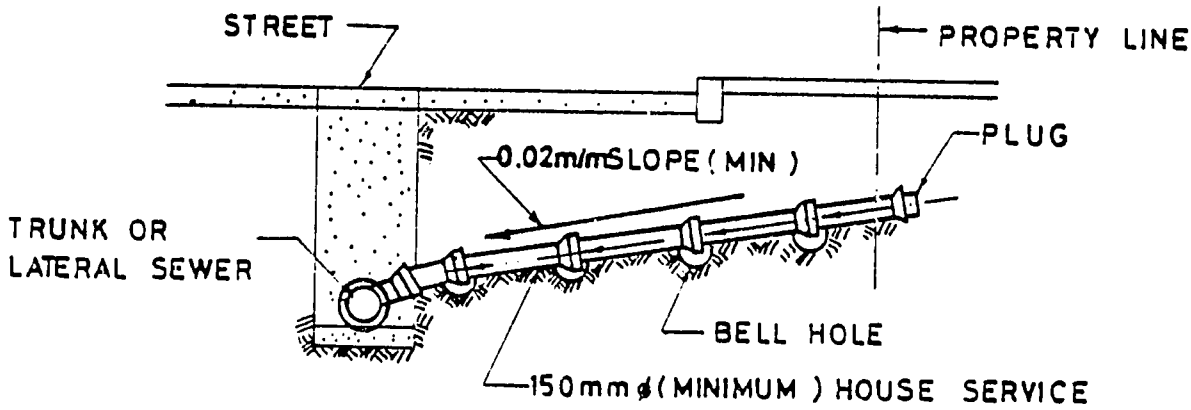


FOR SINGLE DWELLING LOT



FOR MULTI DWELLING LOT



PROFILE

TYPICAL HOUSE SERVICE CONNECTION DETAILS

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 3-3 DATE: SEPT. 1979 BY: F. R. A. TAYEH CHECKED:

1. The facilities are often vandalized, rendering them inoperable much of the time.

2. They are poorly maintained and serviced.

3. Lack of maintenance and vandalizm cause them to become a nuisance rather than the convenience for which they were installed.

For these reasons it is not planned to install any public sanitary facilities in the Municipality of Irbid under this project.

3.3.2.2 Collection System Design Criteria.

These criteria are intended for use as a guide in the preparation of the master plan, as well as for developing design and specifications for the final collection system.

1. Sizing and Slope.

Interceptors, trunk sewers and lateral lines will be designed for the design flow at the projected saturated population of the tributary area.

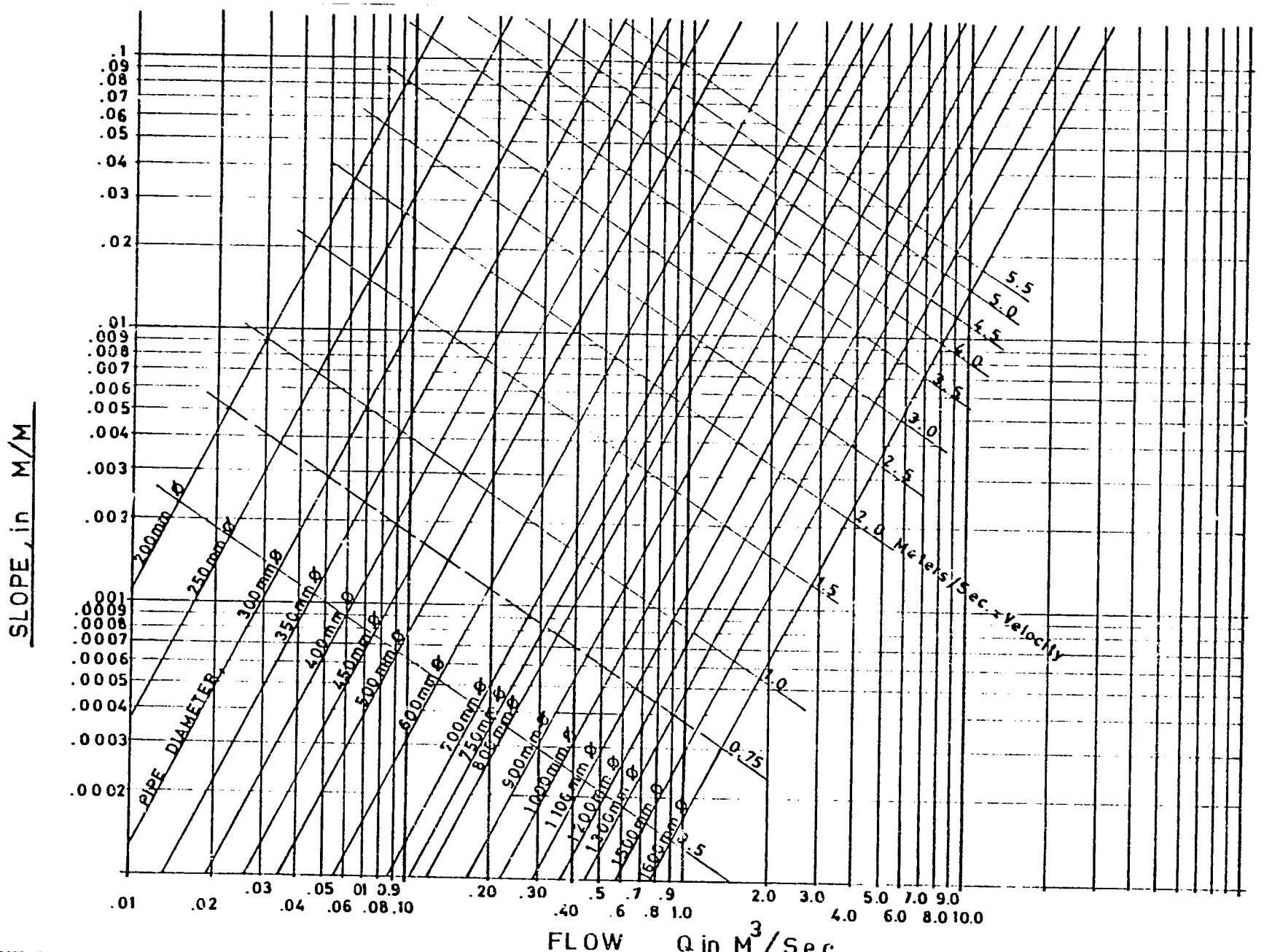
All sewers will be designed and constructed to have mean velocities, when flowing full, of not less than 0.60 m/sec based on an "n" value in Manning's formula of 0.013 (see Figure 3-4). Although 0.60 m/sec is a recommended minimum velocity, serious consideration will be given to maintaining flow velocities in all pipe sizes sufficient to minimize hydrogen sulfide generation. Hydrogen sulfide is an odoriferous noxious gas which creates an oxygen demand in wastewater treatment processes, and promotes corrosion of various sewer construction materials. Minimum pipe slopes are listed in Table 3-1; however, slopes greater than these are preferred.

Sewers on 0.20-m/m slopes or greater will be anchored securely with concrete anchors.

Downstream pipe sizes will never be smaller than upstream pipe sizes.

2. Pipe Materials and Joints.

Gravity sewers will be circular reinforced concrete pipe. The pipe will be bell and spigot push-on type with compression rubber gasket joints. This type of joint minimizes infiltration and is flexible and root-resistant. All gravity sewers will be air tested for leakage; permissible leakage rates will be included in the design specification. The minimum size lateral sewer pipe to be installed in public streets or rights-of-way shall be 200-mm inside diameter.



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co.,Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	PIPE FLOW CHART MANNING'S n=013	FIGURE 3-4 DATE SEPT.1979 BY A.TAYEH CHECKED P.I.H.

Table 3-1

Minimum Slopes of Sewers

Sewer Diameter (mm)	Minimum Slope
200	0.0043
250	0.0032
300	0.0025
350	0.0021
400	0.0017
450	0.0015
500	0.0013
600	0.0010

Force mains will be ductile iron, cement-lined, mechanical joint pipe, with a pressure rating of two to three times that of the shut-off head of the pump. A minimum velocity of 0.60 m/sec at the design flow will be maintained to prevent solids deposition. Force mains will be equipped with air release valves at the high points, and concrete thrust blocks at all changes in direction. The minimum pipe size used in force mains will be 100 mm.

All sewer and force mains shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the pipe shall be made as they relate to the width and depth of trench. When standard strength pipe is not sufficient, the additional strength may be obtained by using extra strength pipe, special construction, or special pipe bedding.

3. Manholes.

Manholes shall be installed at all changes in grade, direction, size at all intersections, and at the end of each line. The maximum spacing of manholes shall be 125 m for sewers 400 mm in diameter and smaller, and 150 m for sewers 450 mm to 800 mm in diameter. Flow channels through manholes shall conform in shape and slope to the sewer pipe invert. Manhole covers will be the nonvented type except to terminal manholes which will have vented covers. Watertight covers will be used wherever the manhole tops may be subjected to flooding from street runoff, especially where streets are expected to carry overland flow to the storm drainage system. Manholes will be precast concrete with cast in-place bases. Manhole diameter is a function of the size of the sewer pipes entering and leaving the manhole. The following criteria are used:

Sewer Size	Manhole Inside Diameter
200 mm through 500 mm	1,200 mm
600 mm through 800 mm	1,500 mm
900 mm and above	Special construction

Typical manhole details are shown on Figure 3-5.

4. Trench Criteria.

Trenches for the sewer construction will be excavated in three general soil classifications:

a. Clayey soils.
b. Clayey soils with rock and rock fragments.
c. Rock.

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The trenches will generally be excavated to a depth that will provide a minimum cover over the installed pipe of not less than 1.0 m. The trenches will be excavated in such a manner that the pipe installation can be accomplished in a safe, workmanlike manner.

Trenches will be excavated as shown on Figure 3-6. For the various soil conditions, the trench widths will be as shown on Table 3-2 for the various size lateral sewers.

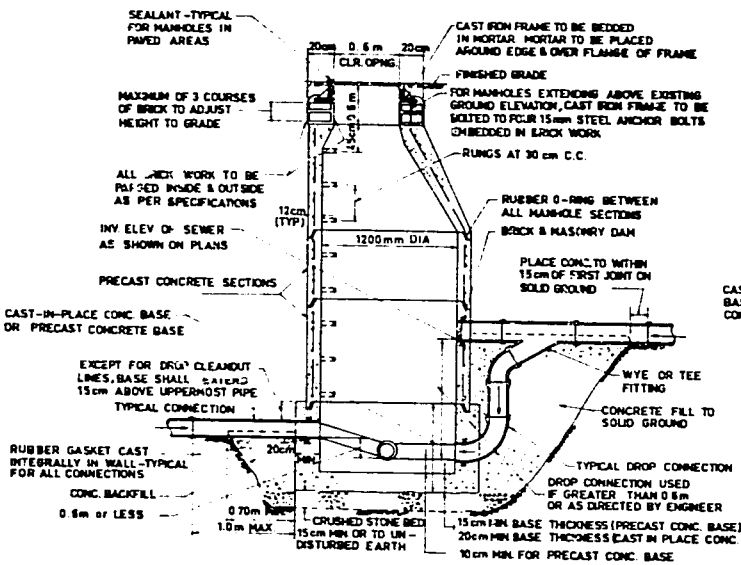
3.3.2.3 Pumping and Life Stations.

Pumping stations shall be buried and consist of a separate wet well and dry well; all pump stations will be designed for the maximum capacity of the sewer feeding the wet well. The wet well will provide storage capacity for pump operation, and will be constructed of precast concrete sections, provided with a manually-cleaned bar rack and an access platform. The bar rack will be placed at a 45-degree angle to the influent pipe entrance, and have a maximum bar spacing of 5 cm. The effective capacity of the wet well will provide a holding period not to exceed 10 minutes at average flow. The wet well floor will have a minimum slope of 1 to 1 to a hopper bottom. The suction pipes connecting the wet well and dry well will be at least 100 mm in diameter. The dry well will have at least two centrifugal pumps each sized to handle the maximum flow, one being a complete spare. The pumps will be capable of passing at least 7.5-cm diameter solids. The dry well construction will be circular precast concrete sections. Both the wet well and dry well will be mechanically ventilated.

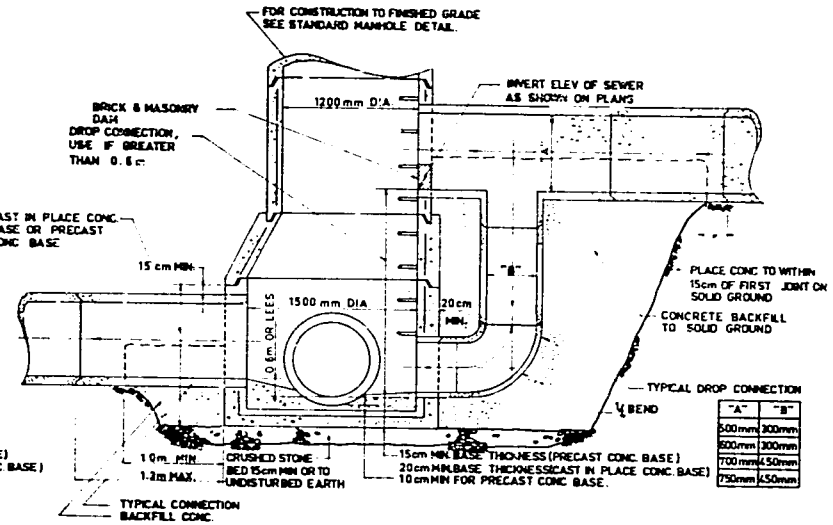
The pumps will operate intermittently and will be controlled automatically from the level in the wet well. An alarm system will be provided for each pump station which will transmit a signal to the wastewater treatment plant if a malfunction occurs.

Since a dependable electrical power supply is mandatory for the proper operation of a pump station, an auxiliary generator will be provided at each pump station. The pumping system and discharge force main will be sized to provide a cleaning velocity of 0.60 m/sec at design average flow. The minimum force main size will be 100 mm inside diameter.

Figures 3-7 and 3-8 illustrate typical pumping station designs anticipated to be utilized in the City of Irbid sewage collection system.

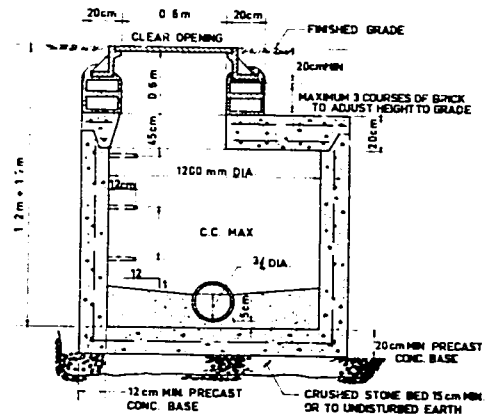


STANDARD MANHOLE DETAIL
(TYPICAL FOR ALL MANHOLES UNLESS NOTED ON PLANS)
NO SCALE

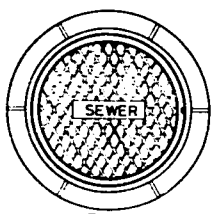


"A"	"B"
500mm	300mm
600mm	300mm
700mm	450mm
750mm	450mm

1500 mm DIA. MANHOLE DETAIL
NO SCALE



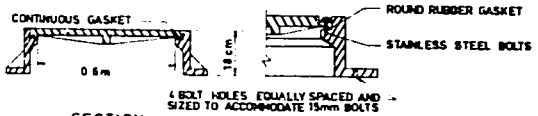
SHALLOW MANHOLE
FOR M.H. 1.2m TO 1.7m DEPTH
NO SCALE



PLAN

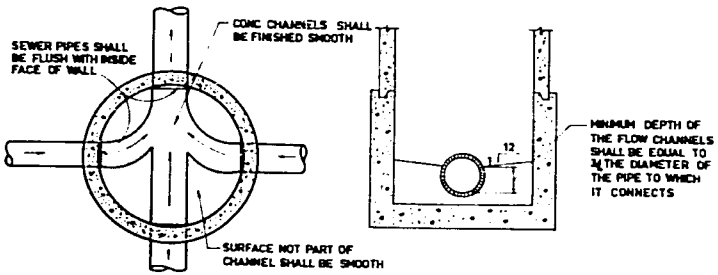
NOTES:

1. STANDARD MANHOLE AND FRAME SHALL BE SELF-SEALING TYPE.
2. ALL COVERS SHALL HAVE CONCEALED PICK HOLES.
3. PLAN IS THE SAME FOR ALL COVERS EXCEPT FOR VENT AND BOLT HOLES. ALL COVERS TO BE SOLID EXCEPT AS NOTED ON PLAN. VENTED COVERS TO HAVE A MINIMUM OF FOUR - 22 mm DIAMETER HOLES



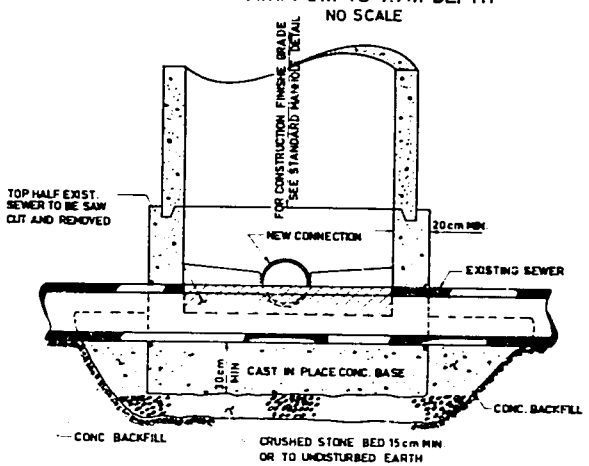
SECTION

STANDARD WATERTIGHT
CAST IRON MANHOLE FRAMES & COVERS
NO SCALE



PLAN TYPICAL SECTION

TYPICAL MANHOLE CHANNELS
NO SCALE



MANHOLE OVER EXISTING SEWER
NO SCALE

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MRM CONSULTING ENGINEERS CO., LTD

IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

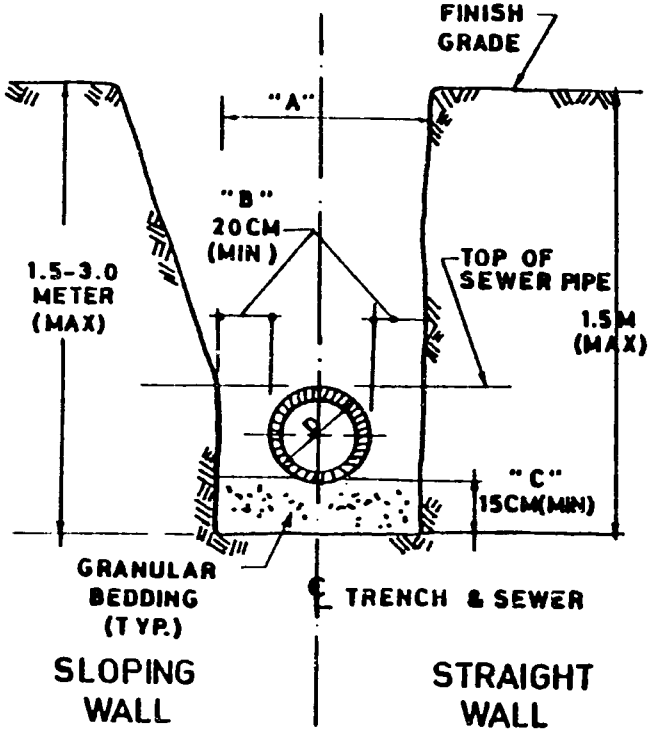
TYPICAL MANHOLE DETAILS

FIGURE 3-5

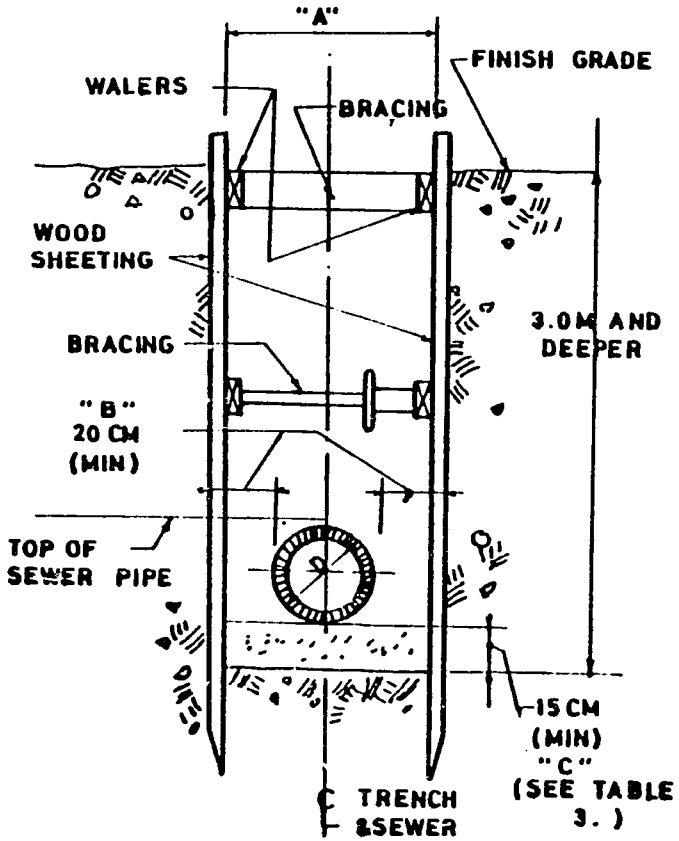
DATE: SEPT. 1970

BY: A. TAYEH

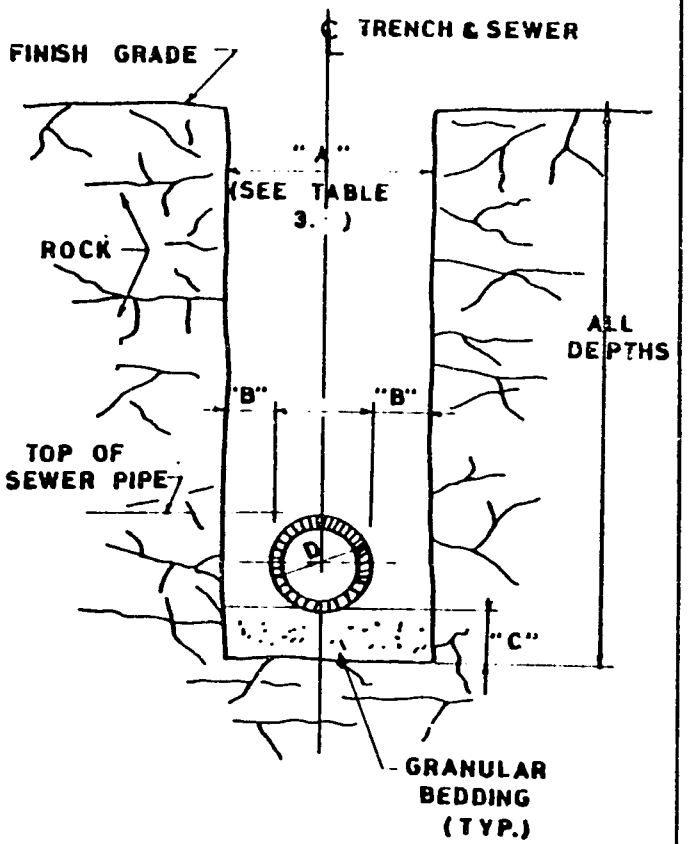
CHKD: HALVERSLEBEN



IN TOP SOIL



WITH SHEETING & SHORING



IN ROCK

IN CLAYEY SOILS and CLAYEY SOILS WITH STONES

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	TYPICAL TRENCH DETAILS	FIGURE 3 - 6 DATE: SEPT. 1979 BY: A. TAYEH CHECKED: D. I. M.

Table 3-2

Table of Trench Dimensions[1]

Pipe Dia. (mm)	Pipe Outside Dia. (mm)	B Dim. (mm)	C Dim. (mm)	A Width (mm)
(mm)	(mm)	(cm)	(cm)	(m)
200	270	20	15	0.67
250	330	20	15	0.73
300	390	20	15	0.79
350	450	25	15	0.95
400	520	25	15	1.02
450	585	30	15	1.185
500	640	30	15	1.240
600	750	30	15	1.350
750	910	30	15	1.510
800	980	30	15	1.580

[1] See Figure 3-6.

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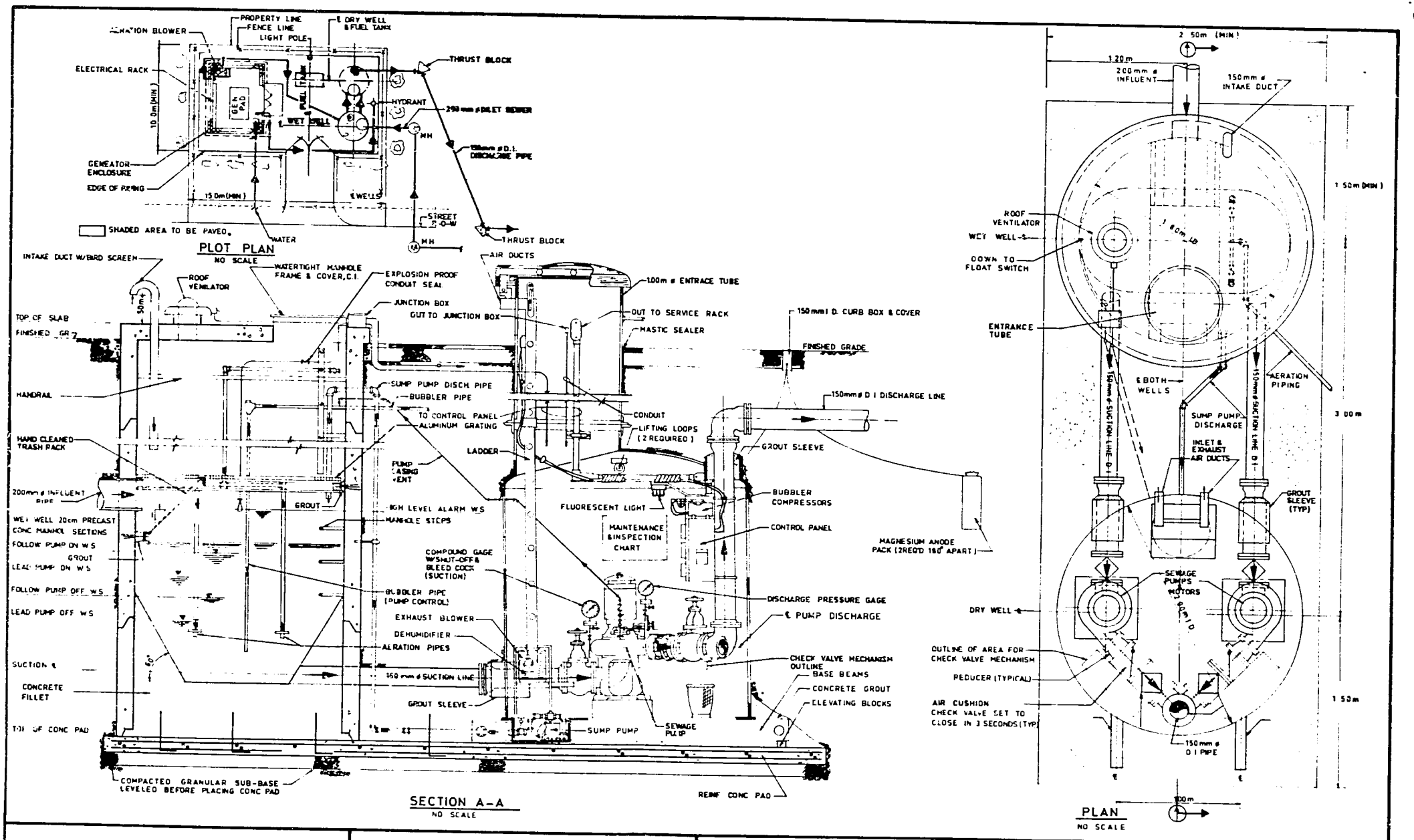

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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

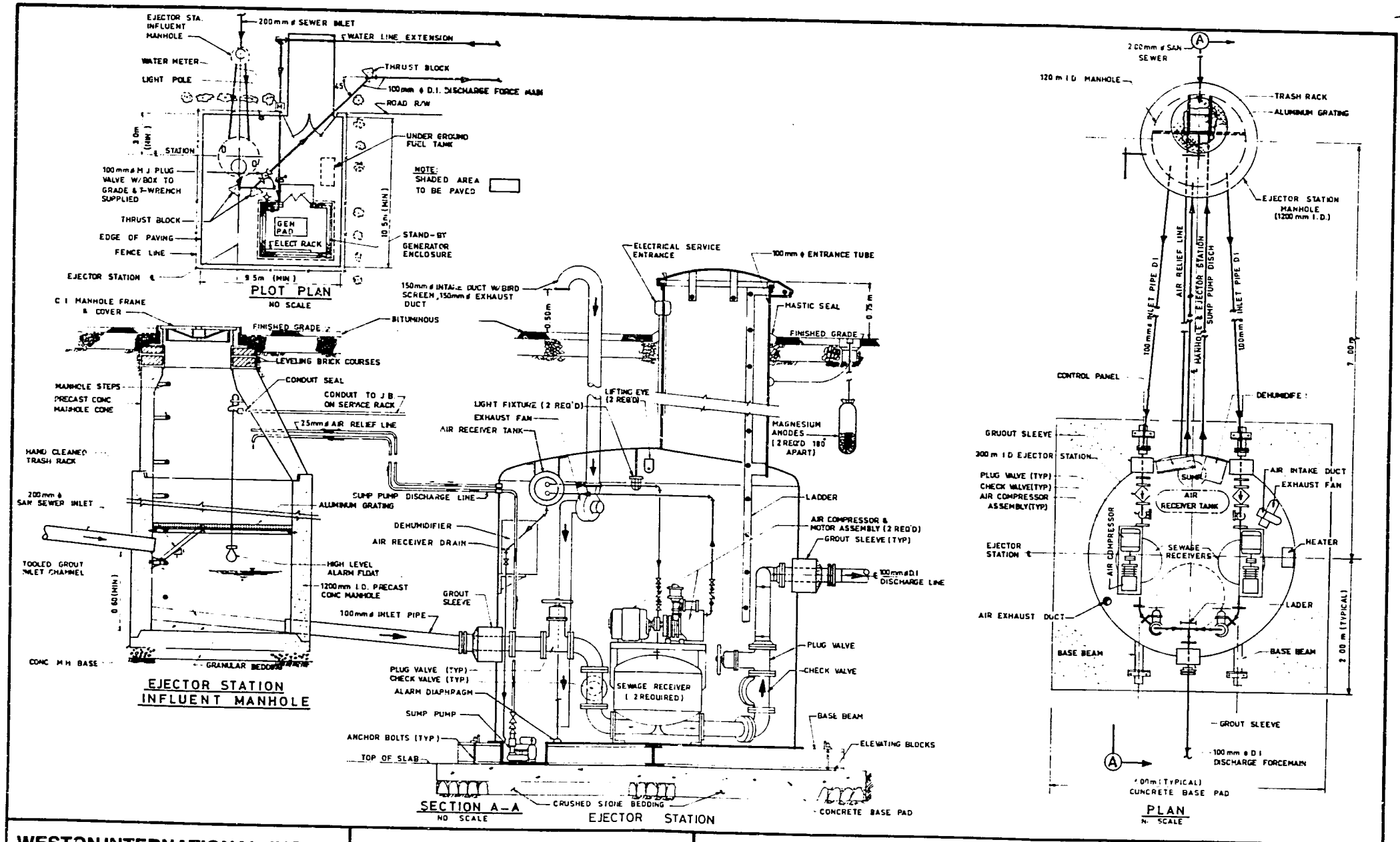
TYPICAL SEWAGE PUMPING STATION

FIGURE 3 – 7

DATE: SEPT., 1979

BY: F. RAHHAL

CHKD: HALVERSLEBEN



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

TYPICAL SEWAGE EJECTOR STATION

FIGURE 3 – 8

DATE: SEPT., 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

3.3.2.4 Operation and Maintenance.

The preceding criteria define the requirements for design and construction of the sewage collection system. After these phases of the project are completed, standards for operation and maintenance of the sewer system must be developed. The following paragraphs describe some of the most important standards and criteria.

1. Cleaning and Flushing.

Before the sanitary sewer collection system is allowed to receive and carry the sanitary wastewater through the network to the wastewater treatment plant, the entire network of pipes, manholes and other appurtenances should be thoroughly cleaned of all construction debris and any other foreign material that may have accumulated in the system.

The major portion of this clean-up procedure can be carried out during the actual construction phase of the sewer system. This should then be followed by a flushing operation to remove loose debris and material not removed or not accessible by hand or mechanical cleaning. This cleaning and flushing operation permits the collection system to operate with a minimum of defects or stoppages during the early part of its useful life.

After the sewer has been in operation for some months, especially during the rainless periods of the year, there will be occasions where stoppages will occur in various parts of the system. A program of periodic cleaning and flushing will minimize these stoppages. The entire system should be cleaned and flushed at least once every two years. Disinfected wastewater treatment plant effluent can be used for sewer flushing.

2. Inspection.

The sanitary sewer collection system can be efficiently and economically operated and maintained when an organized program of regular inspection is instituted and conducted consistently and diligently.

The inspection program should include all lateral, trunk and interceptor sewers, manholes, and pumping stations. Regular inspections should look for any and all symptoms and indications that a stoppage or flow restriction has occurred, or that a flow condition exists that could or has damaged a portion of the collection system.

The inspection should identify prohibited or harmful discharges and conditions such as the following:

a. Acid or alkaline wastes.
b. Hydrogen sulfide gas formations.
c. Silt or debris in manholes and pipes.
d. Broken or damaged structures.
e. Flammable waste discharges.

3. Safety.

The observance of several safety precautions is necessary to prevent accidents and injury to personnel carrying out the inspections and/or maintenance of the sewer system. These precautions are as follows:

a. There should be no smoking by workmen whenever they are in the vicinity of an open sanitary sewer manhole. The hazardous gases generated by confined sewage in the system can pocket in the system, and can be dangerously explosive.

b. No manhole should be entered for maintenance or inspection until that manhole and the manholes immediately upstream and downstream have been opened to the atmosphere for at least 60 seconds. This will allow the manhole and connecting sewers to ventilate and carry off toxic or hazardous gases. This is a safe procedure for manholes less than 1.5- to 2.0-m deep. Manholes deeper than 2.0 m should be ventilated by forced draft from a portable air blower injecting outside air into the manhole at a rate of not less than 3.0 cu m/min (50 liters/sec).

c. When any structure or manhole that is a part of the sanitary sewer collection system must be entered for maintenance, repair, or inspection, there should always be no less than two persons present. This is especially true where manholes or other below-grade structures are entered.

   Usually only one person wearing a safety harness with a safety line attached enters the structure or manhole while the second person watches for external or internal hazards, and is in a position to assist the other in the event of injury, accident, or other unforeseen condition.

d. Protective or cautionary appurtenances (barricades and warning signs) should be used in the work vicinity as a safety measure when inspecting or performing maintenance or repair on portions of the sewer system, particularly where manholes are in streets and pedestrian traffic ways.

3.3.3 Sewage Treatment System Criteria

3.3.3.1 Effluent Discharge Criteria.

The treated effluent from the Irbid wastewater treatment plant will be discharged to the riverine system of the Wadi el Arab. The treated effluent will constitute a significant portion of the total flow to the Wadi Arab reservoir. The reservoir will be used primarily for irrigation purposes, but may also be made available for livestock watering and future industrial supply. There are no present intentions to use the reservoir for public water supplies, water contact sports, or other recreational purposes.

At the present time, there are no water quality standards promulgated, or otherwise documented by the pertinent ministries within the Kingdom. The national water meter plan (NWMP) contained proposed standards for effluent discharges to watercourses (these are listed in Table 3-3).

Additionally, the water master plan proposed that the effluent be free of petroleum-type materials, animal or vegetable based-oil and greases, toxic materials, and significant amounts of pathogens.

The proposed water master plan standards were considered with regard to the intended use of the treatment plant effluent, and with regard to the technical and economic resources required to achieve the standards. With the exception of the free ammonia and suspended solids standards, the proposed standards can be achieved via standard activated sludge treatment technology, provided the standards are based on monthly average data, and there is no significant concentration of metals in the influent wastewater. It would be necessary to employ ancillary treatment processes and/or advanced treatment technologies to achieve the proposed free ammonia and suspended solids standards.

The proposed water master plan limits on the various heavy metals also received added scrutiny with regard to intended downstream irrigation uses. The dry weather flow at the Wadi Arab flow measuring station AE-1 is estimated to be approximate 22.6 million cu m/year. Although there are no data (with the exception of sediment quantities) available on the water quality in Wadi Arab, it is reasonable to expect some dilution of heavy metals and other trace elements in the wastewater treatment plant effluent. The concentration of heavy metals or trace elements in the treatment plant effluent is an important consideration because they may be potentially hazardous for irrigation and watering livestock. It is difficult to establish actual tolerance limits to trace elements. With regard to irrigation needs, many factors affect a plant's uptake of and its tolerance to trace elements. The most important factors are genetic variability of plants, nutrient and trace elements reactions, and interreactions within the soil and within the plant. Restrictions on potential hazardous trace elements, however,

Table 3-3

Effluent Water Quality Data

Parameters	Water Master Plan Proposed Limits	USEPA Proposed Limits		Proposed Irbid Wastewater Treatment Plant Effluent Standards	
		Irrigation	Livestock	7-Day Average	30-Day Average
pH	6.5 to 9.0	6.0 to 8.5	6.8 to 8.5	6.0 to 9.0	6.0 to 9.0
Temperature, °C	30	13 to 30	--	--	--
BOD, 5 day, 20°C, mg/L	30	--	--	30	45
Suspended solids, mg/L	≤ 5	--	--	20	30
Ammonia - N, mg/L	--	--	--	1.0	2.0
Free NH_3, mg/L	0.1	--	--	--	--
Dissolved oxygen, mg/L	--	--	--	3.0	3.0
Chlorine residual, mg/L	0.5	--	--	1.0	0.5
Aluminum (Al), mg/L	--	1.0	--	--	1.0
Arsenic (As), mg/L	--	1.0	0.05	--	0.5
Beryllium (Be), mg/L	--	0.5	--	--	0.5
Boron (B), mg/L	--	0.75	--	--	0.75
Cadmium (Cd), mg/L	1.0	0.005	0.01	--	0.005
Chromium (Cr), mg/L	--	5.0	0.5 (as + 6)	--	5.0 (0.5 as + 6)
Cobalt (Co), mg/L	--	0.2	--	--	0.2
Copper (Cu), mg/L	1.0	0.2	--	--	0.2
Iron (Fe), mg/L	1.0	0.3	--	--	0.3
Lead (Pb), mg/L	1.0	5.0	0.05	--	0.05
Lithium (Li), mg/L	--	5.0	--	--	5.0
Manganese (Mn), mg/L	--	2.0	--	--	2.0
Molybdenum (Mo), mg/L	--	0.005	--	--	0.005
Nickel (Ni), mg/L	1.0	0.5	--	--	0.5
Selenium (Se), mg/L	--	0.05	0.01	--	0.01
Vanadium (V), mg/L	--	10.0	--	--	10.0
Zinc (Zn), mg/L	1.0	5.0	--	--	5.0

must be reasonably defined on the basis of available information. Information provided in the "Report of the Committee on Water Quality Criteria" for the U.S. Department of the Interior provides limits for trace elements for irrigation waters and livestock water supply.

Although these standards are more restrictive in some cases than those proposed in the national water master plan, there is no anticipated problem in meeting the standards if the water supply does not contain significant concentrations of trace elements, and if there are no major industrial contributions. It is not intended to infer that adoption of these standards will prevent all future problems with regard to intended downstream uses. Other parameters, such as salinity and phototoxicity, are concerns which cannot be addressed here but which may develop in the future. In such cases, these problems should be addressed separately.

The proposed effluent standards for the Irbid wastewater treatment plant (refer to Table 3-3) reflect the needs of intended downstream users, preservation of the environment, and the maintenance of public health and well-being. It is anticipated that the effluent from the proposed wastewater treatment plant will discharge to a wadi-drainage system where there will be no benefit of dilution during most of the year. The steep hydraulic gradient of the wadi system will provide sufficient energy to maintain dissolved oxygen in the stream.

As the wastewater treatment plant effluent travels downstream, the decomposition of remaining organic matter will be continued by aerobic organisms which are contained in the effluent as well as indigenous in the stream bed. During moderate stream temperatures, the residual oxygen-demanding materials will be diminished by 40 to 50 percent before the stream flow joins with the waters of the Wadi Arab reservoir (refer to Figure 3-9). Preliminary design information provided by the Jordan Valley Authority for the Wadi Arab reservoir is as follows:

1. Effective storage capacity -- 6.05 million cu m.
2. Storage capacity range -- 3.05 to 9.10 million cu m.
3. Water surface elevation at minus 136.5 m to minus 122.0 m.

The proposed standards may be subject to change as additional field data on actual water quality become available in the future. At that time, the operation of the proposed wastewater treatment plant may be altered accordingly, within the flexibility limits of the adopted design.

3.3.3.2 Influent Characteristics -- Domestic Sources.

During the course of the preliminary study, several visits were made to existing wastewater treatment plants in Jordan including the following:

1. Salt.
2. Jordan Royal Medical City.
3. Aqaba.
4. Amman -- Ain Ghazal Wastewater Treatment Plant.

The Salt treatment plant was near completion at the time of the visit on 26 June 1979 (it required only electrical power on-site to begin treatment of wastewater). The wastewater was by-passing the treatment plant at this time, and there was no available data on the wastewater flow or its loading characteristics.

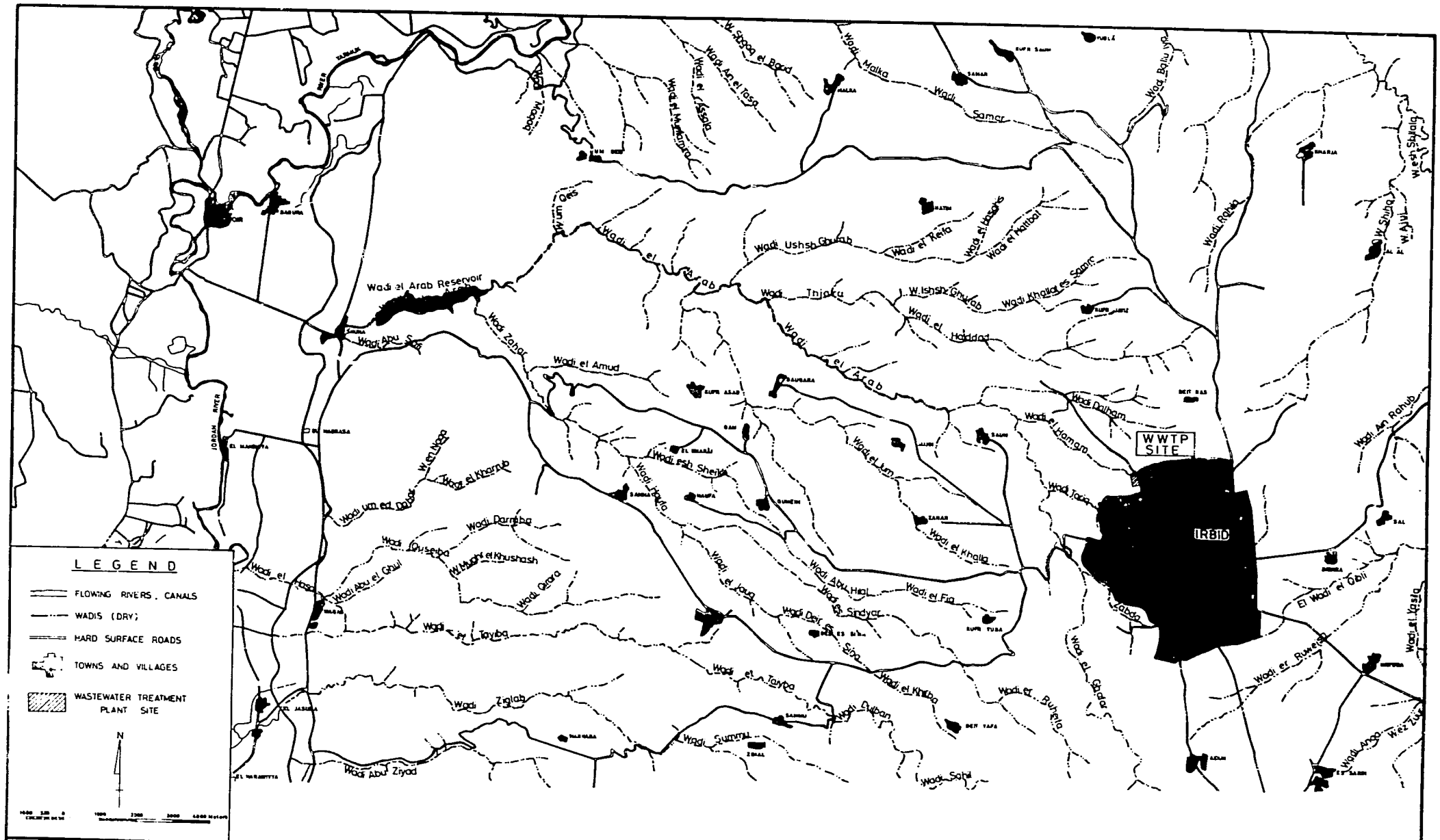
The Jordan Royal Medical City operates an extended aeration activated sludge wastewater treatment plant. At the time of our visit (16 July 1979) the plant was experiencing difficulties due to a heavy spill of crank case oil into the system. Despite the shock loading, the plant appeared to be sustaining operation. Operation of this facility was reported as steadily improving, but reporting of operational and performance data was not expected of or performed by the plant operator.

The existing treatment plant at Aqaba consists of preliminary/primary treatment and disinfection. The primary sludge is anaerobically digested in a two-stage digester. The plant was essentially nonoperative during our visit.

The Medical Center and the Aqaba treatment plants offered no information relative to sewage flow and strength, or plant operations and performance. Records are nonexistent, nor is there analytical capability at either plant site. The plant inspections revealed an insight into the probable fate of any wastewater treatment plant if the staff is not properly trained and motivated, and not provided with necessary institutional support to accomplish their mission.

1. <u>Amman -- Ain Ghazal Wastewater Treatment Plant</u>.

Operational as well as raw wastewater data for the period of June 1973 to May 1979 were obtained from the staff at the Amman -- Ain Ghazal wastewater treatment plant over several visits in June 1979. The data and observations are considered particularly valuable in this investigation because of the size and make-up of the existing service area of the Amman treatment plant and its similarity to the proposed Irbid service area. The Ain Ghazal plant is presently providing service to approximately 150,000 people (estimate by treatment plant personnel), and has no major industrial wastewater contributors (except a slaughterhouse). The influent characteristics were determined to be typical of a medium-large community in an arid Mediterranean climate. Influent wastewaters are sampled on a flow proportional basis on an irregular monthly schedule by plant staff. The influent flow is determined from a level recorder which measures the height of discharge at a flow proportional weir. The influent flows, waste


LEGEND
FLOWING RIVERS, CANALS
WADIS (DRY)
HARD SURFACE ROADS
TOWNS AND VILLAGES
WASTEWATER TREATMENT PLANT SITE
N
WWTP SITE
IRBID
Wadi el Arab Reservoir
Wadi Abu Sifa
Wadi Zahar
Wadi el Amud
Wadi el Arab
Wadi Ushsh Ghurab
Wadi Thjaka
Wadi Khalid es Samr
Wadi el Haddad
Wadi Dalham
Wadi el Hamam
Wadi Jaka
Wadi el Khalig
Wadi Abu Hal
Wadi el Fig
Wadi Deir es Sindyar
Wadi el Khiba
Wadi Dilban
Wadi Sahil
Wadi Summu
Wadi el Tayba
Wadi Ziglab
Wadi Abu Ziyad
Wadi el Tayba
Wadi Qrara
Wadi Abu el Ghul
Wadi Dusenba
Wadi Darneba
Wadi Khamb
Wadi um ed Dabar
Wadi el Khamb
Wadi esh Sherka
Wadi el Jous
Wadi el Ghadar
Wadi er Rumeel
Wadi Anga
Wadi el Kasla
El Wadi el Gbil
Wadi Ar Rahub
Wadi Rabba
Wadi Malka
Wadi Samar
Wadi Batu'ya
Wadi Shubaq
Wadi Ajlun
Wadi Shalalah
Wadi Ar el Tasa
Wadi el Mukhaprra
Wadi el Assala
Wadi Ghuwaiyr
Wadi Um Qais
Wadi el Arab
Wadi el Khalig
Wadi Ar Rahub
Wadi el Hasa
Wadi Ghuwaiyr
Wadi Ghuwaiyr
Wadi Ghuwaiyr

waste concentrations, and loadings are presented in Table 3-4. Analysis of the plant's flow charts indicated that the hourly flow ratios during dry weather flow conditions are as follows:

a. Maximum peak hourly flow/average hourly flow -- 2.92

b. Average peak hourly flow/average hourly flow -- 2.50

c. Average daily minimum hourly flow/average hourly flow -- 0.69

d. Minimum hourly flow/average hourly flow -- 0.60

These diurnal flow variations are considered within the normal range for the service area characteristics.

2. Correlation of Irbid Water Use Characteristics with Amman Data.

Analysis of the Ain Ghazal treatment plant data produced no unexpected observations. Although there is no definite verification of the service population, the 150,000 person estimate is reasonable. The per capita loading values given in Table 3-4 are well within the expected range for developing countries, and the calculated per capita flow contribution correlates with the information provided in the Water Use Strategy -- North Jordan report. The Water Use Strategy -- North Jordan (1978), and National Water Master Plan of Jordan were reviewed and were found in reasonable agreement with respect to the similarity of water use patterns for both Irbid and Amman. Water usage is developed on a subarea basis in the socioeconomic section of this report.

3. Per Capita Flow and Loading Factors -- Irbid.

The average wastewater flows and loadings from domestic sources are derived from the estimated per capita contribution for the projected service area population. Projected sewer flows were estimated from water use factors developed in Chapter 4. The portion of municipal water supply that reaches the sewer is normally 60 to 80 percent of consumption. The percent of the water supply that reaches the sewer will depend upon many factors, such as climate and the economic status of the water users. For example, in arid climates, the lower and middle income groups may reuse gray wastewater for watering gardens and dust control. This would increase the amount of consumed water with respect to the sewage contribution. The available data from the City of Amman indicate 80 percent of the metered water reaches the sewer. This may reflect some of the "lost water" reaching the sewers. The Irbid design is based on 80 percent of the "metered water" reaching the sewer.

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Table 3-4

Ain Ghazal Wastewater Treatment Plant Influent Characteristics

Date	Flow (cu m/day)	BOD (mg/L)	BOD (kg/day)	SS (mg/L)	SS (kg/day)	VSS (mg/L)	VSS (kg/day)
14/6/78	14,800	1,043	15,400	1,365	20,200	1,058	15,600
25/7/78	17,400	1,252	21,800	1,280	22,300	1,009	17,500
14/10/78	13,700	1,177	16,100	1,620	22,200	1,177	16,100
15/11/78	11,800	1,250	14,800	1,868	22,100	1,384	16,300
12/12/78	13,000	780	10,100	768	10,000	395	5,100
27/2/79	19,100	1,166	22,300	543	10,400	460	8,800
13/3/79	15,000	1,653	24,800	632	9,500	453	6,800
24/3/79	13,900	1,180	16,400	963	13,400	707	9,800
10/4/79	15,100	657	9,900	751	11,300	578	8,700
22/4/79	13,200	713	9,400	787	10,400	617	8,100
9/5/79	12,800	990	12,700	1,274	16,300	983	12,600
Average	14,500		15,800		15,300		11,400
Septage	1,300		6,200		3,100		700
Net	13,200		9,600		12,200		10,700
Commercial/industrial	3,600		2,600		3,300		3,800
Domestic	9,600		7,000		8,900		6,900
Per capita contribution[1]	64 liters/capita/day		46.7 g/capita/day		59.3 g/capita/day		

[1] Based on a service population of 150,000 after allowance for septage at typical strengths, 27.8 percent commercial/industrial loads, and a 20 percent consumed water allowance.

This corresponds to 64 percent of the total water delivered to the storage reservoirs for domestic use.

The projected organic and solids loadings are critical when determining a basis for design of a wastewater treatment plant. As indicated, the approximate per capita loadings for the City of Amman appeared to be a reasonable basis for design. Just as water consumption rises in relation to the standard of living, however, so does the amount of pollution per capita. Normally, the increased use of water rises faster than the sewage loadings, so that wastewaters tend to become less concentrated. The projected per capita flows and loads for the City of Irbid are as follows:

Projected Per Capita Flow and Pollutant Loadings -- City of Irbid

Parameters	Year 1985	1990	2000
Flow (liters/capita/day)	64	68	76
BOD (g/capita/day)	50	52	55
Kjeldahl-N (g/capita/day)	10	10	10
Suspended solids (g/capita/day)	60	62	66
Volatile suspended solids (g/capita/day)	45	47	50
Oil and grease (g/capita/day)	15	15	15

These loadings do not reflect screenings and grit quantities which will be removed in the preliminary treatment process.

4. Septage loading.

Septage represents a significant wasteload contribution to the Amman Ain Ghazal wastewater treatment plant. It is anticipated that septage from the Irbid subdistrict will be treated at the Irbid wastewater treatment plant. It is possible that some septage could be transported to the plant from outside the subdistrict, but this is not likely due to the long haul distances. As the haul distance increases, the septage haulers will most probably find more expedient disposal sites even though the disposal may not be as hygienic. The proposed septage loading criteria for this study are based on available general information and assumptions as follows:

a. Septage tank cleanouts occur at an average interval of seven years.

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b. There are eight residents per household.

c. There is one tank per household.

d. The average cleaning produces 40 cu m of septage.

e. Septage pollution concentrations are as follows:

Parameters	Concentration (mg/L)
BOD	4,800
SS	2,350
VSS	500
NH_3-N	60

These values for septage pollution parameters were taken from a study performed in the United States entitled, "Treatment and Disposal of Septage Tank Sludge in Tompkins County, New York." Consideration was given to conducting an extensive septage sampling and analysis program at the Ain Ghazal wastewater treatment plant. Due to time constraints and an already overloaded schedule at the Royal Scientific Society, however, it was decided that such an endeavor would not be feasible at that time. As a check, the septage values were plugged into the data obtained at the Ain Ghazal plant and found to provide a reasonable balance in conjunction with other assumptions in determining the raw waste loadings.

5. Domestic Mass Loading Rates.

Domestic mass loading rates (MLR) have been developed for future design population, and include the treatment of septage from the unsewered population in the Irbid subdistrict. The per capita contribution of pollutants to the design were discussed previously. A load allocation which reflects the anticipated future development for the area presently occupied by refugee housing is included. This allocation will be sufficient to handle the present gray wastewater and septage tank discharge loadings from the existing population. For the purposes of determining the domestic MLR, the population projections developed in the socioeconomic studies, Tables 2-10 and 2-12, are used for design periods to the year 1990 and year 2000, respectively. It is anticipated that by the year 2000 every household within the present boundaries of the City will be serviced by the sewerage system. The assumption regarding the serviced population and the projected water use presumes the adoption of an adequate City sewer ordinance (refer to Appendix C) and its strict enforcement.

The proposed domestic MLR for the years 1990 and 2000 are presented in Table 3-5. This domestic MLR presented in Table 3-5 includes

Table 3-5

Domestic Mass Loading Rates (MLR)

Year / Season	1990 Cool	1990 Warm	2000 Cool	2000 Warm
Service Population				
Sewered--city	242,200		353,400	
Septage tanks--subdistrict	179,800		273,600	
Domestic Wastewater Flow (cu m/day)				
Sewage	16,246	16,246	26,752	26,752
Septage	352	713	535	1,086
Total	16,598	16,959	27,287	27,838
BOD_5 Loading (kg/day)				
Sewage	12,837	12,837	19,437	19,437
Septage	1,690	3,422	2,568	5,213
Total	14,527	16,259	22,005	24,650
Kjeldahl-Nitrogen Loading (kg/day)				
Sewage	2,422	2,422	3,534	3,534
Septage	21	43	32	65
Total	2,443	2,465	3,566	3,599
Suspended Solids Loading (kg/day)				
Sewage	15,016	15,016	23,324	23,324
Septage	827	1,676	1,257	2,552
Total	15,843	16,692	24,581	25,876
Volatile Suspended Solids Loading (kg/day)				
Sewage	11,383	11,383	17,670	17,670
Septage	176	356	267	543
Total	11,559	11,739	17,937	18,213
Oil and Grease Loading (kg/day)	3,633	3,633	5,301	5,301

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anticipated seasonal variations. The peak loading indicated for the warm season reflects the anticipated increased activity of the septage haulers during this period.

3.3.3.3 Influent Characteristics -- Commercial/Industrial/Institutional Sources.

The commercial activity in the City of Irbid is comprised mainly of retail stores and shops. Significant portions of the wasteloads from these facilities are generated by commuter population, and can be expected to be typical of domestic wastewater characteristics of the sewered population. Numerous laundries, restaurants, and some car washes are distributed throughout the City. These commercial enterprises generate a wastewater significantly different in character from that of domestic wastewater, but comparable in strength with respect to oxygen demand. Other existing commercial activities include a storehouse for fruits, vegetables and foodstuffs, and vehicle repair shops. Some degree of housekeeping will be required from these commercial establishments as described in paragraph 3, "Pretreatment Requirements."

1. Institutional Facilities Impact.

Institutional facilities are comprised of mosques and other religious centers, schools, government offices, military installations, hospitals, and miscellaneous public service institutions. The number and description of institutional facilities is described in greater detail in Chapter 2 of this report. The wastewater generated by institutional facilities will have characteristics similar to domestic wastewater. A proposed extension to the existing hospital will probably make it the largest single water user and wastewater discharger in this group. Though no special wastewater problems are anticipated, the hospital kitchen should have grease traps, and special care and procedures for disposing of possible radiological and pathological wastes should be developed and closely monitored.

2. Types of Industries and Their Impact.

It is not possible at this point to forecast the exact impact of industrial loading on the wastewater treatment plant during its design life. The existing and identified future industrial loadings are quantified as part of the design basis for this study. An allocation for future growth of the identified industries has been provided and is presented in Table 3-6.

For purposes of this study, industry has been classified as either "dry industry" or "water-intensive industry." Dry industries are those which do not use significant quantities of water in their process. Existing industries at Irbid which fit into this classification include pen and furniture manufacturing. Battery manufacturing

Table 3-6

Commercial/Industrial/Institutional
Mass Loading Rates (MLR)

Year	1990	2000
Flows (cu m/day)	266	491
Identified industries	5,534	8,509
Total	5,800	9,000
BOD_5 (kg/day)		
Identified industries	754	1,324
Other commercial/industrial/ institutional	4,151	6,456
Total	4,905	7,880
Kjeldahl-Nitrogen (kg/day)		
Identified industries	66	136
Other commercial/industrial/ institutional	747	1,162
Total	813	1,298
Suspended Solids (kg/day)		
Identified industries	302	555
Other commercial/industrial/ institutional	4,981	7,748
Total	5,283	8,303
Volatile Suspended Solids (kg/day)		
identified industries	247	447
Other commercial/industrial/ institutional	3,735	5,811
Total	3,982	6,258
Oil and Grease (kg/day)		
Identified industries	24	42
Other commercial/industrial/ institutional	1,107	1,722
Total	1,131	1,764

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has also been identified as a future dry industry. Several wet industries were identified, including the following with their respective status:

a. Irbid slaughterhouse -- Existing.

b. Yarmouk Company, dairy and food products -- Existing physical plant, awaiting start-up.

c. Soft drink bottling plant -- Future.

d. Ice house -- Existing.

The slaughterhouse presently processes about 10 cows and 120 sheep and goats daily. A 1973 publication entitled "A Municipality; a Service to the People," stated the average capacity of the slaughterhouse is "600 head of livestock, 55 head of camels and 4,000 chickens." Presently, the only by-product recovery is feet and hides. The offal is disposed of on land, and the blood is discharged to the sewer. The existing wastewater is discharged to the Wadi el Hamam after passing through a skimming facility. This facility presently provides little or no treatment of the wastewater because it is not cleaned or otherwise maintained. Influent and effluent wastewater samples were collected across the skimmer, and the results presented in Table 3-7. The future of the slaughterhouse production is uncertain. Presently, the Jordanian government is importing sufficient meat to meet most of the domestic demand. This has had a depressing effect on the slaughter rate. There are several other locations in Irbid with limited slaughtering operations, but no significant impact is anticipated.

The Yarmouk Company will produce ice cream, yougart, milk, and sour milk. At the time of this study, it was estimated that the initial production levels will be approximately 1 ton/day. The design capacity of the plant was reported to be 12 tons/day. Projected water usage is not known, and no pretreatment facilities are planned. The effluent will discharge to the Wadi Tariq Saum. There was no wastewater discharge from the plant during this study because its operation was delayed pending arrival of equipment. There are several other dairy operations in the City which are very small and will not significantly impact on the proposed wastewater treatment plant.

A soft-drink production facility is planned for the industrial park area in the near future. Its initial production capacity was estimated at 12,000 bottles/day, with an estimated design capacity of 20,000 bottles/day.

The ice house is a water consumer, but does not discharge wastewater. It is anticipated that the only discharge will be sanitary sewage.

Table 3-7

Analytical Test Results on Industrial Wastewaters

Sample Identification	COD (mg/L)	Kjdl-N (mg/L)	SS (mg/L)	VSS (mg/L)	O and G (mg/L)	pH --	Alk (mg/L)
Irbid Slaughterhouse							
Raw wastewater	4,283	352.22	1,650	1,210	46	--	--
Skimmer effluent	3,487	382.60	1,188.4	899.8	61	--	--
7-Up Bottling Plant--Ruseifa: (2 days data)	885.9	12.0	47.4	12.5	65.5	--	8.9
	1,315	12.71	58.1	23.4	--	--	--
Jordan Dairy--Ruseifa:							
Production with yogurt clean-in-place	17,459	203.62	3,045.1	2,956.5	191.0	--	--
Normal production	6,845	67.87	2,612.4	2,529.2	269.5	--	--
Equipment--clean-in-place	1,746	25.11	96.2	49.9	197.5	11.4	31.2

3. Pretreatment Requirements.

The development of pretreatment requirements necessitates an analysis of not only the needs of the total sewerage system, but of downstream water uses and the environment which the sewerage system is intended to protect. In this regard, there are three categories of waste which should be controlled at the source:

a. Pollutants which can cause physical damage to the sewerage system.

b. Pollutants which cannot be removed or abated by the treatment plant, and therefore are incompatible with downstream uses.

c. Pollutants which, although compatible with the proposed sewerage system, will be present in such high concentrations as to overload the system or otherwise impair its efficient operation.

It is the intention to treat existing and future industrial wastewater in the proposed treatment plant. Since industrial wastes vary so widely in character and strength, however, it is necessary that limits for allowable discharges be set in a City sewer ordinance. (Refer to Article VI of the sample sewer use ordinance, Appendix C of this report.) The ordinance should require each industry to apply for, and receive specific limits for the discharge of each pertinent pollutant to the sewerage system (including trace metals or elements where appropriate). This permitting procedure can be included in the permit application form required of new industry by the Ministry of Health, Pollution Control Department. As a minimum, the sewer ordinance should provide for the following:

a. Prohibit the discharge of waste having a temperature greater than 66°C.

b. Prohibit discharge of waste containing excessive oil and grease.

c. Prohibit the discharge of any flammable materials.

d. Prohibit the discharge of ground garbage.

e. Prohibit the discharge of any materials which may be toxic or otherwise hazardous to the wastewater treatment plant staff, or downstream users.

f. Limit the pH of discharge waste to within the limits of 5.0 and 10.0.

g. Require a flow measurement and sampling station where deemed appropriate.

Additionally, the ordinance should require that industry pay its fair share of the operating costs of the treatment plant. Where the industrial wastes are comparable in strength to domestic wastes, the cost of waste treatment may be based on a unit flow basis, i.e., the anticipated annual cost divided by the total annual flow. In cases where the strength of the waste is higher than domestic waste, the added cost of waste treatment should be assessed to the industry, e.g., cost of power, solids handling, etc. It may be necessary to require industry to pretreat its waste to remove some part of the waste strength in order not to overload the treatment plant. The proposed plant is intended to accept and adequately treat some high strength waste where justified by specific existing or identified future industry in the City of Irbid. The need to require an industry to reduce the quantity of compatible pollutants should be made on a case-by-case basis. The reduction in pollutants may be achieved by either in-plant controls or end-of-pipe pretreatment.

The installation and operation of grease traps and screening devices should be required where deemed appropriate to protect the sewerage system. Grease traps should be located as close to the source of grease as possible. Vehicle maintenance shops, hospitals, hotels, restaurants, and many manufacturing plants are examples of establishments where grease traps should be required. Screening devices should be installed and operated at markets, foodstuff storage, and ahead of pretreatment facilities. The installation of grit and sediment traps at car wash facilities should be considered.

4. Flow Factors Based on Employment or Area.

The existing proportion of commercial, industrial, and institutional (C/I/I) wastewater flow to domestic flow is low. If increased industrialization occurs, however, the percentage of industrial loading in the City's raw wastewater will increase. A reasonable way to determine commercial, industrial, and institutional flows would be to base the flow projections on employment or area. The difficulty encountered when basing flow projections on employment is that the breakdown of existing and future job locations must be identifiable. Such is not the case for Irbid at this time. It is more appropriate to determine flow factors based on area. Accordingly, the future commercial, industrial, and institutional flows were categorized into two parts as follows:

a. Industrial wastewaters which will originate from the industrial park area.

b. Dispersed commercial, industrial, and institutional flows which originate outside the industrial park, or throughout the City.

An allowance of 2,000 cu m/day/sq km was selected for industrial flows originating from inside the industrial park. This allocation is an average figure for the whole industrial park. Some industries which are water-use intensive will exceed this value, while the relatively dry industries will discharge very little wastewater. Based on information presented in Chapter 2, it is anticipated that the ultimate industrial park area will be approximately 1.15 sq km. The design wastewater flow from this area is then established at 2,300 cu m/day.

The dispersed commercial, industrial, and institutional wastewater flow contribution factor was established at 248 cu m/day/sq km for the year 1990, and at 320 cu m/day/sq km for the year 2000. The present dispersed flow factor is approximately 293 cu m/day/sq km. It is not intended to infer that these flow factors are precise. They have been calculated to determine their validity, and to ensure adequate capacity in the sewerage works. The major existing dispersed commercial, industrial, and institutional flow contributors are identified as follows:

a. Irbid slaughterhouse.
b. Yarmouk dairy products.
c. Yarmouk Hospital.

5. Sampling.

Since Irbid has no sewage collection system, a sampling effort was not developed for determining domestic waste loadings. The data provided by the staff at the Amman Ain Ghazal treatment plant are considered appropriate and sufficient to determine an adequate design basis.

For industrial wasteload determinations, interviews were held with various industrial plant staffs to obtain information on water use and wastewater generation. After the interviews, the plant effluents were measured using a 90 degree V-notched weir to verify the information provided during the interviews. Additionally, multiple wastewater samples were taken for flow measurement and composited. The samples were then taken immediately to the Royal Scientific Society in Amman for analysis. The results of the analysis were presented in Table 3-7.

The raw wastewater from the slaughterhouse was sampled immediately upstream of the plant's skimming tank. Comparison of the skimmer effluent data with the raw wastewater data (see Table 3-7) reveals little or no treatment. This was due in large part to lack of skimming tank maintenance. The tank had not been cleaned for some time prior to our sampling, and was therefore completely ineffective. Samples were collected from the Jordan Dairy Company and the 7-Up Bottling Company in Ruseifa because these were considered representative of the water use-intensive industries proposed for Irbid. The staffs at both plants were extremely cooperative and helpful to us in this project.

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The assistance of the 7-Up Bottling Company, Ruseifa, was sought to enable us to obtain data which would be applicable to the proposed soft drink bottling plant at the Irbid industrial park. Samples were obtained during the morning hours of 9 and 17 July 1979. The measured wastewater rate was three times higher than the rate estimated by plant engineers. The measured wastewater flow, however, was in reasonable agreement with other available sources of information on soft drink production. In addition to the pollution parameters presented in Table 3-7, the plant added about 120 kg/day of various salts for water treatment operations.

The Jordan Dairy Company, Ruseifa, produces labanne, yogurt, milk (15 percent whole, 85 percent powdered), cheese, and ice cream. The exact product make-up proposed for the Yarmouk Dairy and Food Products plant in Irbid was not known exactly. Additionally, changes in equipment make-up, such as clean-in-place (CIP), may constitute a major impact on loadings and wastewater generation. The Jordan Dairy staff was helpful in providing input regarding their plant operations. This input allowed us to tailor our end-of-pipe sampling schedule to match the in-plant operations. The sampling period occurred from 1300 hours on 10 July, and was divided into three separate sampling phases to coincide with in-plant activities, as follows:

a. 1300 to 1400 hours -- Normal production with concurrent clean-in-place of labanne production line.

b. 1500 to 1730 hours -- Normal production.

c. 1830 to 2200 hours - Shut-down of production lines and clean-in-place of all production equipment.

6. <u>Commercial, Industrial, and Institutional Mass Loading Rates.</u>

The majority of the commercial, industrial, and institutional wastewater contribution will be comparable in strength and in most characteristics to normal domestic wastewater. The exceptions will be the water-intensive industries which have been identified. In order to assess the potential impact of the industrial loadings, basic assumptions regarding the expected production levels of the various industries had to be made. After the expected production levels for each industry are established, it is possible to project an anticipated wastewater flow and loading by applying unit wasteloads per unit of production. It should be noted that unit wasteloads were based on production levels at each of the visited plants. After their derivation, the unit wasteloads were compared with other background information to check the reasonableness of the data.

As stated before, the projected ratios and the composition of the slaughter at the City-owned slaughterhouse will be directly affected

by the government meat importation policies. Slaughter projections are speculative for purposes of this study. It was assumed that the slaughterhouse would achieve full capacity (including chicken slaughter) by the year 2000, and about one-half capacity by the year 1990. On the basis of these assumptions, the slaughter levels with raw wastewater flows and loadings for 1990 and 2000 are as follows:

Year	1990	2000
Slaughter		
Equivalent cattle	132	263
Chicken	2,000	4,000
Flow (cu m/day)	188	375
BOD_5 (kg/day)	515	1,026
kjdl-N (kg/day)	66	131
Suspended solids (kg/day)	207	413
Volatile suspended solids (kg/day)	157	312
Oil and grease (kg/day)	11	22

The proposed soft drink bottling plant was reported to have an initial production level of 12,000 bottles/day and a capacity of 20,000 bottles/day. It is assumed for the purposes of this study that the plant will be at capacity in the year 1990, and a 50 percent increase in capacity is projected for the year 2000. Based on these assumptions and the unit wasteloads obtained from the 7-Up Bottling Company at Ruseifa, the raw wastewater flows and loadings for 1990 and 2000 are as follows:

Year	1990	2000
Production (bottles/day)	20,000	30,000
Flow (cu m/day)	33	49
BOD_5 (kg/day)	8.9	13.4
kjdl-N (kg/day)	0.55	0.83
Suspended solids (kg/day)	1.73	2.60
Volatile suspended solids (kg/day)	0.59	0.89
Oil and grease (kg/day)	2.15	3.23

An analysis of water use at the 7-Up bottling plant indicates reasonably good water use practices. The wasteloads from the two sampling periods yielded similar, but lower than expected, results. Based on information obtained during discussions with 7-Up Bottling Company staff,

it is anticipated that production will be seasonal. The impact on the operation on the proposed treatment plant, however, will be negligible.

Based on the information obtained at the Jordan Dairy Company, Ruseifa, wastewater flows and loadings for the Yarmouk Dairy are projected as follows:

Year	1990	2000
Production (tons)	12	18
Flow (cu m/day)	45	67
BOD_5 (kg/day)	190	285
kjdl-N (kg/day)	2.8	4.2
Suspended solids (kg/day)	92.8	139.2
Volatile suspended solids (kg/day)	89.4	134.2
Oil and grease (kg/day)	11.2	16.8

The proposed commercial, industrial, and institutional mass loading rates for the years 1990 and 2000 were presented in Table 3-6. In deriving the mass loading rates, the waste concentrations from the unidentified and/or diffused commercial, industrial, and institutional discharges are assumed to be comparable to domestic waste. Typical industrial wastewater strengths are assumed as follows:

a. BOD_5 -- 750 mg/L
b. kjdl-N -- 135 mg/L
c. Suspended solids -- 900 mg/L
d. Volatile suspended solids -- 675 mg/L
e. Oil and grease -- 200 mg/L

These concentrations are less than the maximum limits proposed in the sample sewer use ordinance presented in Appendix C. The operating authority should have flexibility in administering the ordinance as long as the discharges do not adversely impact on the operation of sewerage facilities.

3.3.3.4 Unit Process Selection Considerations.

1. Influent Wastewater Characteristics.

Wastewater characteristics will be influenced by the make-up of the

contributing population which will impact on water use patterns, and on the make-up of commercial, industrial and institutional, wastewater contributions. The industrial component of the wastewater will be significantly affected by the vigorous enforcement of the industrial pretreatment requirements of the City sewer ordinance. Without proper enforcement of the ordinance, raw wastewater discharges may be characterized by acute shock loadings of toxic or organic materials which could hamper the efficient operation of the treatment facility.

The proposed treatment facility should be designed with an inherent reserve capacity to absorb moderate transient loadings of nontoxic substances without major process upsets.

2. Site Area Limitations.

In evaluating alternative wastewater treatment plant alternative sites, the criteria will include the following appropriate parameters:

a. Elevation and relief -- The site should permit the flow of wastewater by gravity. Only sidestreams or recycle flows should require pumping.

b. Proximity and access to the service area -- The site should be located as close to the service area as environmental and land use considerations will permit, and have ready access via an existing road network.

c. Land use -- Unless mandated by technological and/or economical limitations, the site should be located in an area of compatible existing and proposed land use. Land use evaluation should include existing and proposed uses of the adjoining properties, proximity of living areas, and recreation and institutional facilities.

d. Further expansion -- The site should have the availability to expand the proposed treatment facility for treatment of projected wastewater flows through the year 2000.

e. Effluent assimilation capacity -- It is anticipated that there is no reasonable location where a continuously flowing stream is available to dilute the treatment plant effluent. Therefore, a rudimentary model is used to determine the impact of the site location on the continued rejuvenation of the effluent and the impact on downstream water uses.

f. Land cost -- Land cost is somewhat related to land use. Usually the more remote the site, the cheaper the land cost; however, this must be balanced against the increased cost of sewer interceptors, sludge, and other material transport costs.

3. Degree of Treatment Requirements.

Various wastewater treatment schemes will be evaluated in terms of their net environmental impact. Significant effects should include the local water quality and its anticipated uses, and the protection of groundwater if possible recharge is anticipated or suspected. Protection of downstream users would also include direct reuse of the treated wastewater, if appropriate.

4. Appropriate Technology.

The selection of the wastewater treatment scheme should be based on achieving the desired effluent quality and solids management by the simplest and most direct means. The process evaluation and selection should be based on the following basic principles:

a. Simplicity -- Simple, but adequate, process controls and use of a minimal number of unit operations is highly desirable.

b. Compactness -- The overall treatment scheme layout should be compact to allow ready access by the plant operating staff and to minimize land requirements. Unit operations, such as solids handling, should be consolidated for efficient operation.

c. Resiliency -- The evaluation of a wastewater treatment process should consider the ability of the specific unit process and the total treatment system to absorb transient shock loadings and occasional operational oversights without serious deterioration of the final effluent quality.

d. Reliability -- This criteria should be applied in consideration of specific equipment selection. Additionally, sufficient stand-by electrical generation capability should be provided to ensure the operation of vital process equipment during power outages to ensure the viability of the treatment processes.

5. Operation and Maintenance.

Every vital mechanical component in the wastewater treatment plant will be designed to allow repair or replacement without significant impairment of the effluent quality, and without causing diversion of raw wastewater to the wadi. Minimum standards for equipment start-up procedures will include adequate instructions to plant operation and maintenance staff. Provisions for adequate spare parts and storage will be addressed.

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6. Septage Handling.

Facilities for accepting and handling septage tank waste in an innocuous manner will be provided at the treatment plant site. Provisions will be made for controlled feeding of septage waste into the main treatment scheme to minimize any adverse impact on the treatment plant effluent quality.

7. Solids Management.

Wastewater treatment plant solids include residual sludges, screenings, scum, and grit materials. The management of these solids residuals can generally be broken down into three stages:

a. Generation -- Primarily dependent on the raw wastewater solids content, and the selected wastewater treatment design scheme.

b. Handling -- Includes solids concentration, stabilization, and dewatering operations. Not all of these operations may be needed, depending on the specific solids material in question, and depending on the type of treatment processes selected.

c. Disposal -- Alternatives will include direct application to agricultural land, disposal to landfill, and co-composting or coincineration with municipal refuse. Not all of these alternatives are equally applicable to all of the waste solids generated in the treatment plant (e.g., screenings would not be considered for direct application to agricultural land).

8. Effluent Reuse Renovation and Disposal.

The following alternative wastewater treatment and disposal schemes will be considered:

a. Treatment and direct discharge to the wadi-drainage system.

b. Treatment and reuse.

c. Treatment and land application.

Although all three schemes require wastewater treatment, the degree of treatment may vary depending on the type of final effluent disposal. Disposal to agricultural land may not require the same degree of treatment required for disposal to the wadi system since the crops remove nutrients from the water, and the wastewater receives additional treatment as it passes through the soil.

3.4 STORMWATER DRAINAGE SYSTEM CRITERIA

Planning and design of storm drainage systems must conform to two distinct types of criteria: hydrologic and hydraulic. Hydrologic criteria establish the stormwater design flows resulting from the design rainstorm. Hydraulic criteria, on the other hand, control the size and configuration of the conduit or channel to convey the design flows.

Hydrologic criteria include considerations of flood frequency and acceptable flood risk, methodology for computation of runoff, and rainfall runoff relationships. Hydraulic criteria include factors involved in the determination of conduit or channel capacity, such as applicable formulae, friction factors, freeboard allowances, and maximum allowable velocities.

3.4.1 Hydrologic Criteria

The development of hydrologic criteria relies heavily on past records of rainfall and runoff. Although over 40 years of daily rainfall data for Irbid have been compiled, only the last eight years have included automatic continuous recorders. Prior studies of stormwater runoff in Jordan have utilized rainfall intensity-duration curves developed by Ibbitt in an unpublished document entitled "Rainfall Intensities in Jordan for Use in Engineering Design," technical paper no. 2 by M. Ibbitt of the Natural Resources Authority in 1969. These curves were developed from historic 24-hour records for all of Jordan, and correlation factors for rainfall statistics in the United States and Australia. The last eight years of continuous records are utilized in this study to develop rainfall intensity-duration relationships. There are no corresponding stream flow records that could be correlated with rainfall data to derive full statistical runoff estimates. Consequently, engineering judgement was applied along with empirical methods to determine acceptable and meaningful rainfall runoff quantities.

Detailed information relative to the development of the hydrologic criteria as described is more fully presented later in this subsection.

3.4.1.1 Degree of Protection.

The average frequency of rainfall occurrence established the level of protection afforded by the drainage system. The degree of protection provided has serious economic implications as the capital cost, as well as the maintenance cost, of facilities must be consistent with the amount of flood damage prevented. Because records of flood damage are almost nonexistent, and probably subjective in regarding the value of the damages incurred, detailed cost-benefit analyses of urban storm drainage system alternatives are difficult to accomplish.

Insurance policies are not purchased for fire or flood water damage. Thus, this approach to ascertain property damage due to flooding problems was abandoned. Neither the government nor other municipal public agencies appear to be liable for damages sustained by private properties due to the inadequacy of public storm drains.

The general lack of specific flood damage information in the Irbid area precludes undertaking even a simplistic cost-benefit analysis. Instead, there must be reliance on good engineering judgement, taking into account the technical and financial feasibility of providing an acceptable level of protection.

The range of design frequencies commonly used for drainage systems in residential areas is 2 to 15 years, with five years being the most common. For drainage systems in commercial or high-value districts, design frequencies typically range from 10 to 50 years, depending on the degree of economic justification. For culverts, a design frequency of 25 to 50 years or more is used. Even with these criteria, consideration is given to conveying, as street flow, the storm runoff from the less frequent occurrences that cannot be fully accommodated within the drainage system. In this manner, the actual level of protection before significant flood damage occurs is considerably greater than the design frequency of the storm drainage conduit.

Because the existing storm drainage networks are in the center of town (high density commercial area), and since it is probable that augmentation of these systems would also be within the same area, it was concluded that a 10-year design storm for runoff analyses and sizing of new stormwater collectors would be most appropriate. Discussions with the Natural Resources Authority, the National Planning Council, and with Irbid City officials led to concurrence with a 10-year design storm. For major culverts, the 25-year design storm is used.

3.4.1.2 Runoff Determination Methodology.

Currently, three general methods are employed in storm runoff determinations and are commonly identified as statistical, hydrographic, and empirical methods.

1. Statistical Method.

This mode determines flood runoff volume based on statistical analysis of accurate, long-term runoff records. This method is reliable only if the period of record is sufficiently long to reasonably include rare runoff events, and if, during the same period, the character of the drainage basin does not undergo significant change. Because of the lack of such data and the projected changes within the various watersheds, statistical methods are not deemed viable for this analysis.

2. Hydrographic Method.

This is a relatively recent development that has evolved primarily with and as a product of advances in computer technology. It is relatively sophisticated and equires a significant amount of data input. The method produces a hydrograph of runoff for a design storm, utilizing data on rainfall quantities, time pattern, and watershed characteristics, including depression storage, infiltration, imperviousness, slope, channelization, and other parameters. This method is well suited to large drainage areas where sufficient data are available. In the Irbid study area, data for a hydrographic approach are inadequate.

3. Empirical Method.

This method is based on relationships between observed flows, drainage areas, and rainfall characteristics. The most widely used and recognized of these methods is based on the rational formula, $Q = CIA\ (1/360)$. For the peak runoff rate in cu m/sec, Q is the product of the runoff coefficient, C; the rainfall intensity in mm/hr, I; and the drainage area in hectares, A. The rainfall intensity to be used in the formula is a function of the time of concentration (Tc) of the watershed. The Tc is defined as the time for runoff to travel from the hydraulically most remote point in the drainage basin to the point under consideration. The professional judgement, whether by individual or group consensus, required for estimation of the value of the runoff coefficient, as well as the time of concentration, are the most important factors in the use of the rational formula. Although the rational formula method differs from others because of its simplicity, it nevertheless enjoys wide acceptance as a wholly adequate method of approximating the peak rate of runoff from small drainage basins, providing sound judgement is used in selection of the various factors introduced into the basic equation.

Because of its simplicity and suitability for small drainage areas, the rational formula was selected for use in the Irbid study area.

3.4.1.3 Rational Formula Parameters.

The following paragraphs detail the various parameters entering into the use of the rational formula.

1. Rainfall Intensity/Duration/Frequency Data.

The climate of Jordan is typical of the east Mediterranean basin. There is a significant variation in the east-west and north-south directions, both in temperature and rainfall patterns. Irbid is situated in the northern part of the country with an average temperature in the summer of 25°C, and 9°C in the winter. There are two rainfall gauging stations in Irbid. The first was established at the secondary school with records kept since 1937-1938. The second station, established at the Agricul-

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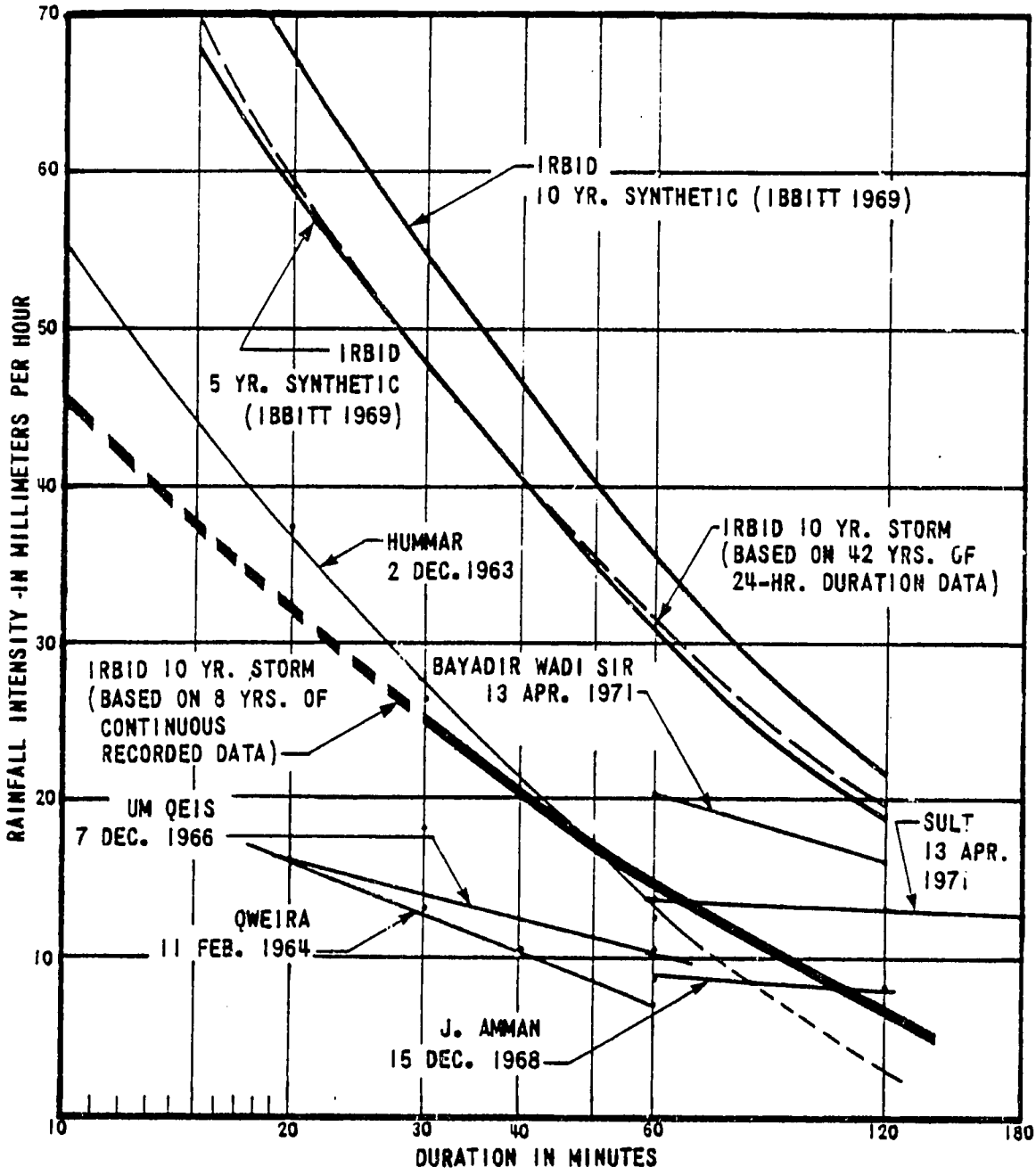
tural Experiment Station, has records dating to 1954-1955. A continuous recording station was established at the first station in the late 1960's. Average annual rainfall for the first station has been documented as 426 mm, with a maximum of 757 mm and a minimum of 172 mm. The average annual rainfall for the second station is 444 mm, with a maximum of 753 mm and a minimum of 212 mm. The Natural Resources Authority maintains and analyzes the records at these and all precipitation gauging stations in Jordan.

There are no published rainfall intensity/duration/frequency curves which are based on actual record rainfall intensities. The only available publication is technical paper no. 2. This paper is based on a correlation of annual to daily rainfall, and hourly rainfall to shorter duration rainfall. In pursuing this analysis, the author used some factors from the United States and Australia. Since the time of this paper, eight years of continuous precipitation recordings at the secondary school station enable a more appropriate statistical analysis to be made for shorter duration storms. Also, 42 years of 24-hour duration data from this station were available for analysis. For the short duration storm analysis, the log normal distribution was used for increasing durations for each maximum annual storm since the initial continuous recorded year. The standard deviation, exceedence probabilities, return periods, and average rainfall intensity were computed for each duration.

The earliest continuous record for the Irbid secondary school station was for the water year 1969-1970. The rainfall recorder is a Stevens type, and the shortest interval on the chart is 30 minutes. The heaviest storm in each year was selected from the record for 30 minutes, one hour, and two hours. The eight-year storm was extracted from this record and plotted on Figure 3-10. The curve was compared with the synthetic rainfall intensity/duration curves which were prepared by Ibbitt of the Natural Resources Authority (1969).

The curve indicates a lower intensity than Ibbitt's, and this fact necessitated plotting other curves for the recorded rainfall intensity in various stations in Jordan. This was done for the heaviest storms in the Um Qeis, Salt, Hummar, J. Amman, Bayadir Wadi Sir, and Qweira, also shown on Figure 3-10. Some of these stations have a much higher rainfall average than Irbid. The resulting plot confirmed the previous finding that Ibbitt's curves significantly over-estimated the rainfall intensity.

The 42 years of 24-hour data were then analyzed; the two-year 24-hour storm was converted to two-, five-, 10-, and 25-year storms using correlation factors from the United States, Australia, and the USSR. The 10-year storm from these data was plotted on Figure 3-10. It compares rather closely with Ibbitt's curve for the two-year storm. Because of



RAINFALL INTENSITY — DURATION
IRBID AND OTHER CITIES, JORDAN

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 3-10 DATE: SEPT; 1979 BY: CHECKED:

the lack of continuous recorded data (only eight years) and the fact that the last several years have been relatively dry in Jordan, the converted 24-hour data are believed to be more reliable. These curves are presented on Figure 3-11, and are adopted for use in the design of storm drainage systems for the City of Irbid.

2. Time of Concentration.

The time of concentration for a watershed is the time required for runoff to be established, and flow from the hydraulically most remote point to the point under consideration (usually the basin outlet). The time of concentration must be estimated as accurately as possible so that the average rainfall intensity corresponding to a duration equal to Tc can be determined from the intensity/duration/frequency curves.

For urban areas, Tc consists of the overland flow time to a street, travel time in the street to a storm drain inlet, plus the travel time in the storm drainage conduit. Travel time in drainage conduits is a function of velocity, which can readily be determined by the Manning equation (refer to the following discussion on hydraulic criteria).

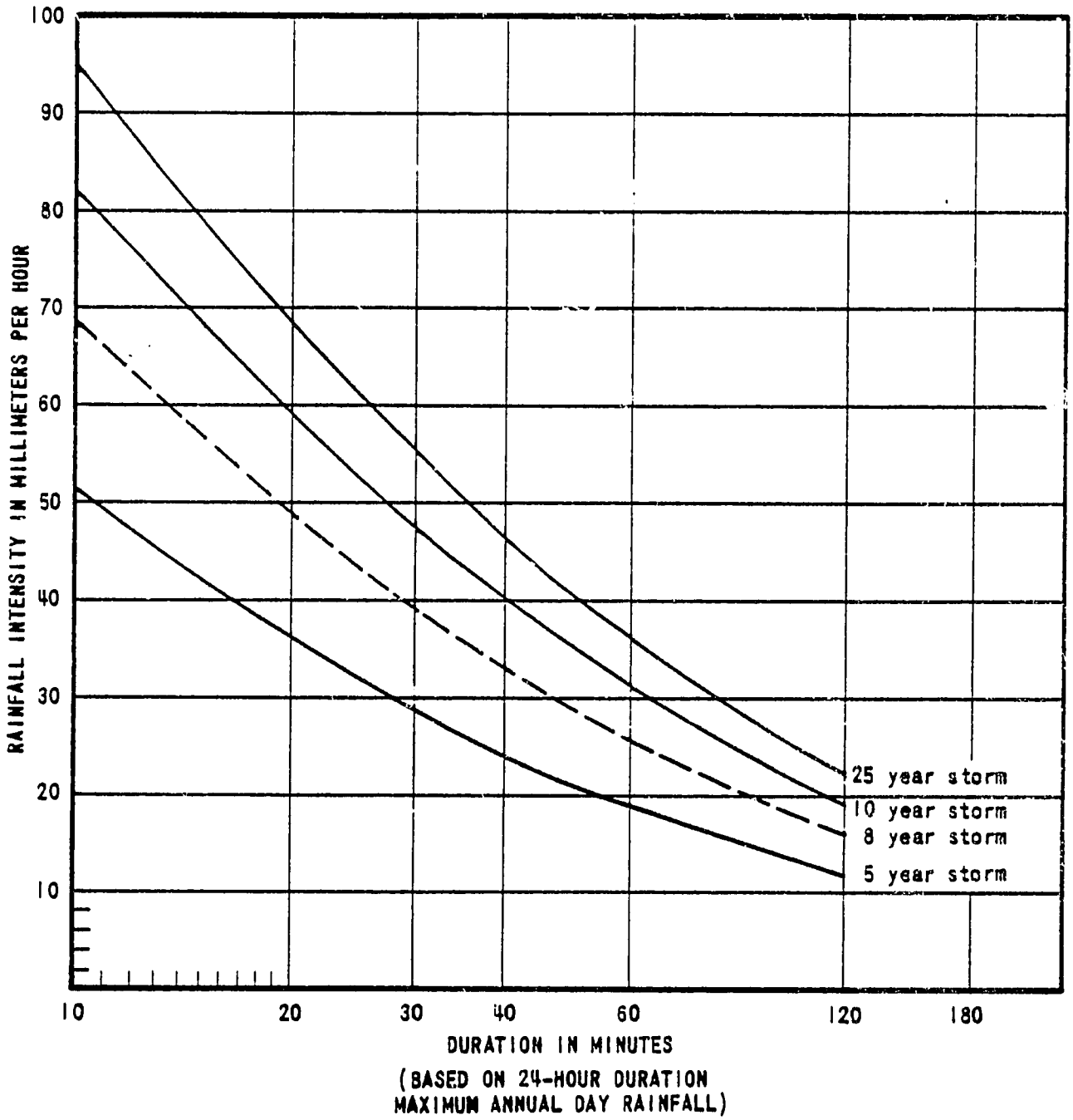
Overland flow time in the street was determined by empirical sheet and gutter flow data developed by the United States Soil Conservation Service. Figure 3-12 displays the relationship of street slope versus velocity. Overland flow from the rooftops to the street, or the time required for the runoff to accumulate to the point it begins to flow, was estimated as five minutes. This delay time was used because of typical dry conditions in this semiarid area.

3. Runoff Coefficients.

The runoff coefficient, C, is the variable in the rational formula least subject to precise determination. Consequently, considerable judgement and understanding is required in order to accurately determine runoff utilizing the rational method. While the runoff coefficient implies a fixed ratio of runoff to rainfall for any given drainage area, it actually represents the integrated effects of infiltration, detention/storage, evaporation, retention, flow routing, and interception, all of which effect the time distribution and peak rate of runoff.

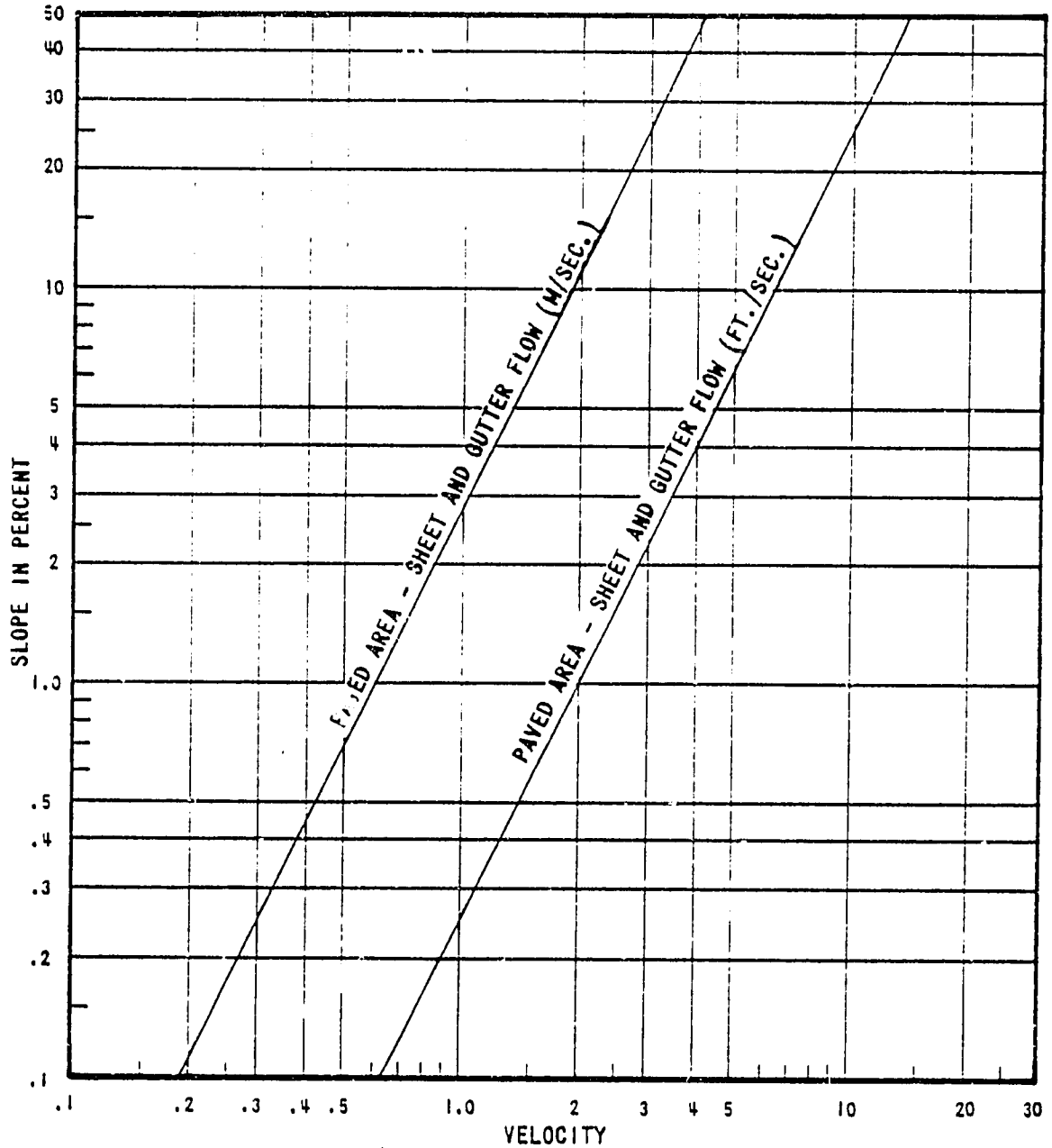
Runoff coefficients will be estimated by categorizing the year 2000 drainage areas into three types of surfaces which are assigned the following values:

a. Sidewalks and streets -- 0.95
b. Rooftops -- 0.85
c. Bare ground and other surfaces -- 0.20



DESIGN RAINFALL INTENSITY — DURATION
IRBID, JORDAN

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 3-11 DATE: SEPT. 1979 BY: CHECKED:



SOURCE: U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TECHNICAL RELEASE NO. 55
URBAN HYDROLOGY FOR SMALL WATERSHEDS
(Applicable to Semi-Arid Regions)

PAVED AREA — SHEET AND SHALLOW GUTTER FLOW

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 3- 12 DATE: SEPT., 1979 BY: CHECKED:

In developing a runoff coefficient to be used in the rational equation, a composite coefficient is developed for a given drainage subbasin. Utilizing the existing zoning criteria, projected population, and street plans within the planning area, a weighted runoff coefficient can be developed by population or land use zone for a specific drainage area.

3.4.2 Hydraulic Criteria

The analysis of the capacity of the existing storm drainage network, as well as the planning and design of proposed flood control works, is based on the laws of hydraulics. For planning and preliminary engineering purposes, a simplified approach is applied wherein the flow is assumed to be steady and uniform with friction loss being the dominant energy loss.

3.4.2.1 Uniform Flow Formula.

There have been a number of practical uniform flow formulae developed, with the Manning formula perhaps the most universally-known and used. Because of its wide acceptance, the Manning formula is used in this study.

The Manning formula is: $Q = \frac{1}{n} AR^{2/3}S^{1/2}$, where

Q = discharge at uniform flow in cu m/sec.

n = coefficient of roughness.

R = hydraulic radius in meters (the hydraulic radius is the flow area divided by the wetted perimeter).

S = slope of the energy gradient in m/m (for uniform flow, the slope of the energy gradient equals the slope of the hydraulic gradient or water surface which coincides with the slope of the channel bottom).

3.4.2.2 Roughness Coefficient.

The greatest difficulty in the application of the Manning formula involves evaluation of the roughness coefficient. Fortunately, many published references contain values of Manning's n, which, through experience, have proven to be reliable. For purposes of this study, the values of Manning's n will be used as follows:

a. Cast-in-place concrete -- 0.019
b. Reinforced concrete pipe -- 0.013
c. Corrugated metal pipe -- 0.025

3.4.3 System Details

Other new system design details applied to this project are outlined in the following subsections.

3.4.3.1 Pipe Material.

The types of conduit materials considered for use in the stormwater drainage system are:

a. Reinforced concrete pipe.
b. Corrugated steel pipe.
c. Cast-in-place concrete box conduit.

Asbestos cement pipe was not considered because of strength problems, lack of availability in large sizes, and extra care required for installation. Chapter 6 presents a cost-comparison analysis of these conduit materials at equivalent sizes for the collection network. Equivalent conduit size for a given stormwater flow is based upon hydraulic slope, and the roughness coefficient of the three materials considered.

3.4.3.2 Maximum Velocity.

The maximum velocity used for storm sewer design is 6 m/sec. Although slightly higher than normal design practices, this velocity was chosen because:

1. Infrequent and short duration rainfall events are typical for this region. Also, since pipe scour is a function of time of flow, a slightly higher velocity is acceptable.

2. A lower velocity would require additional rock excavation and drop manhole structures.

Manhole and drop structures placed downstream of high velocity conduit sections are designed for maximum flow forces. Conduit anchors are not provided since the greatest stormwater sewer slope is below 8 percent. Normal practice in sewer design is to provide pipe anchors when the slope is 20 percent or greater.

3.4.3.3 Culvert Design.

Culvert design is based on inlet control with headwater depth equal to 1.0.

3.4.3.4 Maximum Manhole Spacing.

The maximum manhole spacing has been set at 100 m.

3.4.3.5 Minimum Cover.

The minimum cover of 1 m is specified due to the drop required at the inlets. With this depth of cover, the average class strengths of pipe can be used. Average class strengths of reinforced concrete pipe will require less quality control and be less costly.

3.4.3.6 Inlets.

Grate-covered channel, curb, and manhole inlets will be used. Channel inlets which traverse the road section are to be placed at key intersections along existing and proposed lines. These were chosen mainly due to the flat shape of the road surface. Curb and manhole inlets will be used where appropriate.

3.5 SOLID WASTE DISPOSAL SYSTEM CRITERIA

Four distinct types of criteria were established for planning and design of a solid waste disposal system:

1. Public health criteria.
2. Collection system criteria.
3. Transportation system criteria.
4. Disposal criteria.

The input data that provided the background for formulating the solid waste criteria were developed during field investigation of the existing system. The following subsections provide a detailed description of the four criteria established.

3.5.1 Public Health Criteria.

First, and most important, is the establishment of the public health criteria. The fundamental objective of these criteria is to reduce and eliminate the potential health hazards associated with inadequate waste disposal in the Irbid area.

3.5.1.1 Vector Control.

The constituents of solid wastes, especially municipal wastes, provide a potential source of food and haborage for a variety of vectors. A vector is defined as an agent capable of carrying and transmitting disease pathogens. Vectors include flies, rats, mosquitoes, and occasionally birds. A properly-designed solid waste disposal and collection system minimizes animal attraction and vector breeding. The main criterion is to restrict the availability of food and harborage.

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Rats and other burrowing animals are attracted to landfill and waste storage areas by the availability of food waste and shelter. This problem can be alleviated by daily cover application at a landfill, and adequate storage containers within the collection system. By sufficient containment flies can also be reduced.

Since mosquitoes utilize waterfilled areas for propagation, control is best achieved by preventing stagnant or septic waterbodies.

If the vector population becomes established or shows a seasonal increase, extermination using insecticides and rodenticides will be necessary. This type of action must be carefully monitored to prevent any subsequent health or safety hazard.

3.5.1.2 Aesthetic Considerations.

Solid waste, particularly paper and other light density wastes may be dispersed by wind as it is stored, transportation, or disposed of. Containment and periodic clean-up of litter is required.

3.5.2 Collection System Criteria

Before a solid waste management system can be effective, a well-engineered collection system is required. The main criteria considered in our study include:

1. Population distribution and density in the collection area.

2. Overall physical configuration of the areas.

3. Refuse characteristics.

4. Land use.

5. Type of collection equipment.

6. Collection frequency.

7. Final disposal method.

8. Distance to final disposal area.

It is necessary to point out that the success of any collection system will depend in large part on the proper selection of equipment. Various types of equipment will be considered so that economics and collection efficiency can be evaluated. For example, houses situated on narrow streets, or houses having long setbacks at considerable distances from

the roadways, amy be serviced by small pick-up units such as motorized wagons, hand wagons, or corner greenboxes.

Routing is an important consideration in the basic criteria. Most collection routes are not economically arranged, and consequently consume time. The basic criteria for routing will require operational policies such as:

1. Crew size and labor force.
2. Type and size of equipment.
3. Scheduling of pick-up.
4. Districts.
5. Route variation.
6. Level of service.
7. Storage and collection containers.
8. Route balancing.

In order to develop and characterize a solid waste collection system, it is necessary to analyze areas using population density distribution such as high, medium, and low density, and land use type such as residential, institutional, and industrial.

The basic criteria to be utilized to be used to formulate various collection systems are as follows:

1. The present system will be integrated into any proposed system.

2. Collection will be implemented on a regularly-scheduled basis.

3. Equipment used for collection will be capable of reliable operation.

4. Use of local unskilled and semiskilled labor will be maximized.

5. Costly and highly sophisticated equipment will not be considered unless operating and maintenance costs can be justified by the benefits and revenues produced.

6. All systems will be economically and environmentally justified.

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3.5.3 Transportation System Criteria

The basic transportation system will consider all vehicles associated with transporting solid waste from the study area to the final disposal site. Each collection district will be analyzed for the most optimum transport vehicle. The following will be the basic criteria for selecting a transportation system for each district:

1. Type of waste being transported.

2. Distance from the particular district to disposal site.

3. Performance, reliability, and efficiency.

4. Maintainability and suitability.

5. Simplicity and safety in operation.

6. Capital, as well as operation and maintenance, costs.

If considered necessary, a transfer station will be studied in conjunction with the various systems.

3.5.4 Solid Waste Disposal Criteria

Selection of the final disposal system is most crucial in that the selection guides the design of the collection, storage, and transportation systems. The identification and evaluation of several potential disposal systems are necessary and vital steps in solid waste planning.

The approach to selecting an ultimate disposal system follows a stepwise procedure, including:

1. Identifying the field of candidate disposal technologies available and suitable for Irbid.

2. Selecting particular technology through a preliminary screening process, and defining the appropriate waste allocation system.

3. Evaluating each of the technologies against a specific list of selection criteria.

Each of the potential systems will be evaluated using the following major criteria:

1. Public Health Improvement.

   a. Prevalent communicable disease.
   b. Disease vectors, i.e., insects, rodents, birds, and dust.
   c. Community sanitation practices.

2. Environmental Quality.

   a. Air and water quality.
   b. Aesthetic values.
   c. Nuisance and annoyance factors.
   d. Land use needs including rehabilitation and reclamation.

3. Waste Characteristics.

   a. Types and sources.
   b. Quantities.
   c. Composition.
   d. Locational factors.

4. Overall Cost.

   a. Initial capital replacement costs.
   b. Operating and maintenance costs.

5. Institutional.

   a. Operational structure.
   b. Jurisdictional and legal.
   c. Management and administrative.

6. Public Support and Participation.

7. Flexibility. Three methods of final disposal are considered, each of the systems is screened utilizing the listed criteria. The three systems to be addressed are:

   a. Resource recovery.
   b. Composting.
   c. Sanitary landfill.

A significant consideration in evaluating solid waste disposal alternatives is that land disposal of some waste is ultimately required. The disposal system selection process selects a system which cost-effectively maintains environmental, ecological, and public health requirements, and provides long-term disposal at a minimum cost.

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3.6 FINANCIAL ANALYSIS -- GUIDELINES AND PROCEDURES

Various guidelines are available for directing the methods of evaluating the economic feasibility and project implementation aspects of the Irbid project. Since a portion of this project is being financed by USAID funds, particular attention has been directed toward AID guidelines and procedures.

The standards and criteria used to determine eligibility of water-related land use projects for AID financing were introduced in 1963 by the Foreign Aid Appropriations Act. That Act required AID to employ the same standards and procedures established in the Memorandum of the President dated 15 May 1962, which related to the feasibility of projects proposed for construction within the United States. This intent has been reaffirmed in the 1974 Appropriation Act where Congress in Section 101 stated:

> "None of the funds herein appropriated ... shall be used to finance the construction of any new ... water or related land resource project or program which has not met the standards and criteria used in determining the feasibility of such projects as proposed per Memorandum of the President dated May 15, 1962."

Responsibility for establishing these necessary policies, standards, and procedures was assigned to the Water Resources Council by the President.

The basic objectives of these policies, standards, and procedures is to produce the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs. Regarding development, projects of this type will benefit national economic development and regional development to maintain national strength and satisfactory living standards. In addition, these projects will recognize the need for proper stewardship in the long-term interest of the Nation's natural resources, and provide for the general well-being of the people.

The USAID Feasibility Analysis Procedures Manual, "Benefit-Cost Evaluation -- Water and Land Use Projects," provides the basic direction for economic evaluations used in this study. USAID is beginning to incorporate some of the evaluation requirements specified in "Principles and Standards for Planning Water and Related Land Resources," 38CFR24778, 10 September 1973 (Principles Economic Development, a plan which maximizes net economic benefits) or EQ (Environmental Quality, a plan which minimizes impacts to the environment) plans; the analysis of beneficial and detrimental impacts is conducted in the spirit of Principles and Standards. Included in this study are "system of accounts" tables which have been used to summarize various alternatives with respect to economics, and social, cultural, and environmental impacts. Appropriate dis-

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count or interest rates have been established. Although the rates are not the rates typically used in Federal United States projects which are based on the estimated average cost of Federal borrowing as determined by the Secretary of Treasury, they do reflect the opportunity cost of funds that will be used in the project.

CHAPTER 4

WATER SYSTEM STUDIES

Portions of the municipal water system are over 30 years old. Since construction of the initial system, there have been substantial additions. The last addition of major system components occurred in 1967. During the last few years a 2-inch main has been installed serving new areas and replacing older mains. Since the 1967 addition, there has been a sizable increase in the population of Irbid. Thus, the major components of the system are not sized to provide the level of service required by the existing population in the service area. Until recently, the hydraulic deficiencies of the system have been masked by a lack of water supply.

This chapter deals with the evaluation of the existing water system and determination of a system which is capable of providing adequate water supply to the people of Irbid. The recommended water system will consist of the usable portions of the existing system, and new construction.

4.1 EXISTING FACILITIES

4.1.1 Source of Supply

Presently, the Municipality of Irbid purchases most of its water from the Water Supply Corporation (WSC). WSC obtains the water from wells and springs in the Azraq, Dhuleil, and Sammaya areas which are approximately 60-to 120-kms east and south of Irbid. The WSC transmission system supplies not only Irbid, but most of the other north Jordan villages and municipalities.

The Municipality of Irbid maintains pumping stations at two springs as a source of water supply. These springs are located at Rahoub and Khreiba, 10-km northeast and 12-km north of Irbid, respectively. The present supply system is shown on Figure 4-1.

Supply from the WSC sources will continue until completion of the Jordan Valley Authority (JVA) North Jordan domestic water supply project in approximately 1984. This project will supply water to Irbid from the Yarmouk River. Initially, the supply will come from the river, but upon completion of Maqarin Dam, the supply will be from the reservoir. Water transmission facilities will be provided by JVA linking the Yarmouk supply to the WSC system.

4.1.1.1 WSC-Houfa Reservoirs.

These reservoirs are the terminal storage facilities for the WSC supply. At this site, there are two 6,000-cu m reservoirs, built in 1977, which

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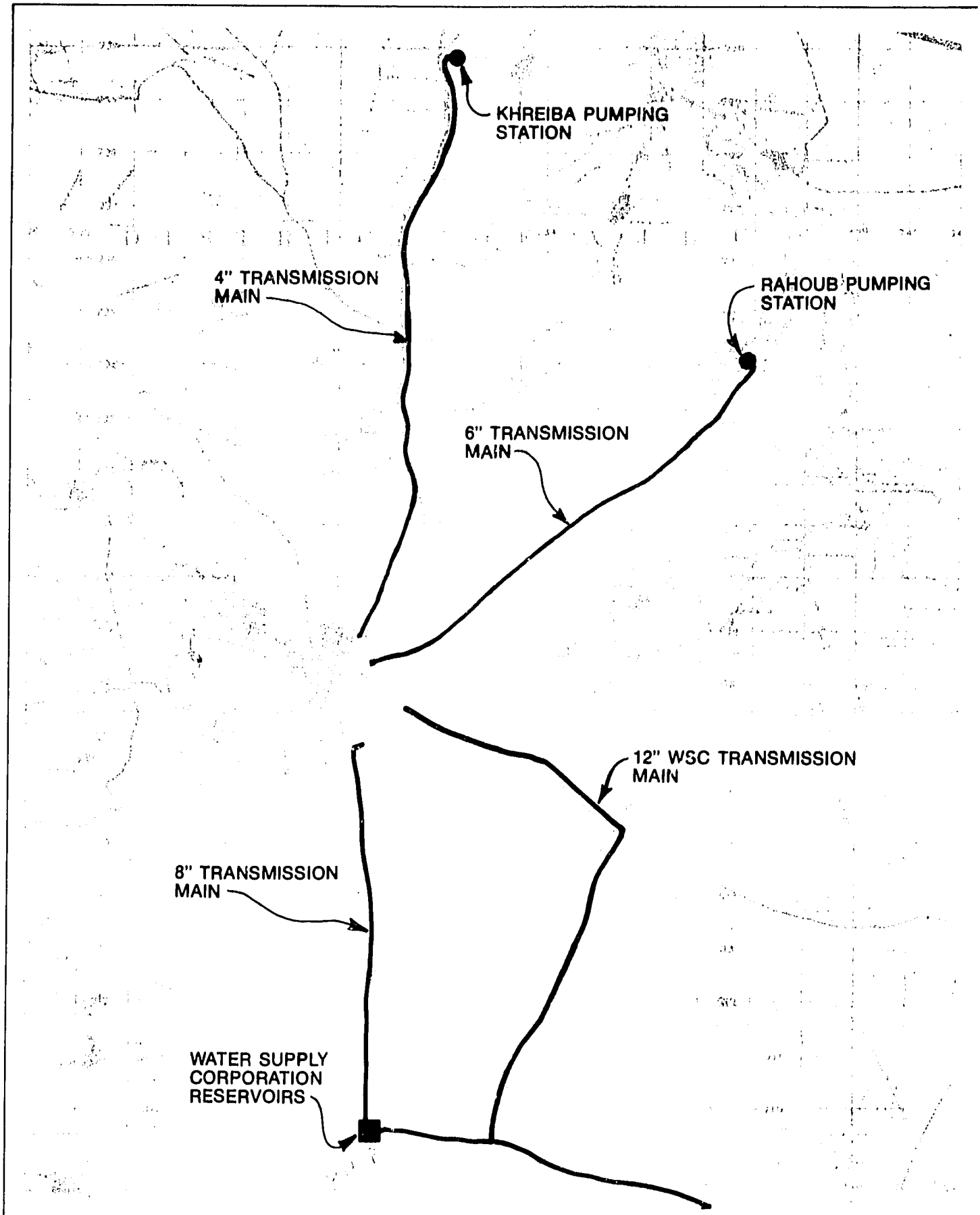

EXISTING IRBID WATER SUPPLY

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-1 DATE: SEPT. 1979 BY: CHECKED:

serve as the major supply to Irbid. An 8-inch (20 cm) main connects the reservoirs with Irbid. Immediately adjacent to the reservoirs WSC maintains a metering station. In early July 1979, this installation was supplying approximately 5,000 cu m/day.

The Houfa reservoirs are located at about elevation 800 m. At the current rate of flow, the delivery head in Irbid is about 630 m, giving a main pressure of approximately 529 kPa. Because of the size of the main connecting the reservoirs to Irbid, delivery of more than 5,500 cu m/day results in a delivery pressure too low for adequate distribution. Because of the limit on flow from Houfa to Irbid, the WSC is currently investigating increasing the amount of flow by either replacing the existing transmission main from the Zataary-Houfa line to Kairawan Circle (see subsection 4.1.1.2) with a 14-inch (35 cm) main, or by replacing the present Houfa-Irbid line with a 14-inch (35 cm) main. An analysis of these alternatives shows the first can deliver approximately 18,600 cu m/day from both Kairawan Circle and Houfa combined, while the second can deliver approximately 26,400 cu m/day. From the viewpoint of the Municipality of Irbid, replacement of the present 8-inch (20 cm) line from Houfa to Irbid is the preferred alternative.

4.1.1.2 WSC-Kairawan Circle.

The WSC transmission main which supplies the Houfa reservoirs has a branch main upstream of Houfa which supplies Husn, and then connects to the southeast corner of the Irbid system. This 12-inch (30 cm) main terminates at a metering, pressure reduction, and chlorination station near Kairawan Circle. Presently this connection supplies 1,400-1,700 cu m/day.

Delivery head is unknown, but the head in the transmission main where it branches to Husn and Irbid is greater than 800 m. The pressure reducing valves where the main terminates in Irbid reduce the pressure to about 60 m of head.

4.1.1.3 Rahoub and Khreiba Pumping Stations.

Supply from these sources is intermittent and variable in quantity. In 1979, these two sources combined provided 700-750 cu m/day. Supply to Irbid is by pumping from storage at each site.

The Khreiba station is connected to the Irbid system by a 4-inch (10 cm) galvanized iron pipe approximately 12-km long. The pumping capacity at Khreiba is 56 cu m/hour. Friction losses in the transmission line exceed the rated head of the pumps at the rated capacity. Since the pump curves are unknown, actual delivery quantities and heads cannot be calculated.

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A 6-inch (15 cm) cement-lined ductile iron pipe connects Rahoub and Irbid. This line is approximately 10 km in length, and has a branch line which supplies the village of Mughaiyir. The Rahoub pumping capacity is 210 cu m/hour. Friction losses in the transmission line again exceed the rated head of the pumps at the rated capacity. Actual delivery quantities and heads cannot be calculated because the pump curves are unknown.

4.1.2 Distribution System Description

The existing distribution system consists of a network of mains with appurtenances and two small storage facilities. There are no pumping stations within the distribution system. Supply to the system is as described in subsection 4.1.1.

4.1.2.1 Water Mains.

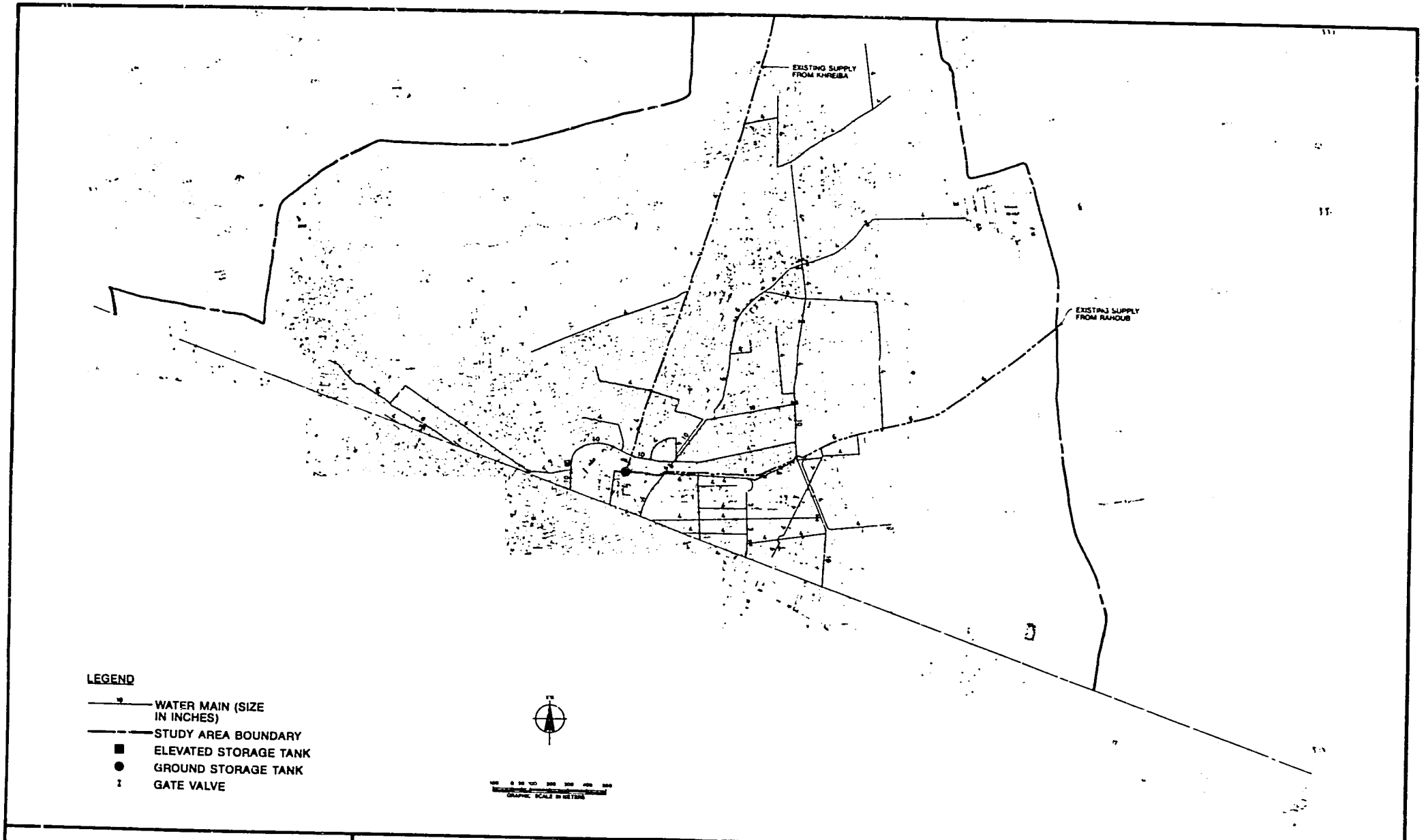
Within the system, pipes used as mains range from 1 inch (2.5 cm) to 10 inches (25 cm) in diameter. Locations and sizes of existing mains 2 inches (5 cm) in diameter and larger are shown on Figure 4-2a and b.

Most larger (greater than 2 inches) mains are buried to a depth of 40-60 cm. Some pipe is laid on the ground surface alongside the street. In highly developed areas, small diameter (less than 1 1/2-inches) pipe is sometimes placed in the gutter section of the street against the curb. Most mains are placed under the sidewalk or alongside the street.

1. Pipe Materials -- Galvanized iron pipe is used for almost all pipe 2 inches (5 cm) in diameter and smaller. Some 4-inch (10 cm) mains are also galvanized iron. Unlined (both internally and externally) steel pipe is used for mains 4 inches (10 cm) and larger. The only cement-lined ductile iron pipe is the line from Rahoub to the Citadel storage tank.

2. Pipe Joints -- Threaded connections are used for pipes up to 4 inches (10 cm) in diameter. Some 4-inch (10 cm) mains have welded joints, as does all larger pipe. Joint type on the ductile iron pipe is not certain, but is either a push-on gasket type or caulked lead.

3. Condition of Pipe -- Overall pipe condition is difficult to assess. Water Department personnel report that almost all of the pipe installed initially, 30 to 35 years ago, has had to be replaced. Most of this was unlined steel pipe. Pipe removed shows extensive corrosion, but no tuberculation. Based upon this information, a service



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EXISTING WATER SYSTEM

SHEET NO. FIGURE 4-2a

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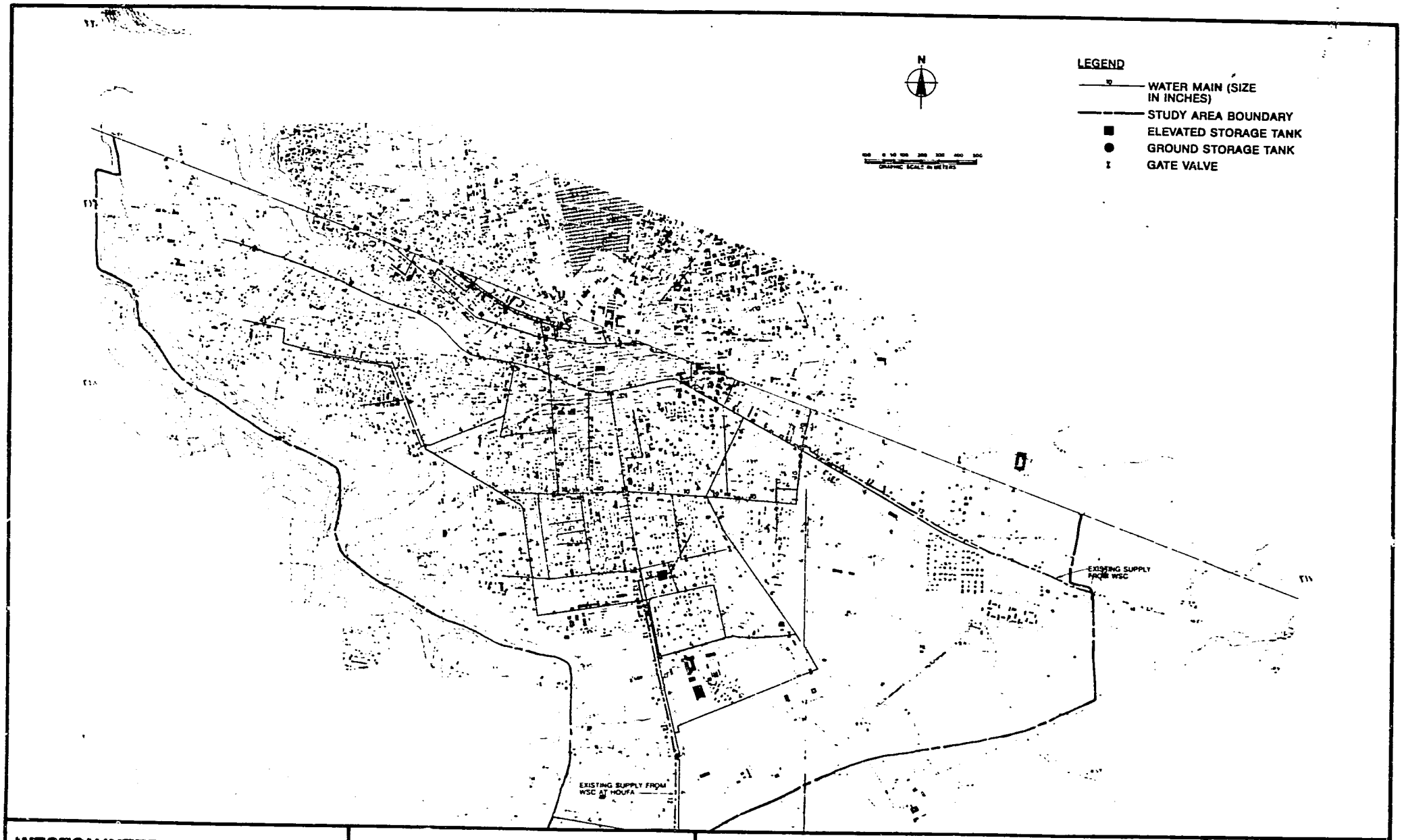

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EXISTING WATER SYSTEM

SHEET NO.
FIGURE 4-2b

DATE: SEPT, 1979

BY:

CHKD:

life of 20 to 25 years is assumed for unlined steel pipe. Overall corrosion rates do not seem to be excessive. Water quality is not of the type considered highly corrosive. However, the mains are alternately filled and drained during normal operation of the system, which is a more corrosive environment than if the mains remain full. External corrosion does not seem to be caused by soil type. The semiarid climate limits the amount of moisture in contact with the main.

Examination of Figure 4-2a and b shows that many of the distribution lines are not looped. Even where one main crosses another, there may not be a connection between the mains. The lack of looping and internal system connection indicates poor system reliability, and places a strain upon the hydraulic capacity of the system.

4.1.2.2 Distribution System Appurtenances.

1. Line Valves -- Known locations of line valves are shown on Figure 4-2. These are gate valves with flanged joints. The pressure rating of the valves is 1,725 kPa (250 psi) or greater. Most of the valves are installed in a small concrete chamber which has a cast iron frame and cover. Some of the valves are operated frequently to zone the system for supply purposes, but there is no regular program of valve exercise.

2. Air Relief Valves -- There are air relief valves within the system, but their type and location is unknown.

3. Hydrants -- There are no fire hydrants in the system. There were seven or eight points where provision was made for filling water tankers. The withdrawal arrangement is a 2-inch (5 cm) pipe with a valve. Field investigation located only three of these installations, two of which were valved, the other was capped.

4. System Meters -- These are meters which measure flows delivered to the distribution system. The WSC maintains meters at Houfa and Kairawan Circle. The municipality of Irbid meters the supply from Khreiba and Rahoub. The master meter at Rahoub is a 6-inch (15 cm) Prema manufactured in Czechoslovakia. It was not possible to field check the accuracy of the Khreiba or Rahoub meters.

4.1.2.3 Water Tankers.

The Irbid water Department maintains one 6-cu m and three 11-cu m

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tank trucks to supply water to customers not connected to the distribution system or not able to receive water because of pressure deficiencies.

4.1.2.4 Residential Connection Details.

The standard residential connection is a 1/2-inch diameter galvanized iron pipe. There is a shutoff valve on the building side of the meter, but none on the system side. To remove the meter for servicing requires shutting down the distribution main. In some locations the tap to the main and service are all above ground. Meters from several manufacturers have been used.

Residences may be set back from 2 m to 20 m from the main. All consumers have local storage, either a roof tank(s), underground tank(s), or both.

4.1.2.5 Commercial and Industrial Connection Details.

There is essentially no difference between residential and commercial or industrial connections. The exceptions are the dairy and slaughterhouse, both of which have 2-inch (5 cm) meters with a capacity of 30 cu m/hour.

4.1.3 Water Storage Facilities

Other than the Houfa reservoirs, which are owned and maintained by WSC, there are two small storage tanks within the distribution system: a ground storage tank on the Citadel, and an elevated tank just north of the present location of Yarmouk University. Location of these tanks is shown on Figure 4-2.

4.1.3.1 Ground Storage Tank.

This tank was part of the original Irbid water system and is about 40 years old. The tank is a circular, reinforced concrete structure on a limited site. The tank is covered and rests on a circular concrete pad. The transmission lines from Rahoub and Khreiba discharge to this tank, and there are three 4-inch (10 cm) effluent lines from the structure. The capacity of the tank is about 240 cu m. The bottom of the tank is at elevation 570 m and the top is at 577 m.

The interior condition of the tank is unknown. Reportedly, the tank has never been cleaned. Condition of the exterior is fair to poor with small areas of exposed reinforcing bars. There are no signs of settlement of the base. Approximately a quarter of the circumference of the tank shows a joint left when pouring the concrete. There has been water leakage through this joint.

4.1.3.2 Elevated Storage Tank.

This tank was constructed as part of the 1967 expansion of the system. It is a rectangular reinforced concrete structure witn reinforced concrete columns and cross beams. The area between the columns at the base has been enclosed to provide a residence for the tank operator.

Ground elevation at the tank is 581 m. The bottom of the tank is at 591 m, and the top is at 596 m. The outside dimension is 6.6 m by 6.6 m. Tank volume is approximately 175 cu m.

The structure appears to be in good condition, with the exception of two facing cross beams. On one beam, the concrete has spalled and the reinforcing bars are exposed. On the opposite cross beam, spalling is more pronounced and the top longitudinal reinforcing bars are broken.

The supply line from the Houfa reservoirs is connected to the Irbid system at this point. Valving at the connection permits bypassing the elevated tank.

4.1.4 Water Pumping Facilities

There is no internal pumping within the distribution system. The Water Department maintains pumping stations at Rahoub and Khreiba to provide water supply to the system.

4.1.4.1 Rahoub Pumping Station.

The pumping station is about 9 km northeast of Irbid at an elevation of approximately 400 m. There are four buildings on the site: the pump house, warehouse, chlorination building, and residence and office.

Water flows from two springs, Forat and Shallala, to an underground concrete reservoir (about 500-cu m capacity) which serves as a wet well for three pumps. Two are KSB pumps with a capacity of 70 cu m/hour at a head of 265 m, installed in 1952. The other is a KSB pump with a capacity of 70 cu m/hour at a head of 275 m, and was installed in 1976. The pumps are provided with pressure gauges and check valves. One of the older pumps leaks water and needs new gaskets.

The older pumps are powered by Duetz A4 m engines, while the new pump is driven by a Daimler-Benz AGT engine. All engines are equipped with temperature, oil pressure, and rpm gauges. Only one pump is operated at a time, and one month's fuel is stored at the site.

Chlorination is accomplished in the flow from Shallala spring. Chlorine residual of the pumped water is determined and recorded.

4.1.4.2 Khreiba Pumping Station.

This station is about 12 km north of Irbid at an elevation of about 425 m. There are two pump houses and a combined residence and office.

Water flows to the site in an ancient (Roman) underground conduit to a reservoir, which is the wet well for the pumping station. There are three pumps. The oldest was installed in 1959 and is a KSB pump rated at 22 cu m/hour at a discharge head of 280 m. This pump is powered by a 53-hp Daimler-Benz engine. Both the pump and motor are not functioning and need repairs. A KSB pump with a capacity of 18-22 cu m/hour at a head of 240 m was installed in 1970. This pump is driven by a 53-hp Man engine. Another KSB pump with a capacity of 35 cu m/hour at a head of 265 m was installed in 1976. This pump is driven by a 79-hp Daimler-Benz engine.

The water is chlorinated, and the chlorine residual is determined and recorded.

4.1.5 Chlorination Facilities

The supply from WSC is chlorinated. Chlorination facilities are also available at the elevated storage tank and Kairawan Circle to provide additional chlorination, if required. Chlorination is handled at the pumping stations at Khreiba and Rahoub.

Chlorination equipment consists of five Advance chlorinators, Model No. 201. Four of these are installed at the locations just discussed, and the fifth is a stand-by. These are cylinder-mounted chlorinators. The Water Department uses 50-, 75-, and 100-kg cylinders.

Normal chlorine residuals are 0-1 mg/L. If mains have been empty, superchlorination is practiced. The Health Department of the Municipality of Irbid is responsible for testing for residual chlorine in the distribution system.

4.2 OPERATION OF EXISTING SYSTEM

The Water Department of the Municipality of Irbid is responsible for all water system operations within Irbid and the two pumping stations at Khreiba and Rahoub. Most of the responsibility for quantity and quality of the water supply lies with WSC.

4.2.1 Water Supply Operation

4.2.1.1 Adequacy of Supply.

Until 1978, the only connection of WSC supply to Irbid was at Kairawan

Circle. Due to hydraulic characteristics, insufficient supply was available to meet system demands. In addition, the WSC well fields did not have sufficient capacity to supply all of their service area. In 1978, additional supply from the Sammaya wells was made available, and storage at Houfa with a new connection to the Irbid system was installed.

The presence of the Houfa storage tanks ensures a more continuous supply. Previously, when WSC was not able to pump, Irbid did not receive any water. Supply is still not able to meet the demand. Part of the problem is the undersize line from Houfa to Irbid.

4.2.1.2 Water Quality.

Chemical water quality is checked at the wells by the Natural Resources Authority. Results of these investigations are given in subsection 3.2.4. The only significant problem is a high nitrate content in some of the wells.

Bacteriological quality of the water delivered by the distribution system is measured by the Ministry of Health. Results of sampling in 1979 are given in Table 4-1. Since the water supply is from wells, it is assumed that most positive bacteriological tests are caused by contamination in the supply or distribution systems. Incidents of no pressure or dewatered mains contribute to potential contamination.

4.2.2 Operation of Existing Distribution System

4.2.2.1 System Hydraulics.

The elevated storage tank is approximately 20 m higher than the ground storage tank. System pressures are so low, however, that usually the elevated tank does not contain water. A pressure survey done as part of this study showed pressures ranging from 0 to 395 kPa. Of the seven readings, four were below 65 kPa.

Table 4-1

Bacteriological Water Quality

Month	Number of Samples	Number of Positive Samples	Percent Positive
January	46	3	6.5
February	33	5	15.0
March	36	3	8.3
April	47	5	10.6
May	54	3	5.5
June	37	3	2.5

Source: Ministry of Health

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4.2.2.2 Alternating Service Plan.

A lack of sufficient supply necessitates dividing the system into areas which receive water on a schedule. Prior to 1978, each area of the municipality received water service one day per week. With the greater supply available now, water is supplied every day to half of Irbid. Palestine Road divides the system for supply purposes.

4.2.2.3 Operating Agency.

The Water Department of the Municipality of Irbid operates and maintains the facilities described, and is also responsible for all record-keeping, billing, and administrative tasks. Organization of the department is as follows:

Mayor

Water Division Director

Financial	Administration	Technical		
Accounting Typing Meter reading Stores	Files Guards	Maintenance Crews 5 crews	Meter Workshop	Inspectors and Operators Storage tanks Pumping stations Chlorination
42 persons	8 persons	20 persons	5 persons	16 persons

The only major equipment consists of four water tank trunks. The Water Department has an excellent facility for testing and repair of water meters. Other equipment consists primarily of hand tools.

4.2.3 Unaccounted for Water

The difference between water delivered to the system and water sold is unaccounted for water. Table 4-2 presents recorded amounts of unaccounted for water for the years 1976-1978. The percent of unaccounted for water is very similar to that reported for other Jordanian communities. Unaccounted for water consists of leakage from the system, water taken from the system without metering (illegal taps), and metering errors.

Table 4-2

Unaccounted for Water

Year	Water to System (cu m)	Water Sold (cu m)	Percent Unaccounted for
1976	1,157,200	865,300	25.2
1977	1,591,900	1,085,200	31.8
1978	1,752,400	1,314,500	25.0

Source: Stanley Consultants

As meters wear they tend to under-register the amount of water passing through the meter. Since the Water Department has a program of maintaining meters, this contribution to unaccounted for water is probably at a minimum. The master meters to the system are all either new or measure only a small portion of the flow, except the installation at Kairawan Circle. Total water delivered measurements should be accurate. Metering errors should not be making a significant contribution to unaccounted for water.

The relative contributions of leakage and illegal taps to unaccounted for water are unknown. The Water Department reports that in 1979 a significant reduction in unaccounted for water was realized by the removal of illegal taps. The age and type of materials used in the distribution system, however, indicate a high potential for significant system leakage. Only further study will be able to resolve the question.

4.2.4 Maintenance

4.2.4.1 Water Distribution System.

Major maintenance activities consist of repairing leaking mains and replacement of mains. There is no program for exercising valves.

4.2.4.2 Storage Facilities.

There is no regular maintenance program for the storage tanks.

4.2.4.3 Pumping Facilities.

Regular maintenance of pumps and engines is carried out. The transmission mains to Irbid are inspected regularly. Obtaining parts for equipment is a major problem.

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4.2.4.4 Meters.

The Irbid Water Department has an excellent facility for testing residential water meters. There is a regular program conducted by the Water Department of checking system meters and repairing defective meters.

4.3 PROJECTED WATER USE/DEMAND ESTIMATES

4.3.1 Estimated Water Demand

The water demand projected for the Municipality of Irbid is based on an examination of the following data resources:

1. Current water use statistics for Irbid.
2. Available water supply studies for North Jordan.
3. Water supply studies for similar developing areas.
4. Experienced water use statistics in similar developing areas.
5. Estimates of projected water availability in Irbid.

4.3.1.1 Data Review for Irbid Area.

1. Data Presentation.

Of the four major socioeconomic studies reviewed in Chapter 2, the "National Water Master Plan of Jordan," the "Water Use Strategy for North Jordan" by Howard Humphreys, and the "Yarmouk River Feasibility Study," all offer independently-derived projections of water demand in the Municipality of Irbid. The "Integrated Regional Development Study of the North Jordan" by the Japan International Cooperative Agency (JICA) accepts the figures put forth by the Humphreys report.

Table 4-3 and Figures 4-3 and 4-4 depict the available estimates of current water use, current demand, and projected demand for Irbid. The data which are presented include total and domestic water use. These data represent estimates of average water demand. The total water demand figure represents system losses, and industrial/commercial/institutional estimated requirements, in addition to the domestic demand cited in Table 4-3. It can be seen that while there is wide disagreement as to current demand, the Master Plan and the Water Use Strategy for North Jordan report come to almost complete agreement on total demand for the year 2000. It can also be seen that the Yarmouk River study is consistently high, and that current demand greatly exceeds current metered use rates in Irbid Municipality.

2. Assumptions.

The three studies cited rely on basic assumptions in deriving projected and current water demand:

a. Water Use Strategy for North Jordan.

- Initial domestic consumption for Irbid will be between that of Amman (80 liters/capita/day), and that of towns with populations in excess of 15,000 (65 liters/capita/day) (Vol. 3, p. 72).

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Table 4-3

Experienced Water Use, Current and Future Demand
Estimates for Irbid Municipality (liters/capita/day)

Source	Type	1975	1979	1984	1985	1989	2000
Master Plan	Domestic	85			110		120
	Total	131			157		158
Vol. VI, p. 41							
Water Use Strategy	Domestic	70			80		95
	Total	112					156
Yarmouk River	Domestic		78	88		98	
	Total		130	160		200	
Irbid Water Dept. Data	Domestic Only[1]	21	28				

[1] Does not include trucked-in water

Source: Stanley Consultants

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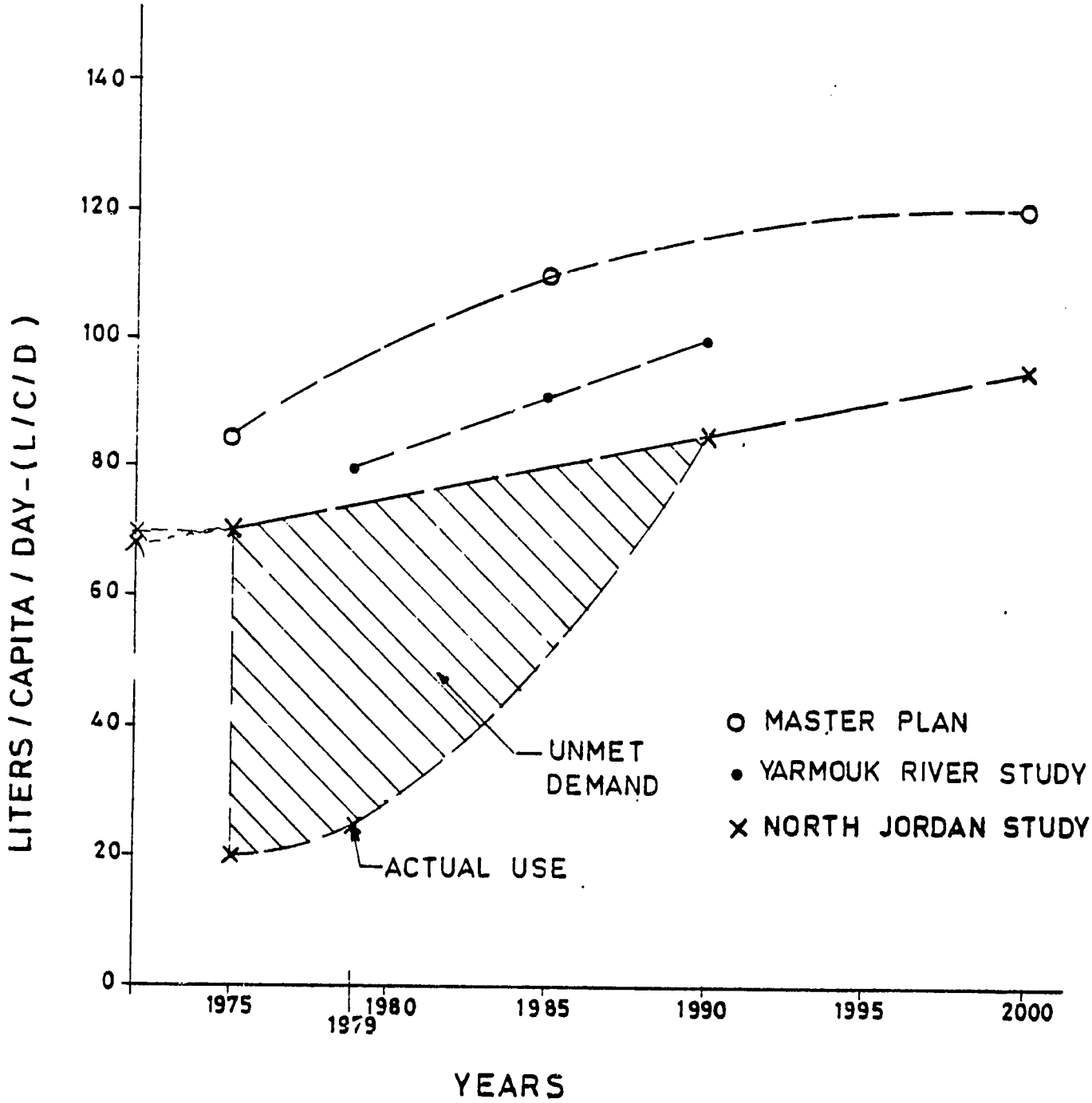

DOMESTIC WATER USE

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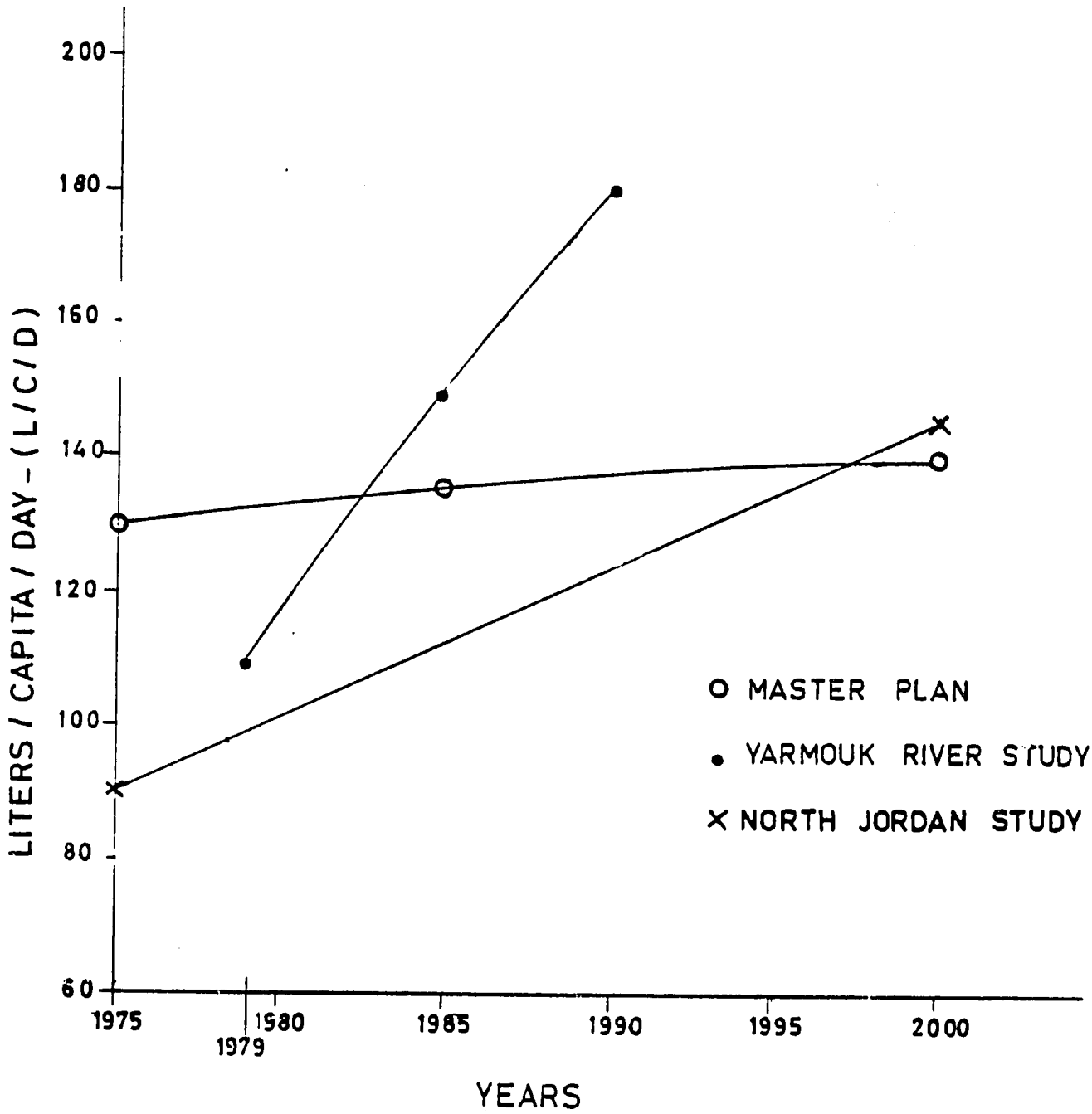
WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-3 DATE: SEPT. 1979 BY: F.R CHECKED: P. J. H.



TOTAL WATER USE

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4 - DATE: SEPT. 1979 BY: F. R CHECKED P. J.

- Irbid's growth will be comprised in larger part by immigration of relatively poor people (Vol. 3, p. 76).

- Irbid plans an extended sewerage system for the future (Vol. 3, p. 76).

- Improved water supply in Irbid (Vol. 3, p. 76). Refer to subsection 4.3.1.3.

- Increase in proportion of connected houses in Irbid (Vol. 3, p. 76).

- Increases in per capita income will permit this level of residential use (Vol. 3, p. 66-70).

b. Yarmouk River Feasibility Study.

- By 1989, there will be a "reliable and sufficient" water supply system (p. 88).

- By 1989, there will be a sewerage system to serve the more densely built-up area of the city (p. 88).

- Nearly every household will be connected (p. 88).

- Nearly everyone will bathe once a day (p. 88).

- A majority (70%) of the population will have flush toilets (p. 88).

- The main domestic improvement before 1984 will be the installation of flush toilets (p. 88).

c. Water Master Plan (Composite assumptions for Amman, Zarqa, and Irbid).

- Expected improvement in standard of living (Vol. VI, p. 39).

- "Appropriate standards" of water supply and sanitary facilities (Vol. VI, p. 39).

As stated earlier, the JICA study adopted the assumptions and corresponding projected water demand statistics of the Water Use Strategy for North Jordan (Chapter V of JICA Report).

4.3.1.2 Data Review for Similar Developing Areas.

The following is a review of experienced and projected water use statistics for other developing areas taken from studies other than those previously mentioned.

1. Freetown, Sierra Leone (Source: "Master Plan Feasibility and Engineering Studies," 1977)

   1974 data:
   Poor area of 65,000 persons
   125 liters/capita/day domestic use
   Affluent area (engineers, doctors, living in apartments):
   177 liters/capita/day domestic use

2. Estimates of Water Demand in the Middle East and Mediterranean (Source: "Water Use Strategy for North Jordan," Vol. 3, p. 83).

City	Year	Total Demand (liters/capita/day)
Athens	1974	128
Suez	1975	130
Jerusalem	1965	146
Istanbul	1974	156
Beirut	1971	166
Baghdad	1965	166
Riyadh	1970	172

3. 1975 Domestic and Commercial Water Use in Jordan Towns (Master Plan, Vol. VI, p. 28)

Aqaba	86.9 liters/capita/day
Wadi Sir	67.5 liters/capita/day
Suweileh	71.0 liters/capita/day
Jarash	59.2 liters/capita/day

4. Zarqa Water Use (Source: "Wastewater Disposal and Stormwater Drainage for City of Zarqa," Scan Plan/Jousy & Partners, 1975).

Current consumption	40 liters/capita/day
Year 2010 consumption	85 liters/capita/day

5. Water Sales to Amman Customers (VVB Report, p. 5-7).

Year	Domestic Water Delivered
1975	46 liters/capita/day
1980	56 liters/capita/day
1985	60 liters/capita/day
1990	70 liters/capita/day
2002	94 liters/capita/day

Does not include trucked-in water.

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6. Amman Current Residential Use Interred From Sewage Treatment Plant Influent.

80 liters/capita/day (includes water from all sources)

Developed in subsection 3.3.3

This corresponds closely to the Water Use Strategy for North Jordan estimate for the residential use in Amman in 1977.

7. Amman Current Residential Use Calculated From Amman Water and Sewerage Authority.

Total water bought by AWSA	16 million cu m/year
Total number of customers (approx.)	350,000
Total water use	125 liters/capita/day.
Losses (20%)	25 liters/capita/day.
Nonresidential use (20%)	25 liters/capita/day
Domestic use	75 liters/capita/day

This is not distinguishable from the estimate of water use derived from sewage treatment influent.

4.3.1.3 Total Available Water.

Several reports outline the availability of water for years between 1975 and 2000. The Water Use Strategy for North Jordan report reviews a number of potential plans to provide water to Irbid. Some plans, while they provide large amounts of water (in excess of 30 million cu m by the year 2000), are rejected because they are too expensive. Other plans which involve less expense are rejected because they do not provide enough water. The recommended plan allows for up to 12 million cu m/year to be initially available to Irbid from the Maqarin Reservoir. Ultimately (year 2002), a supply of 23 million cu m/year could be pumped by gravity from a reservoir at Beit-Ras to Irbid (Vol 5, p. 35-40). A total of 23 million cu m/year would provide a total (residential/commercial/industrial/institutional) of over 170 liters/capita/day. These data are used to substantiate the year 2000 domestic use/demand figure of 95 liters/capita/day.

The Yarmouk River study considered only water demand and source development before 1990. This did not include development of the Maqarin Reservoir as a source. This report, however, recommended the Maqarin Reservoir as a future source. Unfortunately, the Yarmouk River study

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does not specifically address the problem of meeting the demand in Irbid with the supply of water from the Yarmouk River. However, this study predicts availability of 24 million cu m per annum from the Yarmouk River for the Irbid area before 1990.

The National Water Master Plan similarly makes no specific reference to how the water demand in Irbid will be matched with developable, affordable supply.

4.3.1.4 Statistics Adopted in this Report.

The current water demand and projected water demand/use figures to be used in this report are as follows (liters/capita/day):

	1975	1980	1990	2000
Domestic	70	75	85	95
Total	118	126	144	160

Of course, it must be remembered that current demand is no being met. The future system losses are estimated as 20 percent of the total, and commercial/industrial/institutional use is 20 percent of the total as well.

4.3.1.5 Assumptions and Parameters.

The selection of water demand figures for this report involves three factors:

1. Acceptance of relevant assumptions in other reports.

2. Correspondence between projected demand and available supply.

3. Verification of water use by means of sewerage influent characteristics.

Many of the assumptions put forth by the Yarmouk River study are held questionable here. For example, the available water supply may very well not be as large as they have estimated. In any event, the Yarmouk River study population projections have been discredited sufficiently to preclude any water use projections based on them. (See Section 2.2 and the Water Use Strategy for North Jordan, Vol. 3, p. 32-40). Furthermore, many of the Yarmouk River study assumptions concerning the increased quality of life are overly optimistic.

The National Water Master Plan does not, unfortunately, put forth detailed assumptions to support their projected water demand data. Furthermore, they do not offer evidence that supply will meet demand. Consequently, while this report's figures do not differ drastically from those of the Master Plan, further support than that of the Master Plan is necessary.

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All of the assumptions outlined by the Water Use Strategy for North Jordan (subsection 4.3.1.1, item 2.) are objectively and subjectively reasonable. Furthermore, our independent calculation of domestic water use in Amman (80 liters/capita/day) corresponded very closely to that of the Water Use Strategy (84 liters/capita/day for 1979). Since the initial water demand for Irbid was derived by comparison with Amman, our field verification of Amman domestic use lends solid credence to the initial demand figure.

Furthermore, the Water Use Strategy for North Jordan gives strong evidence that there will be a large enough supply in the year 2000 to meet their projected demand. The 1980, 1985, and 1990 projected demands, based on linear interpolations of reasonable demand levels for 1975 (70 liters/capita/day) and (95 liters/capita/day) are similarly reasonable.

The review of available statistics for current and projected use and demand in Jordan and elsewhere similarly support our selected demand figures. In fact, our data are conservative with respect to most of the other available data.

We conclude that our selected figures of 70 liters/capita/day for current unmet domestic demand, increasing to 95 liters/capita/day, are eminently reasonable, and represent the best possible use of available data supplemented with reliable field verification.

4.3.2 Water Use

Actual water use is virtually equivalent to demand by the year 1990. Figure 4-3 illustrates the fact that the unmet demand is exceeded by upwards of 50 liters/capita/day at the beginning of the project period. Between 1984 and 1990 the demand and actual use converge.

4.3.2.1 Current Water Use Patterns in the Irbid Municipality.

Metered water use data were compiled for Irbid for the winter months of 1975 and 1978. The following is a breakdown of the daily use rates (which do not include trucked-in supplies) by subarea type.

Subarea	1975 liters/capita/day	1978 liters/capita/day
A,B	30	42
C	16	21
D	12	14
E	11	9

Areas A and B were combined to yield a total which would approximate current use rates among the affluent communities in Irbid. This was done because A areas are presently not developed.

These per capita current use rates of metered municipal supplies were divided by the average to yield water use dispersion factors:

Subarea	Dispersion Factors 1975	1978
A,B	1.74	1.95
C	0.93	0.98
D	0.70	0.65
E	0.64	0.42

The average dispersion factor is 1.00. These numbers can be applied to projected domestic water use rates to yield disaggregated rates of domestic consumption by subarea.

4.3.2.2 Application of Dispersion Factors.

The 1978 record of dispersion was applied to the 1990 population to yield disaggregated projected water use. The 1975 record was applied to the year 2000 to reflect:

1. Increasing water use as more poorer households connect to the system.

2. Decreasing water use in affluent areas when home construction is completed.

1990 Water Use Disaggregation
(liters/capita/day)

Subarea	Dispersion Factors	Domestic Use	Total Use
A	1.95	200	340
B	0.98	101	172
C	0.65	67	114
D	0.42	45	76
E	0.42	45	76

2000 Water Use Disaggregation
(liters/capita/day)

Subarea	Dispersion Factors	Domestic Use	Total Use
A	1.74	177	300
B	0.93	94	160
C	0.70	72	122
D	0.64	65	110
E	0.64	65	110

The average water use weighted by population in each subarea was in both cases within ±5 liters/capita/day of the projected average use. The difference, of course, occurred because subareas are unequal in size. Each disaggregate water use factor was multiplied by the percent deviation of the calculated weighted average from the projected average. For both 1990 and 2000 only one iteration was required to get the weighted average within ±0.5 liter/capita/day of the projected average.

The basic assumption behind these data is that future variability in water use will reflect past variability. By the year 2000, however, even the poorest areas in Irbid will be using 65 liters/capita/day. It is conceivable that within subareas there will be dispersion in water use. The system is designed to handle this possibility.

4.3.2.3 Breakdown of Domestic Water Use.

This section reviews available data on the lifestyle attributes which will contribute to the increased water use/demand by the year 2000. We make no attempt, however, to predict the precise reasons for increased consumption in Irbid municipal subareas.

Yarmouk River Study (p. 87)

	Type of Consumer	Total Domestic Water Use (liters/capita/day)
1.	Flush toilet, long bath	130
2.	Flush toilet, shower	107
3.	No flush toilet	70
4.	Shares a tap	40
5.	Tap more than 500 m from dwelling	25

By the year 2000 the average consumer type in Irbid should be type 2.

4.3.3 Demand Versus Use

Figure 4-3 demonstrates that current water use statistics are far short of demand. As yet there has not been a reliable estimate of total domestic water use for households utilizing an insufficient water distribution system. Under these circumstances total domestic water use for an individual household would involve:

1. Metered piped-in water from municipal sources.
2. Water borrowed from neighbors.
3. Trucked-in supplies.
4. Water from public taps.
5. Bottled water purchased for consumption.

The Irbid municipal average consumption factors of 21 liters/capita/day for 1975 and 28 liters/capita/day for 1979 document only that water was piped in from municipal sources and registered on a City meter. Thus, the excess of demand over actual use (the shaded area of Figure 4-3) is an overestimate.

Experienced water use will not become equivalent to demand immediately upon the construction of an adequate water system. Rather, use will approach demand asymptotically. Several factors will delay matching demand with actual use:

1. The delay in getting individual homes hooked into the system. This can be brought about in two ways:

   a. Limitations in the number of men and equipment available to perform the work.

   b. Reluctance of homeowners to hook up and incur additional costs (new or rearranged internal piping, costs of new laterals, hook-up fees, etc.).

2. The delay in purchasing those household items needed to consume water (tubs, sinks, toilets, etc.).

3. The retention of former more conservation-oriented water use habits.

4. The continuance of use of purchased water for consumption until it is clear that piped-in sources no longer represent a health danger.

5. Continued maintenance of water tanks and trucked-in supplies until the new system is fully constructed or it becomes clear the new system is fully reliable.

Since we expect almost complete connection of all existing homes in Irbid by 1990, and an efficient, reliable water distribution system by that time, estimated use rates should match demand by 1990.

4.4 ANALYSIS OF ALTERNATIVES

4.4.1 Definition of Alternatives

4.4.1.1 Future Source of Supply.

JVA is presently completing plans for water supply to northern Jordan and Irbid from the Yarmouk River. The supply will initially be from the Yarmouk River, and later from the Maqarin Reservoir. Until Maqarin Reservoir is completed, low flows in the river will restrict the amount of water available to Irbid through this project. The JVA project is shown on Figure 4-5. From a water treatment plant near the Yarmouk River,

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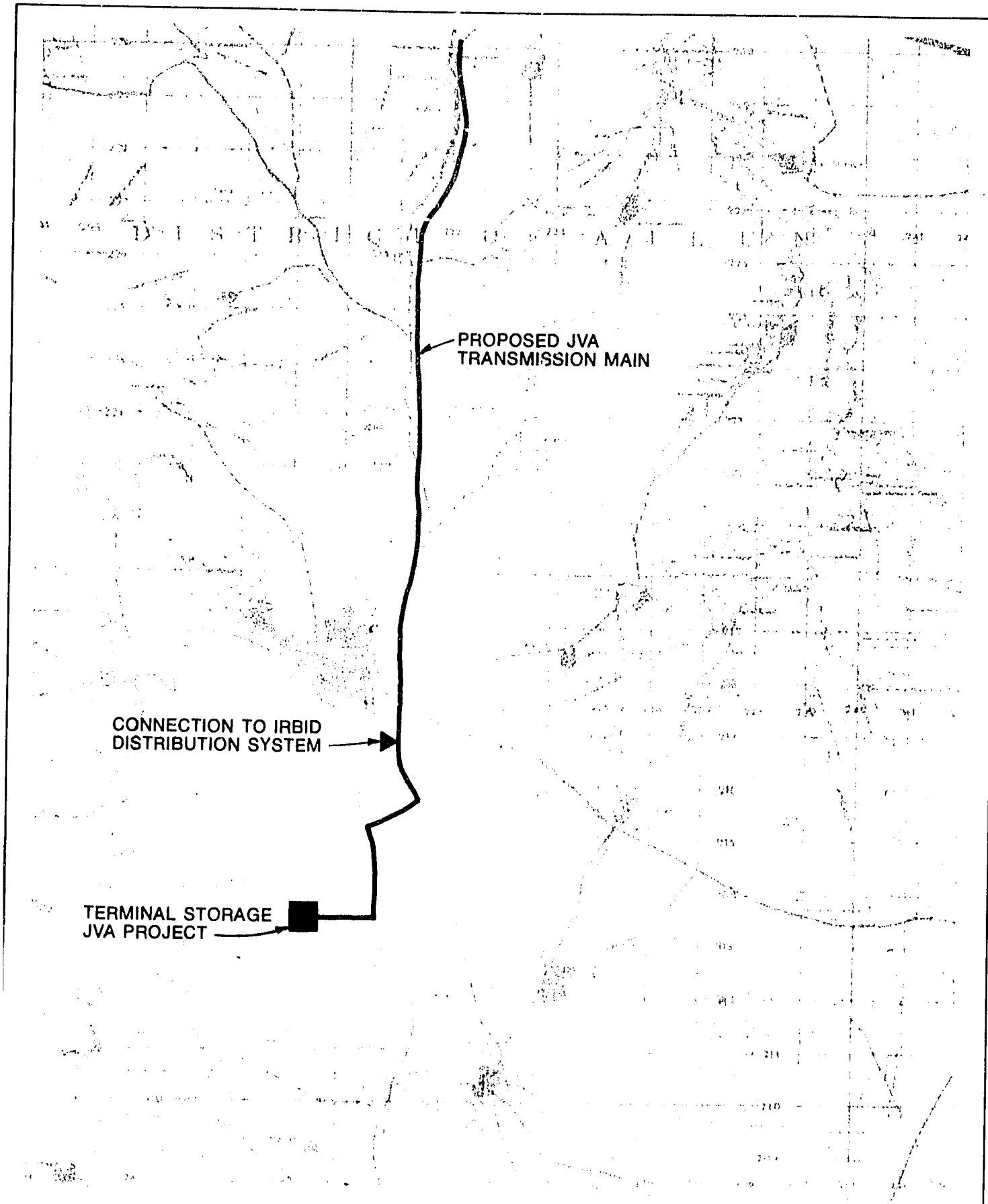


FUTURE WATER SUPPLY

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co.Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-5 DATE: SEPT.1979 BY: CHECKED:

water will be pumped to two 55,000-cu m reservoirs near Natifa. These reservoirs will be at about elevation 710 m, over 100-m higher than the highest portions of the existing Irbid system. Since this project will not be complete until approximately 1984 or later, alternatives will have to be able to utilize both the existing and future sources of supply.

4.4.1.2 Alternatives.

Four alternative water distribution strategies within the Municipality of Irbid were evaluated. Each alternative assumes that the present sources of supply will eventually be phased out of service upon completion of the JVA North Jordan domestic water supply project. The best apparent alternative must be capable of distributing water throughout the municipality while present water supplies are being utilized. It must be easily adapted, however, to accept water from the JVA project once this becomes a viable source of supply. In addition, there is over 155 m of ground surface relief within the year 2000 planning area requiring a distribution system layout with multiple pressure zones.

1. Alternative 1.

With Alternative 1, water supplied by the JVA project is supplied to the northern portion of the Irbid water distribution system, the area with the lowest ground surface elevation. From this area, the water is pumped uphill to successively higher service zones by utilizing a series of booster pump stations with storage reservoirs located near each pressure zone boundary. The water pressure in each zone will be maintained by elevated tanks and by the pumping head at the booster pump stations.

2. Alternative 2.

This alternative utilizes multiple connections between the eastern portion of the distribution system and the JVA project transmission main. Each pressure zone will receive water directly from this high pressure supply line. Transmission main pressures will be reduced by pressure reducing valves to values usable in the system. Pressure zones will also be interconnected by pressure reducing valves to allow the higher zones to supply the lower zones where necessary. No booster pumps, elevated or ground storage tanks are needed for this alternative. Once the water enters the distribution system it flows by gravity to areas of lower elevation.

3. Alternative 3.

This alternative is similar to Alternative 2 except that all of the water supply enters through a single connection between the JVA project supply line and the distribution system at the southern end of the City. The location of this connection at elevation 595 allows most of the water needed by Irbid to enter the distribution system before it is

pumped to the Natifa reservoirs at a much higher elevation, resulting in lower pumping costs for the JVA project. Since this connection is located over 100 m below the Natifa reservoirs, water can backflow through the supply line from the reservoirs to the distribution system with sufficient head to maintain adequate system pressure when water is not being pumped through the transmission main. Once water has entered the system, it will be distributed by gravity to each successively lower service zone. No pumps or elevated or ground storage tanks are needed within the City for Alternative 3.

4. Alternative 4.

Alternative 4 takes all the water that is to be utilized by Irbid directly from the Natifa reservoirs. A large separate water main will be built to connect the reservoirs with the southern end of the Irbid distribution system. Water will flow by gravity from the reservoirs to the distribution system. Sufficient hydraulic head can be attained by the difference in ground surface elevations between the reservoirs and the southernmost portion of the distribution system to maintain adequate service pressures. As in Alternative 3, the water will be distributed by gravity with no pumping or distribution storage required.

4.4.2 Best Apparent Alternative

Alternative 3 is considered the best apparent alternative for the distribution of water in Irbid. This alternative was chosen for the following reasons:

1. The system distributes water totally by gravity, eliminating the need for pumps and storage tanks within the municipality.

2. The distribution system is connected directly to the JVA project transmission main, eliminating the need for separate feed lines.

3. Water from the Natifa reservoirs can backflow to the distribution system through the JVA project transmission main.

4. The single connection at the southeastern corner of the distribution system can easily accommodate a pipe looping concept within the distribution network.

5. System operation and maintenance are simplified with a single connection. The single connection also consolidates record-keeping for water delivered to Irbid.

6. Existing water supplies can easily be accommodated by the distribution system.

Alternatives 1 and 4 have been rejected as viable distribution strategies due to cost factors. In Alternative 4, the cost for construction of about 2 km of large diameter feed line from the Natifa reservoirs is an expense that is not incurred with Alternative 3. Alternative 1 requires a large expenditure for the installation of booster pumps, ground and elevated storage tanks, and the expense of continual operation and maintenance of these facilities.

Hydraulically, Alternative 2 was found to be similar to Alternative 3. No significant advantages were found to indicate that Alternative 2 should be used. In Alternative 2, major distribution mains did not follow the planned development of Irbid as well as in Alternative 3. Multiple connections with the JVA project supply line increase the duties of Irbid Water Department personnel. The arrangement of major distribution mains would not accommodate existing sources of supply.

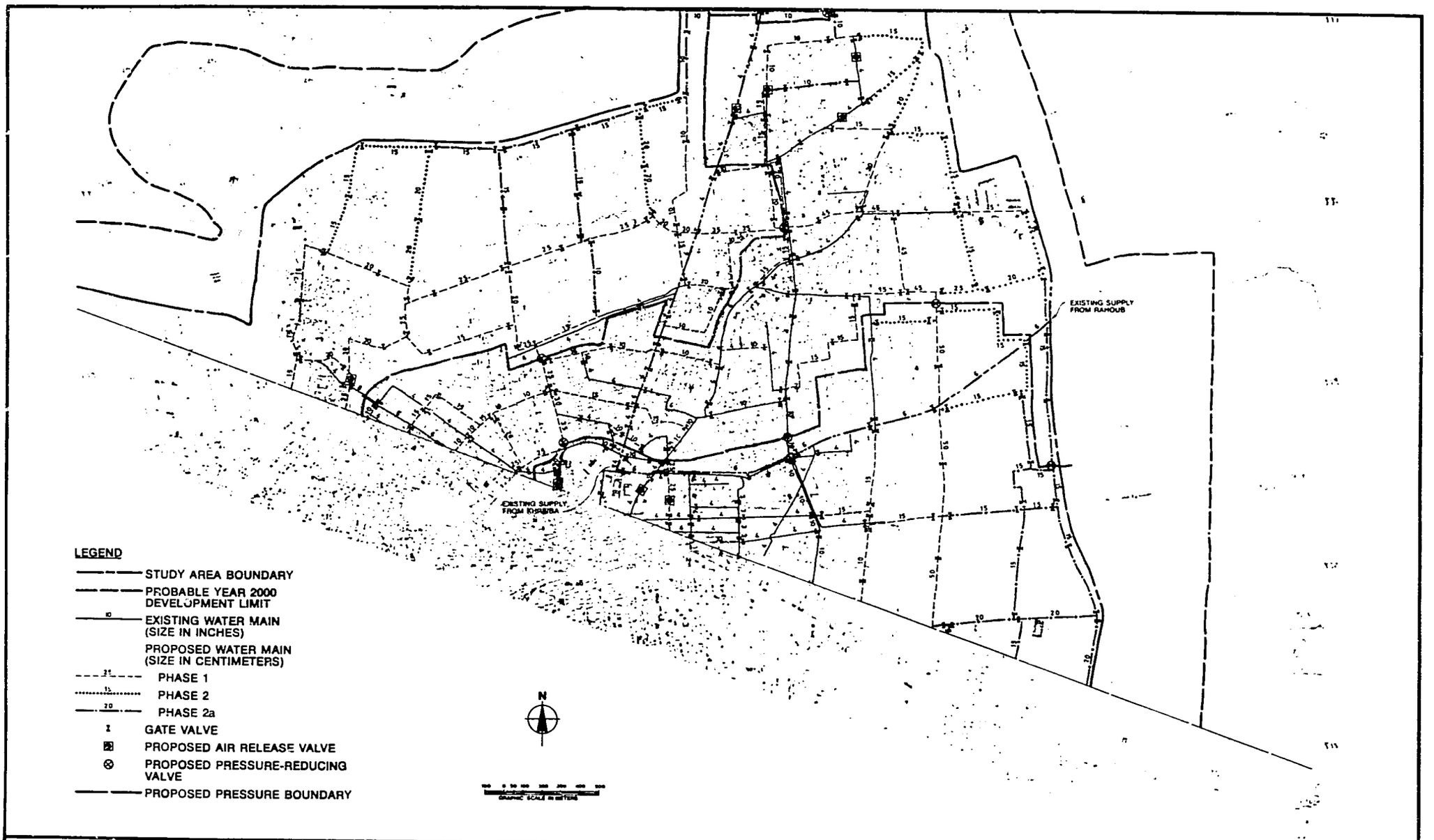
4.4.3 Master Plan

This section describes the Master Plan for phased development of the Irbid water distribution system. A number of improvements to the existing water system are required to assure that an adequate water supply will be available to all water users. The improvements include new water mains and appurtenances, a new water supply source, a distribution strategy that incorporates multiple pressure zones, and rehabilitation of the existing system. Figure 4-6a and b shows the water distribution system Master Plan for the City of Irbid. This plan incorporates all improvements that are required by the year 2000.

4.4.3.1 Computer Analysis.

In order to assure that adequate pressures are maintained under all potential demand conditions, a detailed investigation of the existing Irbid water system with recommended improvements has been conducted to define a master development plan for the distribution system. This was accomplished utilizing a computerized simulation technique to analyze pressure and flow in pipe networks. This simulation technique provides a means to determine the adequacy of the water distribution system to meet future water demands.

Characteristics of the Irbid water system, including length and diameter of water mains, pipe roughness coefficients, ground surface elevations, and sources of supply and demand, were used as input to the computer program. These data, in combination with the generalized computer program, constitute a mathematical model of the Irbid water system. Calculations of flow and head loss in each pipe in the network and the resulting pressure at each pipe intersection are provided by the model. These results indicate whether or not the system can perform as required to meet peak demand conditions.



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WATER DISTRIBUTION SYSTEM MASTER PLAN

SHEET NO.
FIGURE 4-6a

DATE: SEPT, 1979
BY:
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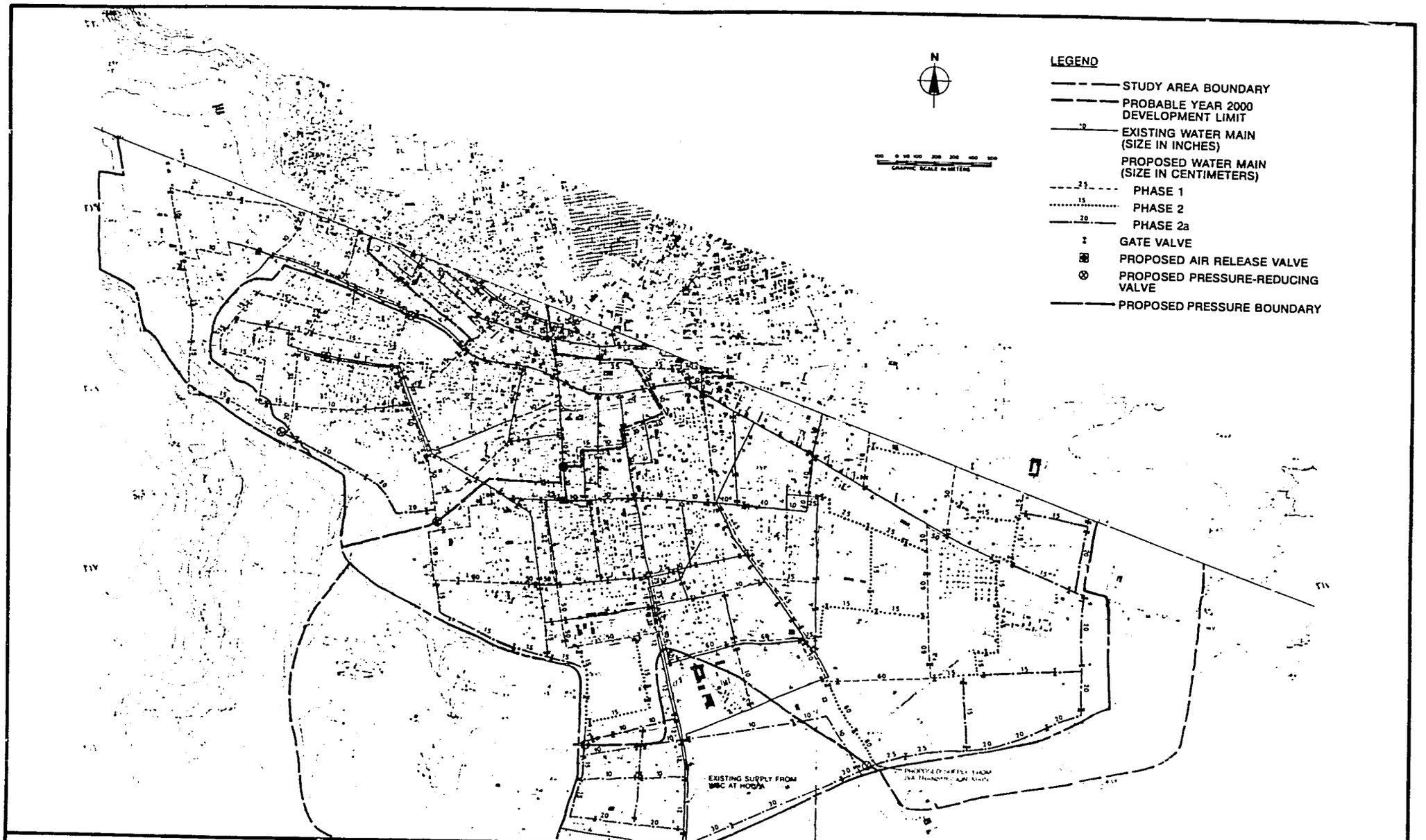

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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

WATER DISTRIBUTION SYSTEM MASTER PLAN

SHEET NO. FIGURE 4-6b

DATE: SEPT, 1979

BY:

CHKD:

Several assumptions were made to facilitate simulation of the Master Plan:

1. Only existing system mains 3 inches (7.5 cm) in diameter or greater were modeled. Pipe sizes less than this have a negligible value in distributing water.

2. When Irbid Water Department records show two pipes in the existing system to be disconnected, they were modeled as being connected. When feasible, dead-end pipes were eliminated from the existing pipe network by completing a loop with new mains.

3. With over 150 m of ground surface relief within the planning area limits, multiple pressure zones are required. Multiple zones allow service pressures to be within the desirable range of 210-620 kPa everywhere in the distribution system.

4. To describe the hydraulic condition of water mains, the model utilized Hazen-Williams "C" coefficients of 90 and 115 for existing pipes and new pipes, respectively. The "C" value allows for a decrease in hydraulic capacity resulting from deterioration in pipe condition and losses through valves, fittings, and pipe elbows.

5. For simulation purposes, it is assumed the distribution system contains no unknown broken or closed valves. The distribution system will respond less effectively than anticipated by computer analysis whenever pipe flow blockages are left undetected.

6. The total average daily water demand for Irbid is projected to be 55,600 cu m/day by the year 2000. Water demands were allocated to the model at nodal points (defined as the location where two or more pipes intersect) representing the water usage of each socioeconomic area of Irbid. Subsection 4.3.2 describes in detail present and projected water demands for the Municipality. The design peak daily water usage is defined in the model as 1.25 times the average daily water usage. The model assumes a peak hourly demand of 1.50 times the average daily demand.

Results of the hydraulic analysis of the Master Plan by computer simulation are presented in Appendix B. The performance of each pipe in the distribution network was examined under peak hourly demand conditions. Pipe sizes were selected to keep minimum pressures above 210 kPa as shown. In Appendix B, Figures B-1, B-2, and B-3 show the response of the distribution system under maximum day demand conditions. The figures indicate that during maximum day conditions, all pressures exceed the minimum desirable pressure of 210 kPa.

4.4.3.2 Description of Master Plan.

An important feature of the Master Plan is the creation of four main pressure zones (five may be necessary if development continues into the southern extremity of the planning area). Figure 4-6 shows that the pressure boundaries generally follow contour lines 630, 595, 560, 525, and 490. These contours define the boundaries of pressure zones 1, 2, 3, and 4, respectively. The boundaries are located to ensure static pressures within a zone will never exceed the desirable upper limit of 620 kPa. Under peak load conditions, the boundary locations will maintain a pressure of at least 210 kPa, the minimum desirable pressure. The pressure boundaries are formed by closing valves to shut off the flow of water between the zones or installing pressure reducing valves (PRV's) at locations where the boundary crosses existing water mains. The only new water mains that will cross a pressure boundary are those containing PRV's. PRV's are located at pressure zone boundaries on major mains to allow flow to cross from a high service zone to a low service zone. Each PRV is set at 257 kPa downstream pressure to allow for dynamic losses within the pipe network near the PRV.

Nearly 75 km of new water mains needed for the Master Plan are shown on Figure 4-6. All new pipes will be in metric sizes and as described in subsection 3.2.4. Main locations were selected to:

1. Best serve future growth areas of the City.

2. Strengthen areas with inadequate existing mains.

3. Provide a means of conveying large quantities of water across pressure boundaries.

Throughout the entire distribution system new water mains are located to form pipe loops. Pipe loops maintain the reliability of the system whenever a break in a line occurs. All existing lines that do not contain PRV's, yet cross a pressure boundary, will utilize valves to shut off flow.

The flow scheme represented on Figure 4-6 is generally from the south to the north. All water enters the distribution system from the single connection with the JVA project transmission main at the southeast edge of the system. A portion of the flow is diverted to zone 1. The remainder enters an 80-cm water main in zone 2. The water then flows by gravity through three large diameter mains to be distributed throughout the system.

The projected average daily water demand is 55,600 cu m/day in the year 2000. The storage requirement for this demand would be 55,600 cu m using the criteria of subsection 3.2.4. It has been assumed that the JVA transmission main will be able to flow in both directions and thus allow water from the Natifa reservoirs to flow into the Irbid system. With this arrangement, the Natifa reservoirs act as storage for Irbid. Total

storage volume at Natifa will be 110,000 cu m. This volume is more than sufficient to meet the criteria, and still leaves sufficient storage to act as a reserve for the other community systems served by the Natifa reservoirs.

The Master Plan shows only those water mains required to distribute water to all sections of the City. Shown on Figures 4-7, 4-8, and 4-9 are typical lateral mains from which most service connections will be made. Each figure indicates that lateral mains are to be installed along every street where water customers are located. All lateral mains are 10 cm in diameter. Figure 4-8 indicates lateral mains are not to cross pressure zone boundaries unless a valve is used to shut off flow between zones.

Service connections will be installed off lateral lines as shown on Figure 3-1 and described in subsection 3.2.4. Service connections can be either copper, galvanized iron, or polyethylene pipe.

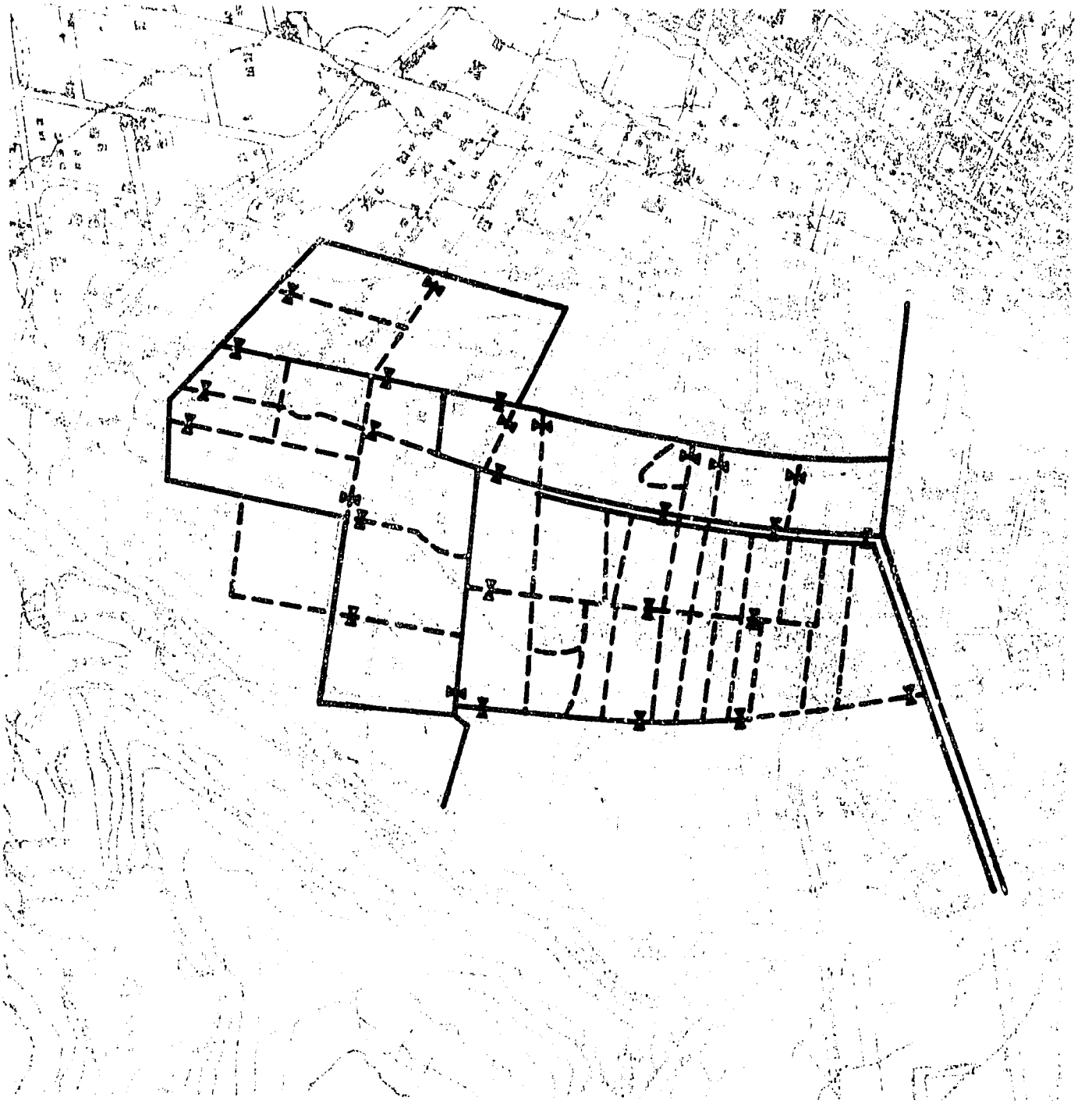
Use of galvanized iron pipe is recommended because it is in common use in Irbid, is less expensive than copper pipe, and is more desirable than PVC due to greater familiarity of local plumbers with galvanized iron pipe.

Service connection diameters will range from 1/2-inch to 2 inches, with 1/2-inch or 3/4-inch being the standard residential connections. Spacing of connections (for estimating purposes only) is according to the following criteria:

Population Zone	Spacing
A	1 every 20 meters
B	1 every 15 meters
C	1 every 12 meters
D and E	1 every 8 meters

Since the refugee camp is a bulk water user, no service connections will be provided in this area.

During the development of the Master Plan, the service life of many existing water mains will be reached. As this occurs, these mains must be replaced to ensure the integrity of the distribution system. Existing pipe 4 inches in diameter or larger will be replaced with new metric pipe of corresponding diameter. Any mains smaller than 4 inches will be replaced with 10-cm pipe.



LEGEND

- WATER MAIN
- LATERAL
- PRESSURE REDUCING VALVE
- GATE VALVE

N

100 0 50 100 200 300 400 500

GRAPHIC SCALE IN METERS

TYPICAL LATERAL NETWORK

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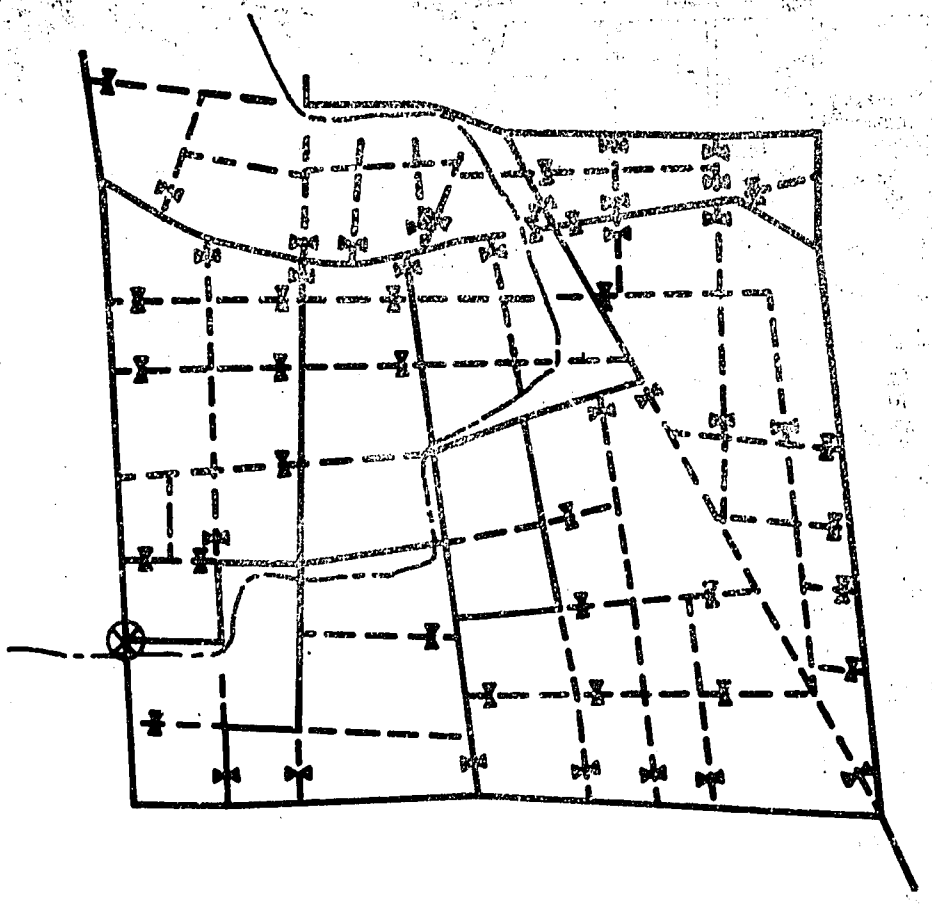
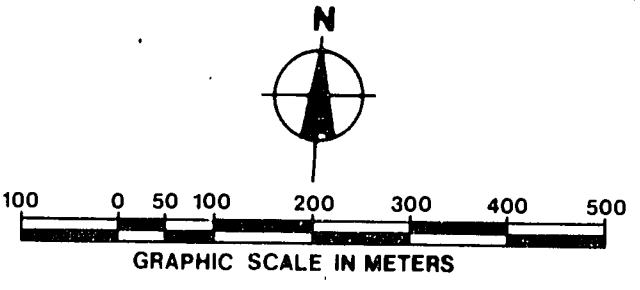
WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-7 DATE: SEPT. 1979 BY: CHECKED:



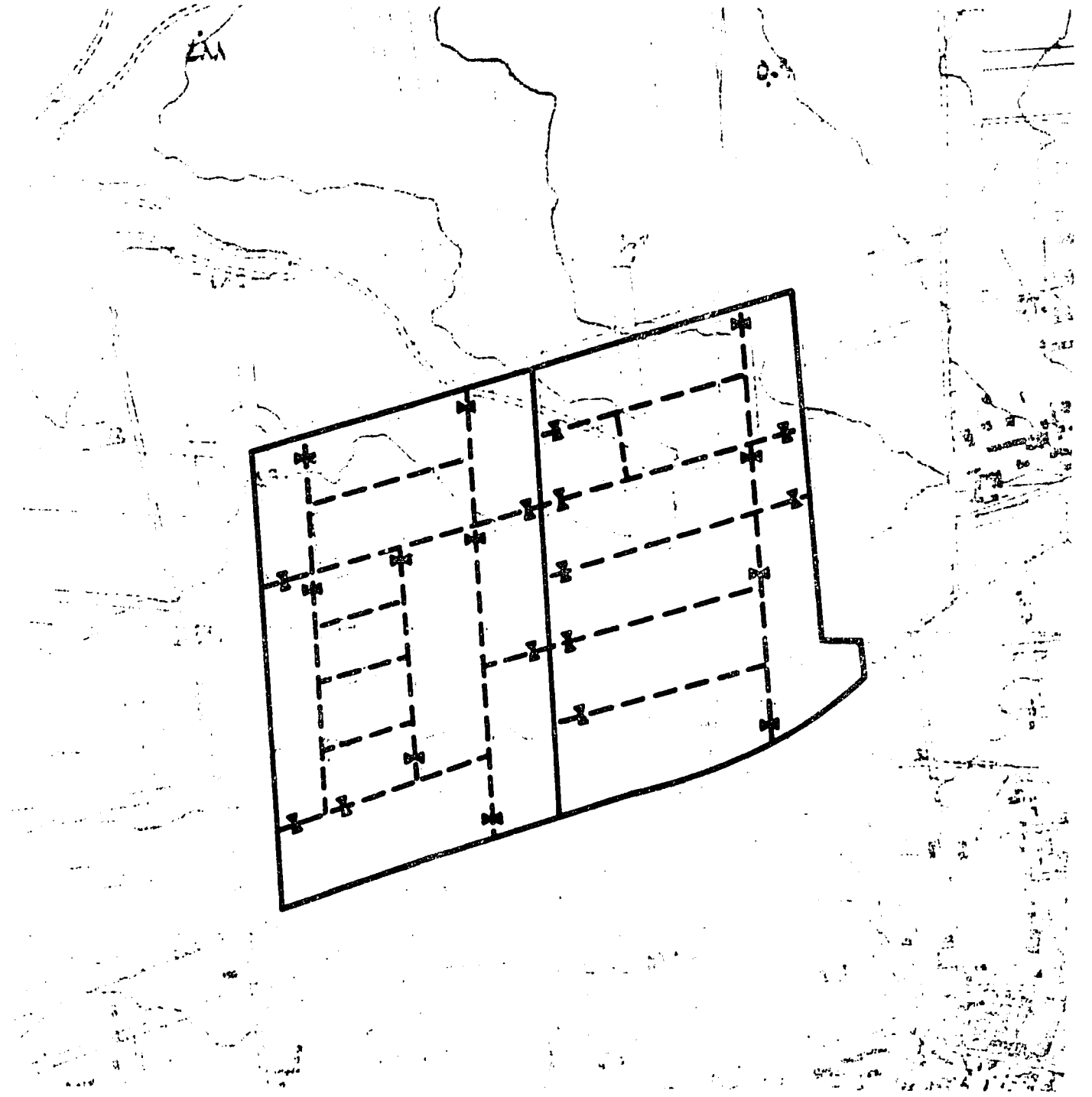
LEGEND

- PRESSURE ZONE BOUNDARY
- WATER MAIN
- LATERAL
- PRESSURE REDUCING VALVE
- GATE VALVE



TYPICAL LATERAL NETWORK

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-8 DATE: SEPT. 1979 BY: CHECKED:



LEGEND

- WATER MAIN
- LATERAL
- PRESSURE REDUCING VALVE
- GATE VALVE

N

100 0 50 100 200 300 400 500

GRAPHIC SCALE IN METERS

TYPICAL LATERAL NETWORK

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 4-9 DATE: SEPT. 1979 BY: CHECKED:

4.4.4 Development Phases

The facilities defined in the Master Plan are those required to supply the study area in the year 2000. Scheduling the construction of the system into two phases will provide service for existing and future development through the study period while delaying construction costs until facilities are required. Rehabilitation of the existing system has been coordinated with construction of new facilities.

4.4.4.1 Phase I.

Figure 4-6 shows the development plan for Phase I construction, which is to be completed by 1982. Approximately 71 km of new water mains are recommended for installation. These improvements are needed to strengthen the existing distribution system and to extend water services to areas of the City not currently being served. It has been assumed that during design and construction approximately 20 percent of the existing system will be found deficient and require replacement. Furthermore, 15 percent of the lateral mains should be constructed during Phase 1. Location of the lateral mains would be set during design to serve areas presently not served, particularly in the poor areas, and to improve system performance.

At the completion of Phase I, the JVA project will not be operational. Existing sources of water supply must be utilized until the JVA project is ready. As discussed in subsection 4.1.1.1, WSC is presently considering alternative means of increasing supply to Irbid. When analyzing the system with present sources of supply, it was assumed that the WSC alternative which delivered the largest flow to Irbid would be the alternative constructed. Based on projected water use, the Irbid water system will be supply-limited until the JVA project comes on line. The hydraulic analysis of Phase I assumes demand will equal supply. Available water will enter the distribution system from the Houfa reservoir and Kairawan Circle. The generalized flow scheme for Phase 1 is similar to that of the Master Plan. Since most of the water enters zone 2 on the existing 10-inch loop, this line is utilized to distribute water to other pipes in zone 2 and to convey water across the pressure boundary. Results of the computer simulation of the Phase I system, with existing sources of supply, are shown in Figures B-4, B-5, and B-6 of Appendix B. The figures indicate that for each pressure zone, service pressures are maintained within design limits during maximum daily demand conditions. The analysis of the Phase 1 system with peak hourly demand conditions showed service pressures can be maintained.

It should be noted that the flow which the WSC system can supply to Irbid is equal to the entire 24-hour output from the present WSC well fields. Although it is very unlikely that this quantity of water will be made

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available to Irbid, the hydraulic analysis was made with this flow because it represents the most severe hydraulic condition.

4.4.4.2 Phase 2.

Figure 4-6 shows the development plan recommended for Phase 2 construction, to be completed in 1990. Over 109 km of new water mains will be installed to serve projected growth areas. It is anticipated that the JVA water supply project will be completed by this time. Water from the JVA transmission main flows into zones 1 and 2 at the location indicated on Figure 4-6. The resulting flows will closely follow those described for the Master Plan.

Additional construction of lateral mains and rehabilitation of the existing system will be necessary both prior to 1990 and afterwards. This construction can best be accomplished on an annual basis. For the subsequent cost analysis, it has been assumed that construction will be carried out during the years 1985 through 1989 and 1991 through 1994.

4.4.5 Cost Estimate

Estimates of construction costs are based upon the information presented in subsection 3.2.4. The basis for estimating operation and maintenance costs given in the financial analysis (Chapter 9) are presented.

4.4.5.1 Capital Costs.

Estimated capital costs for Phases 1 and 2 are presented in Tables 4-4 and 4-5, respectively. Costs are expressed as 1979 Jordanian dinars (JD).

A major portion of the total cost is for construction of water mains. Because of the cost savings, this estimate has assumed the use of PVC pipe for 10-cm through 25-cm mains. In addition to the criteria in subsection 3.2.4, the location of the main was considered as follows:

1. Where existing development limits the space available between buildings and the street, the water main will be constructed under the street. Separation from the sanitary sewer will be at least 3 m.

2. Except when these conditions occur, all mains in right-of-ways with streets will be installed 1-2 m from the edge of the pavement.

Table 4-4

Phase 1 -- Capital Costs

Description	Cost (1,000's JD) Local	Foreign	Total
Water mains	723	815	1,538
Valves	9	34	43
Service connections	341	164	505
PRV installations	12	48	60
Lateral mains	83	197	280
Replace existing system	206	221	427
Probable Construction Cost	1,374	1,479	2,853
Contingencies	206	222	428
Engineering and administration	143	285	428
Total Project Cost	1,723	1,986	3,709

Table 4-5

Phase 2 -- Capital Costs

Description	Cost (1,000's JD) Local	Foreign	Total
Water mains	371	283	654
Valves	7	16	23
Service connections	131	56	187
PRV installations	1	3	4
Lateral mains	744	813	1,557
Probable Construction Cost	1,254	1,171	2,425
Contingencies	187	176	363
Engineering and administration	121	242	363
Total Project Cost	1,562	1,589	3,151

Source: Stanley Consultants

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3. Open land construction will occur when the main must be in an easement or right-of-way with no existing street. Under this construction condition, no service connections to the main will be provided.

The probable extent of rock excavation was also taken into consideration in developing construction costs.

The cost tables separate the project costs into the following components:

1. Water mains installed, inclusive of excavation, bedding, backfill, pavement removal and replacement, and all fittings.

2. Valves, both gate valves and automatic air release valves, including costs for installation and structures.

3. Pressure reducing valve installations, including all piping, valves, structures, excavation, and backfill.

4. Service connections installed (as described in subsection 3.2.4), including all materials, excavation, backfill, and pavement removal and replacement.

These costs include an allowance for contractor overhead and profit. The Phase 1 estimate also includes a cost for replacement of 20 percent of the existing water system, and construction of 20 percent of the lateral mains required in the Phase 1 area. These components are totaled to a probable construction cost. To obtain a total project cost the following items are added to the probable construction cost:

1. Contingencies to allow for unforeseen construction costs.

2. Engineering and administrative costs, including technical assessment, construction management and supervision, and administering agency costs (estimated as 15 percent of the probable construction costs).

3. Right-of-way and other land purchase costs. For the water system it is assumed that all lands will be in public right-of-way or easement.

Interest during construction will be assessed in the financial analysis presented in Chapter 9.

The annual capital cost of replacing the existing water system and constructing lateral mains during the years 1985 through 1994 is given in Table 4-6.

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Table 4-6

Annual Replacement and Lateral Main Costs

Description	Cost (1,000's JD) Local	Foreign	Total
Water mains	52	71	123
Valves	2	5	7
Service connections	127	81	208
Probable Construction Cost	181	157	338
Contingencies	27	24	51
Engineering and administration	17	34	51
Total Project Cost	225	215	440

Source: Stanley Consultants

4.4.5.2 Operation and Maintenance Costs.

Major changes in expenditures for operation and maintenance of the system are not required. As the system becomes larger, a proportionately larger work force will be required for operation and maintenance. New installations do not require any new equipment, except that required to tap mains for service connections and lateral mains.

The estimated cost of required tapping equipment is 7,600 JD. This equipment should be provided as part of Phase 1 construction.

4.4.5.3 Project Cost Components.

In estimating project costs, careful attention has been given to construction methods. Estimates account for mobilization, material supply requirements, local work schedules, evaluation of labor production, and similar factors. All associated costs have been considered including contractor overhead and profit.

In preparing unit costs, consideration has been given to construction equipment size, type, and number of machines that are expected to be used. Work crews have been projected by number and skills required. The costing of construction operations has been discussed with local contractors. Unit costs for materials have been obtained by reviewing bid information on recent projects in Jordan, by interviewing local contractors and consultants, and by contacting suppliers in the Amman area. Proper attention has been given to shipping costs. Allowance has been made for transportation, accounting for delivery to the Port of Aqaba, and trucking to the project site.

Heavy construction equipment, supervisory personnel, and much of the skilled labor force will be mobilized from countries outside Jordan, and demobilized at project completion. The contractor's overhead, estimated as 20 percent of total direct costs, includes supervision, recruiting of key personnel, office staff, purchasing, warehousing, communications, field office, and maintenance of equipment.

Contractor's profit has been assumed to be 10 percent of the total direct and indirect cost. A contingency is included to provide for unforeseen problems during detailed design, constructability, subsurface conditions, and access.

It is assumed that no import duties will be paid on material used on this project or on equipment which will be exported at project completion. Duties, on the value when imported, will be charged on equipment which is not removed from Jordan. It is assumed that a contractor will not be required to pay income tax to Jordan.

Using developed cost parameters, estimates have been prepared on a unit cost basis which involve computing material quantities and multiplying by assembled unit costs. Mobilization, overhead, profit, right-of-way, and contingencies as well as administration and engineering have been added, based on these discussions. The costs presented are financial costs and represent the expenditures required to complete the project as of 1979. Actual costs which will include an allowance for price escalation to the anticipated time of expenditure are presented in the appropriate chapter of this report.

4.4.5.4 Local and Foreign Costs.

Cost estimates have been prepared showing local and foreign costs. The local component is that portion of the cost attributed to direct expenditures in Jordan. Included are costs of local materials and supplies and indigenous salaries and wages. It is understood that import duties will not be assessed on materials incorporated into the project.

The foreign component is that portion of project costs which includes such items as foreign mobilization; a foreign company's overhead and profit; materials and supplies of which Jordan is a net importer; and foreign salaries, wages, and incidental expenses.

Some items are split between local and foreign which indicates an indirect foreign expense. The indirect portion is composed of:

1. Expenses to the economy connected with the importation of components and raw materials which will be subject to further processing in Jordan and then incorporated into the project.

2. Depreciation of the imported machinery and equipment which will be utilized in the construction of the project, but not completely worn out during the course of the project.

4.4.5.5 Implementation.

Consideration given to the time required for construction of the water distribution system has included construction conditions, coincident construction with other utilities and traffic problems. Due to the size of the Phase 1 project, four construction contracts will be required to complete work in two years. Timing of the contracts can be set to provide construction at the earliest possible time in those areas with the greatest need.

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4.5 RECOMMENDATIONS

4.5.1 Use of Existing System

The existing distribution system ranges in age from over 35 years old to practically new. The major diameter loop is only 12 years old.

4.5.1.1 Definition of Usable Facilities.

To be usable, any portion of the system should have remaining service life through 1985, and be a necessary part of the Master Plan.

The estimated service life of existing water distribution mains is 20-25 years. The major loop and other mains constructed in 1967 and later still have considerable service life remaining. Other than the 10-inch (25 cm) line and several others, location of the newer mains is uncertain. It is assumed that 80 percent of the existing water mains will be usable through the year 1985. Beginning in 1985 and continuing through 1994, it will be necessary to replace the existing system. The 20 percent of the system which is not usable through 1985 is to be replaced during Phase 1 construction. Location of mains to be replaced will be done during design and construction.

The existing storage tanks are not usable after the source of supply changes. When the municipality receives water from the JVA North Jordan domestic water supply project, pressure levels will be higher than the top of the tanks, thus rendering them unusable. Piping at the ground storage tank on the Citadel should be reworked to bypass the tank. The elevated storage tank should be removed because of the existing structural defect.

After the JVA project is completed, sufficient water supply will be available so that the Municipality will not have to maintain the pumping stations at Khreiba and Rahoub. In order to continue to use these facilities it would be necessary to completely replace the pumps and engines. It is recommended that these facilities be converted to supplying nearby communities.

4.5.1.2 Required Rehabilitation.

For distribution system mains, rehabilitation into usable facilities requires replacement of the existing main. Existing valves can be reused if they are operable. During replacement, it is assumed that the new pipe will be a metric size closest to the existing pipe size. Replacement has been considered using the criteria in subsection 3.2.4.

4.5.2 Best Apparent Alternative

The Master Plan shown on Figure 4-6 is the best apparent alternative for providing water to meet the demands of the study area in the year 2000. Figure 4-6 represents the system as it should exist in the year 2000. By that time, the existing mains should all be replaced.

Construction of the Master Plan will increase the hydraulic efficiency of the distribution system and necessitate division of the system into pressure zones to prevent extremely high pressures during low flow or static conditions. The least costly and more easily maintained method of pressure zoning for this system is to utilize pressure reducing valves.

The layout of the Master Plan allows easy expansion of the system to serve development after the year 2000. The system can readily expand its capacity to serve more demand either inside or outside of the study area.

To complete the water distribution system, it will be necessary to construct lateral main networks within the major pipe loops of the Master Plan. These lateral main networks will provide service connections to individual buildings.

4.5.3 Recommended Operation and Maintenance Procedures

Substantially, the same operation and maintenance procedures will be required for the Master Plan system as are used now. This is possible because the Master Plan facilities are very similar to those currently being maintained. Some important points of the operation and maintenance program are reviewed in the following subsections.

4.5.3.1 Recordkeeping.

Upon completion of supply by the JVA project, more complete records of water supplied to the system should be maintained. As additional supply becomes available and development of the Municipality continues, it will be important to have data which can identify peak daily demand and can be used to estimate peak hour demands.

Records on the location, type, and size of all mains, pipes, valves, and other appurtenances should be kept. Future construction should be recorded in an easily usable manner. A program of locating and recording existing facilities should be started.

4.5.3.2 System Dependability.

Although the Health Department makes periodic checks on the potability of water, the Water Department should expand its program of testing for chlorine residual. The proposed increase in the size of the distribution system will require more surveillance.

As the size of the system increases and more water-using appliances are installed in homes, the possibility of cross-connection between the water system and contaminated water (sewage) is increased. The present use of building storage minimizes the chance of contamination reaching the dis-

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tribution system, but contamination of building storage can flow back to the distribution system under the proper circumstances. As supply increases and becomes more reliable, plumbing practices may change allowing a greater potential for contamination. Procedures for preventing contamination should be reviewed every two years.

4.5.3.3 Stock.

A supply of parts and replacement materials must be maintained. A stock of repair sleeves, valves, pipe, fittings, and other materials is important because of the delay in getting delivery of these items.

4.5.3.4 Leak Detection.

As shown in subsection 4.2.3, the quantity of unaccounted for water is a significant percentage of the water used. Because of the scarcity and high cost of water it is essential that system losses be held as low as possible. The high cost of water allows a significant continuing effort to reduce unaccounted for water.

Initially, the loss to the system through illegal taps should be determined. If necessary, a program to find and eliminate illegal taps should be instituted. After eliminating or determining the amount of water lost through illegal taps, under-registration of water meters as a type of leakage should be investigated. Results of the Irbid Water Department's meter testing program should be analyzed to determine what percentage of meter checks are inaccurate. The displacement type meter used by Irbid becomes more unreliable when:

1. Wear occurs because the meter is undersized. Flows beyond the rated meter capacity cause excessive speed of operation, wear, and the under-registration of flows.

2. Continuous flow through meters causes excessive wear also.

3. Extreme temperatures, particularly high temperatures, cause under-registration.

4. Suspended materials in the water, particularly sand, clog the mechanism and affect meter operation.

5. Corrosive water slowly deteriorates meters, requiring either more frequent replacement or use of meters with special corrosion-resistant materials.

Of the difficulties listed, only item 5 is not expected to have some effect on meter reliability in Irbid. The best guide to the selection, installation, testing, and maintenance of meters is the American Water Works Association Standard C700-77.

Determination of a program for reducing losses due to leakage should be accomplished by an engineering analysis system which considers:

1. Value of benefits of locating and repairing system leaks.

2. Methods of conducting a leak survey program.

3. Cost of conducting the leak survey and making repairs.

4. Determination of cost-benefit ratio and other considerations for the decision-making process.

Sonic sensors are the most versatile and easily-handled leak detection equipment. A simple, hand-held device would be most easily applied in Irbid. One or two men with a vehicle and appropriate safety devices would be necessary to survey Irbid's system. It would be necessary to establish an office procedure for filing and analyzing results of the leak survey. Utility personnel can be trained in the use of leak detection equipment, but considerable experience is required to develop a skilled operator.

4.5.3.5 System Inspection.

A need for increased inspection frequency of some installations will be caused by the proposed improvements. Pressure reducing valve installations will require weekly or more frequent inspection because of their importance in system operation. All other valves should be inspected and operated at least annually. This inspection will identify maintenance requirements before equipment problems become critical.

Periodic checks of system pressures should be made to ensure that the PRV's are maintaining the pressure zone within the design limits.

4.5.4 Recommended Phasing Plan

Not all of the Master Plan is required immediately. The system should be expanded as development of areas occurs. Description of phasing is given in subsection 4.4.4.

It is recommended that where a pipe is required for serving Phase 1 development, the pipe should be installed at the size given on the Master Plan. Installation of a smaller size during Phase 1, followed by paralleling at a later date, is not a cost-effective means of constructing the system.

The construction of lateral mains, to fill in the Master Plan network, should be an ongoing effort. Development of areas and provision of lateral mains should occur at the same time. The recommended layout of lateral mains is shown on Figures 4-7, 4-8 and 4-9. These mains should meet the criteria of subsection 3.2.4.

4.5.5 Recommended Training Program

During the construction phase a training program encompassing the following should be conducted:

1. Review of recordkeeping procedures and practices.

2. Preparation of a valve location, inspection, and operation program.

3. Training in leak detection and repair if the recommended analysis has shown a need for reducing losses.

4. Training in inspection, operation, and repair of pressure reducing valves.

The training program should be completed prior to final construction of the Phase 1 facilities.

CHAPTER 5

SEWERAGE SYSTEM STUDIES

5.1 EXISTING SEWERAGE SYSTEM

Existing sanitary sewers in the City of Irbid consist of three short lengths of 500-mm diameter pipe having a total length of approximately 600 m. The sewers presently discharge into the box culvert that has been constructed as part of the storm drainage system in the Wadi Tariq Saum drainage area. Wastewater from these sewers flows untreated into the stormwater culvert, and then into the Wadi Tariq Saum.

All other domestic and commercial sewage, with a few exceptions (such as the slaughterhouse wastewater discharge which is described in subsection 3.3.3.3 (2)), is collected and disposed of in cesspools or septic tanks. Cesspools provide a rudimentary level of treatment. They collect most of the heavier solids, and allow the liquid portion of the wastewater to flow into the ground. This liquid wastewater either eventually reaches the groundwater, or returns to the surface. In an area such as Irbid, which is underlain by fractured limestone, it is impossible to determine the travel time or degree of renovation of wastewater discharged through cesspools into the ground.

Solids collect in cesspools and septic tanks, and periodically they must be pumped out to recover storage capacity. In Irbid, cesspools and septic tanks are emptied by pumping into tank trucks at the owner's request. The tank trucks presently discharge into the Wadi el Hamam at a point approximately 3 km northwest of the Irbid City limits.

Our field investigations revealed many locations throughout the City where cesspools are allowed to overflow to the ground surface, and then seep into the ground at another location and/or run off to the nearest natural drainage channel.

Very few community or public sewerage facilities (enclosures housing a series of toilets and sinks located in areas frequented by large numbers of people, such as markets or commercial areas) exist in the City of Irbid. Communities which have installed this type of facility have experienced vandalism and maintenance problems. We have not included provision for new facilities of this type in the Irbid sewerage system design.

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5.2 PROJECTED RAW WASTEWATER FLOW AND LOADING RATES

The methodology for determining raw wastewater flows and loadings from domestic, commercial, industrial, and institutional sources, as well as from septage discharges is described in Chapter 3, Section 3.3 of this report. The raw wastewater flow and load projections are compiled in Table 5-1. These projections are the basic wastewater treatment design criteria used in our study.

Based on a review of the influent flow at the Ain Ghazal wastewater treatment plant, the following observations were made:

1. There was some additional flow during the wet season due to inflow and infiltration.

2. After allowing for the extraneous flows, there was no discernible difference in flow quantities or flow patterns between wet/dry or winter/summer conditions.

Accordingly, infiltration and inflow were presented as a separate component of the raw waste loading which impacted winter flows only.

The quantities presented in Table 5-1 do not include screenings and grit removed in preliminary treatment processes. Projected screenings and grit quantities are as follows:

Year	1990	2000
Screening		
Average	1.33	1.94
Maximum	3.32	4.84
Grit		
Average	3.32	4.84
Maximum	7.97	11.62

Quantities are in cubic meters per day.

5.3 SEWAGE COLLECTION SYSTEM

5.3.1 Introduction

A sewage collection system master plan has been developed based on field inspections, review of recent (1978) 1:10,000 scale topographic maps, and review of previous studies and designs for Irbid by Hydroconsult, Bratislava, Czechoslovakia prepared in 1969.

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Table 5-1

Projected Raw Wastewater
Flows and Loading Rates

	1990		2000	
	Winter	Summer	Winter	Summer
Flow (cu m/day)				
Domestic	16,246	16,246	26,752	26,752
Septage	352	713	535	1,086
Commercial, industrial, institutional	5,800	5,800	9,100	9,100
Total	22,398	22,759	36,387	36,938
Peak Hourly Flow at				
2.5 x domestic and commercial, industrial, institutional (cu m/day)	56,897	56,897	89,630	89,630
Infiltration/inflow (cu m/day)	5,178		5,950	
Peak flows (cu m/day)	62,075	56,897	95,580	89,630
BOD_5 (kg/day)				
Domestic	12,837	12,837	19,437	19,437
Septage	1,690	3,422	2,568	5,213
Commercial, industrial, institutional	4,905	4,905	7,880	7,880
Total	19,432	21,164	29,885	32,530
Kjeldahl-Nitrogen (kg/day)				
Domestic	2,422	2,422	3,534	3,534
Septage	21	43	32	65
Commercial, industrial, institutional	813	813	1,298	1,298
Total	3,256	3,278	4,864	4,897
Suspended Solids (kg/day)				
Domestic	15,016	15,016	23,324	23,324
Septage	827	1,676	1,257	2,552
Commercial, industrial, institutional	5,283	5,283	8,303	8,303
Total	21,126	21,975	32,884	34,179
Volatile Suspended Solids (kg/day)				
Domestic	11,383	11,383	17,670	17,670
Septage	176	356	267	543
Commercial, industrial, institutional	3,982	3,982	6,258	6,258
Total	15,541	15,721	24,195	24,471
Oil and Grease (kg/day)				
Domestic	3,633		5,301	
Commercial, industrial, institutional	1,131		1,764	
Total	4,764		7,065	

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The master plan was designed to accomplish the following:

1. Provide a sewage collection system that will serve the entire City by the end of the planning period, year 2000.

2. Provide sewage collection to both the industrial park and Army housing area in Phase 1 of the construction plan.

3. Develop a plan for staged expansion.

After analyzing both the 1969 report and the 1978 map, it is evident that the Municipality of Irbid has grown considerably between 1969 and 1978. During this time, little, if any, sanitary sewer construction was undertaken. The City of Irbid, essentially, has no sewer collection system.

Irbid's topography slopes from a high area south of the City, declining towards the north. The eastern section of the City is relatively flat, but does decline to the north and east. In the western section of Irbid, these are several steep wadis which flow westerly towards the Jordan River. A ridgeline passes through the center of town from west to east, and creates two natural drainage courses around the City. The City is, therefore, divided into two main drainage basins, with an interceptor serving each basin. Interceptor A serves the southern and western portions of the City, while interceptor B takes flow from the northern and eastern portions of Irbid.

Since the topography of Irbid declines from south to north, a natural location for the wastewater treatment plant is in the northern section of the planning area. The evaluation of alternative wastewater treatment plant sites is discussed in subsection 5.4.1. The drainage areas served in Phase 1 and Phase 2 are shown on Figure 5-1a and b, and Figure 5-2a and b, respectively.

When implementation of the proposed master plan is completed, it will serve the City's projected population for the year 2000 of 353,000 people, with a total drainage area of 25 sq km, and will include 350 km of sewers and six pumping stations.

Interceptor A (proposed in this study) closely follows the routing of the 1969 report with one major exception. The 1969 routing followed the north side of the Wadi Tariq Saum, and the route proposed in this study has been moved to the south side of the wadi along Palestine Road. A new road presently being constructed across the Wadi Tariq Saum provides a suitable crossing for the proposed interceptor from the south side of the wadi where construction is more suitable.

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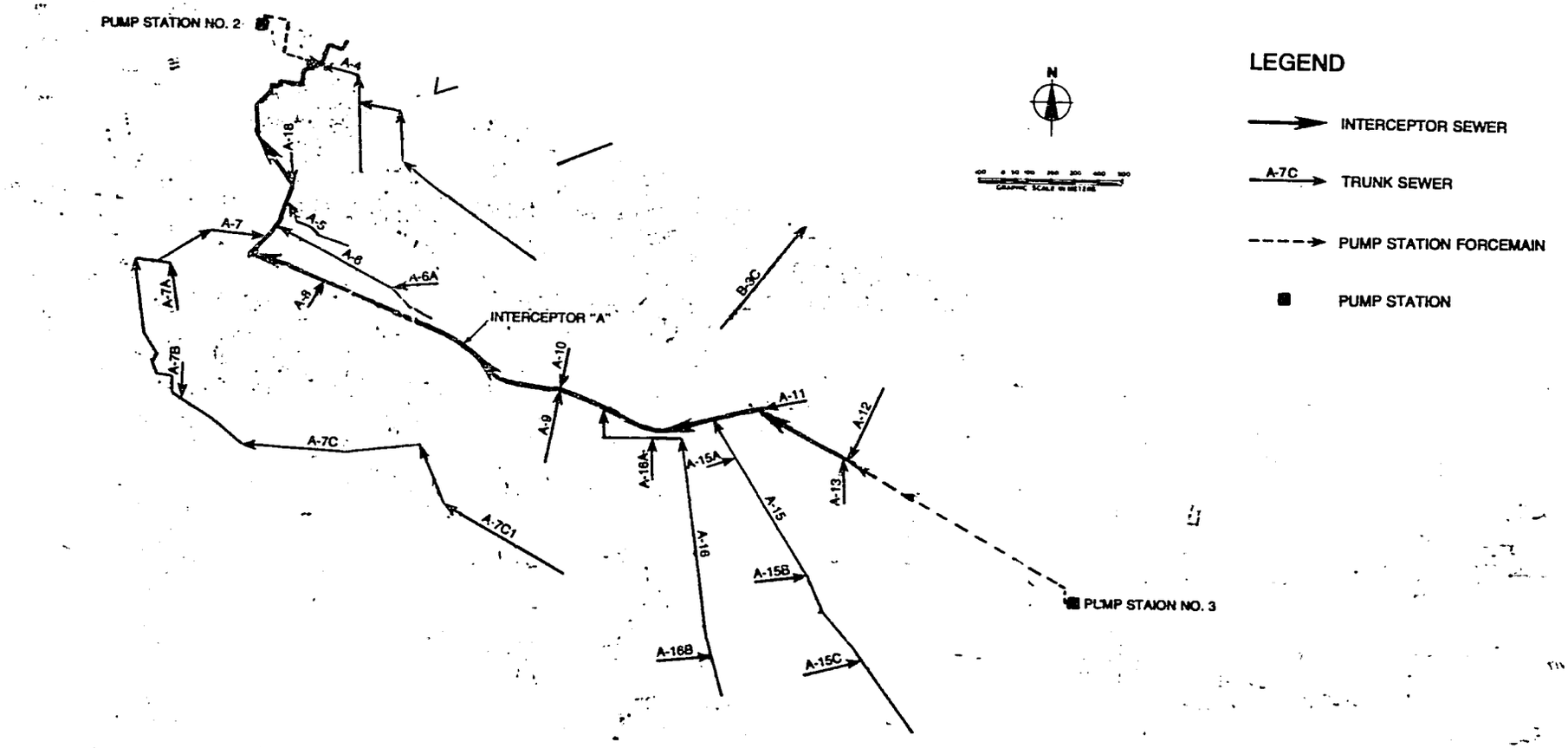
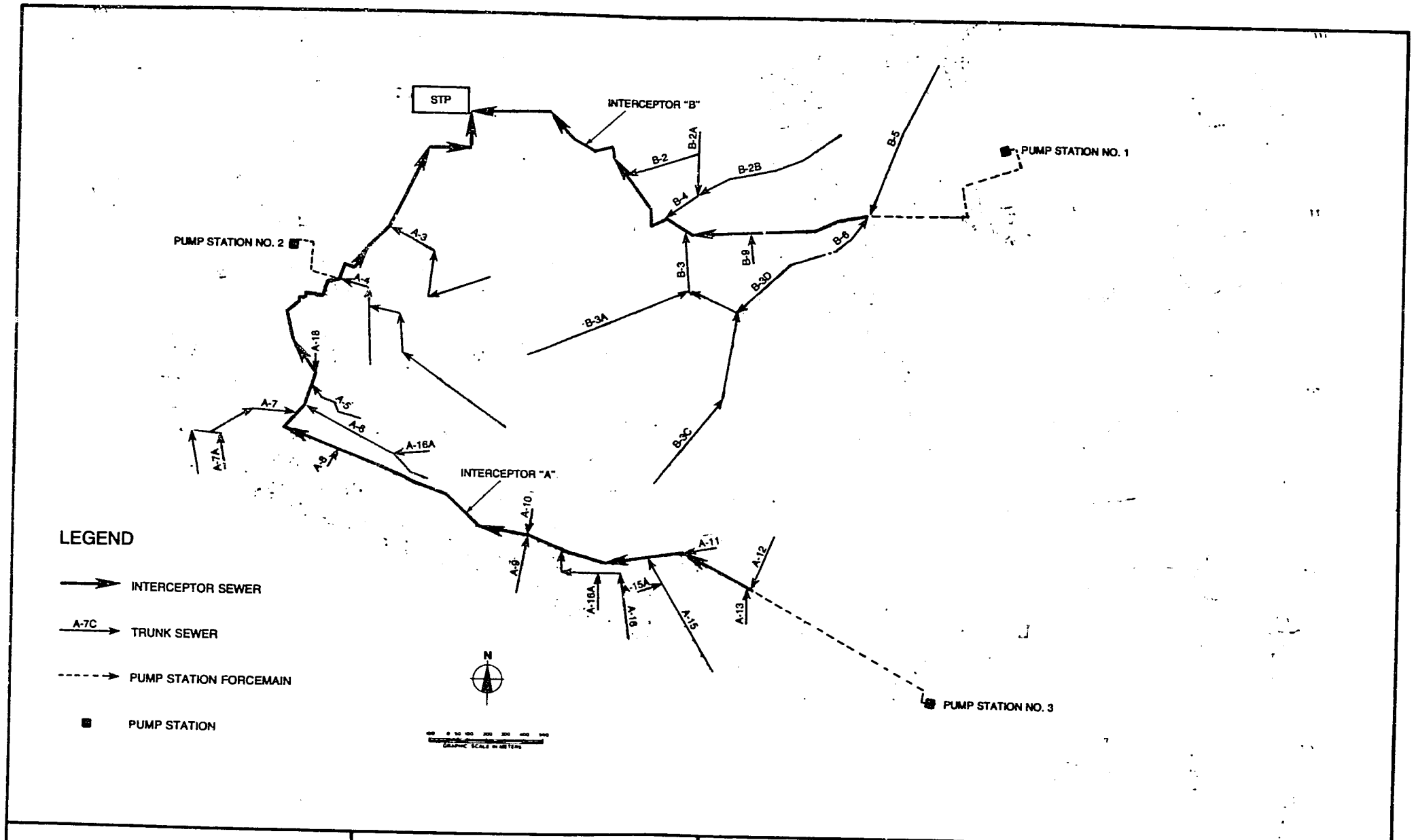


WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS ARMI CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	SEWAGE COLLECTION SYSTEM PHASE I	SHEET NO. FIGURE 5-1a DATE: SEPT. 1979 BY: F. RAHHAL CHKD: HALVENSLEBEN



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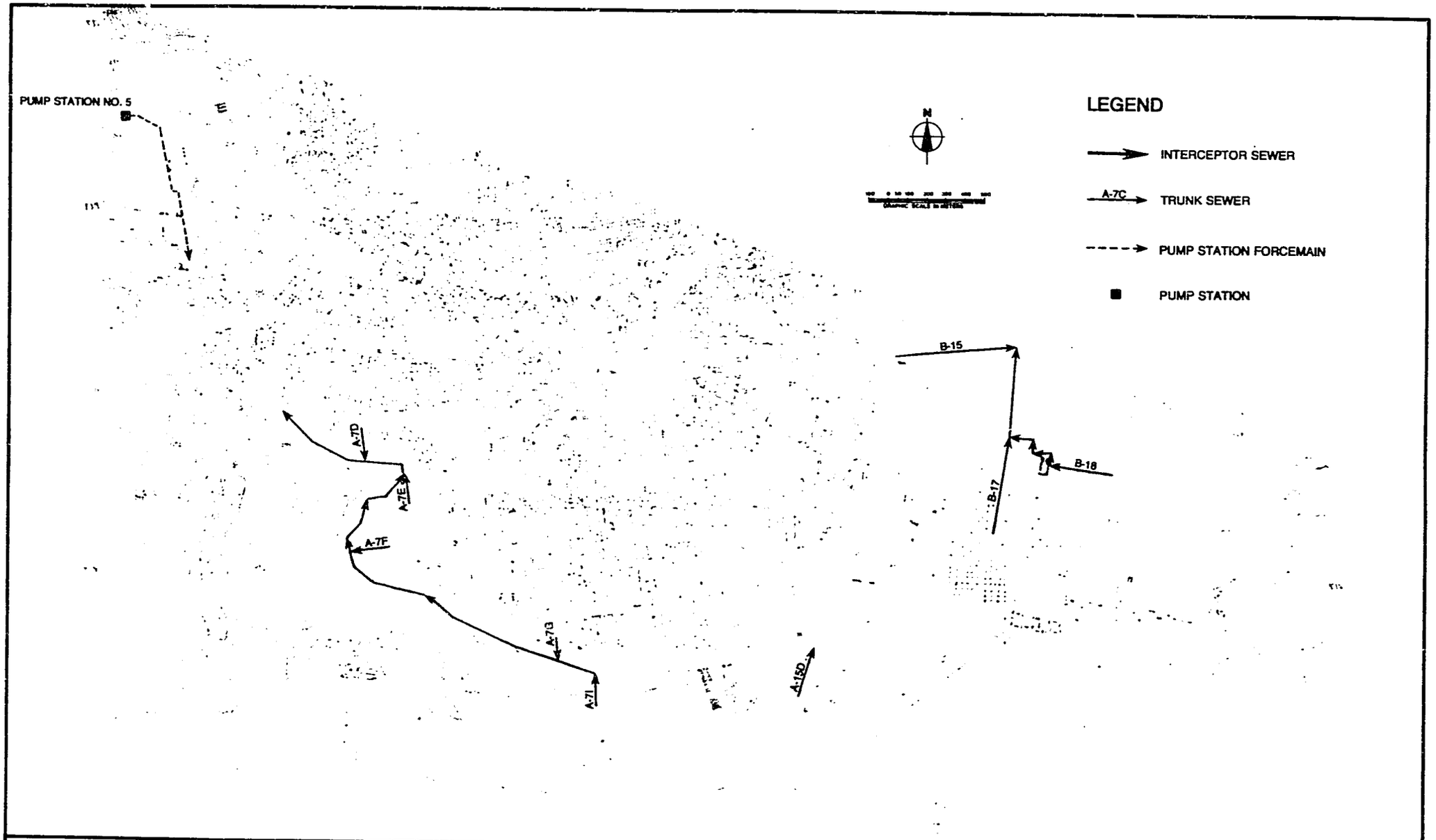

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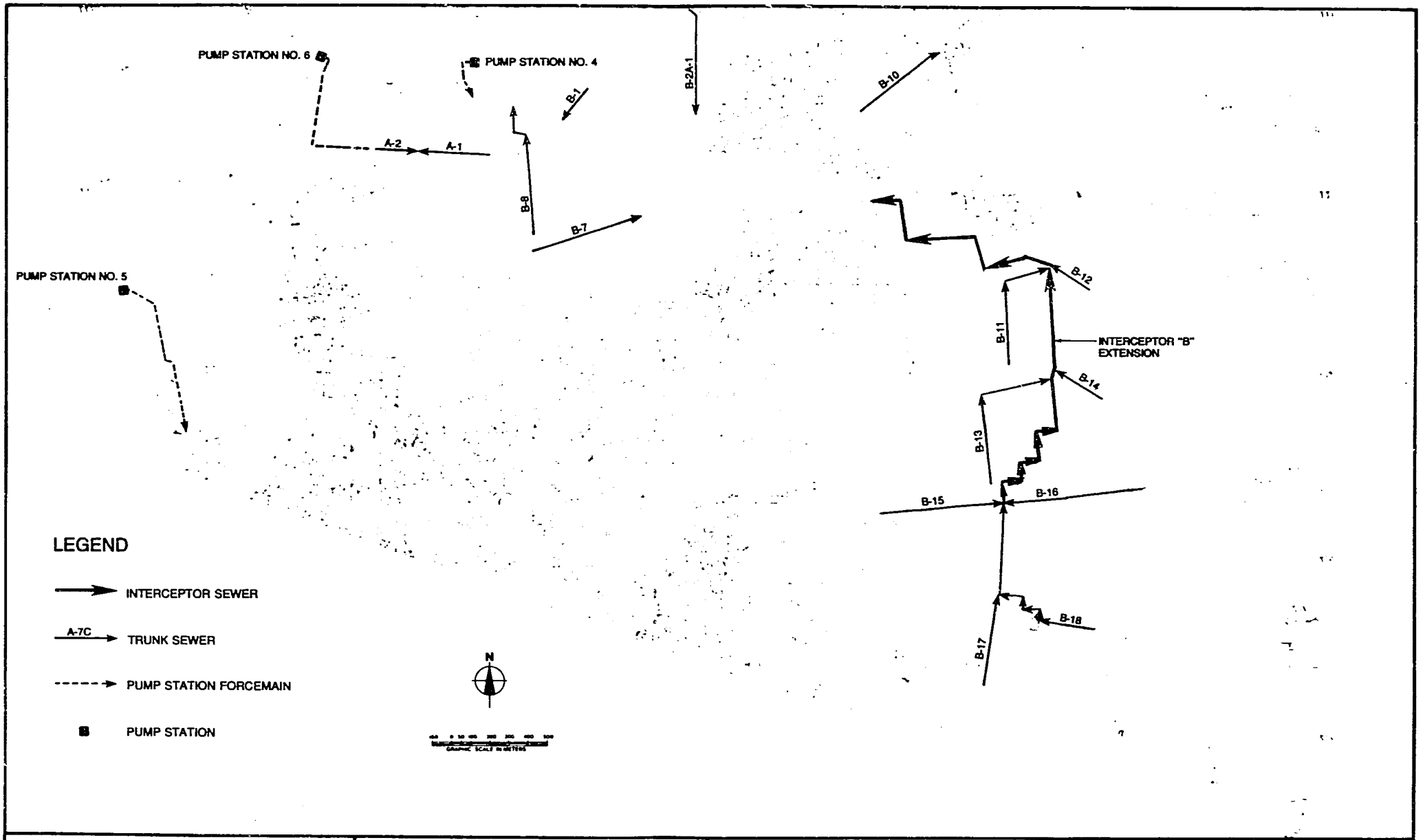
SEWAGE COLLECTION SYSTEM
PHASE II

SHEET NO.
FIGURE 5-2a

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

SEWAGE COLLECTION SYSTEM
PHASE II

SHEET NO.
FIGURE 5-2b

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

In the far northwest sector of El Bariha, a sewage pumping station and force main will be required. Development has occurred in this area, and because the topography slopes steeply to the Wadi Tariq Saum, interceptor A would have to be lowered 12 m to service this area. This deep cut is obviously uneconomical. The pump station will receive wastewater flow from the newly constructed dairy.

The proposed interceptor B routing is similar to that of the 1969 report, but has been moved north and extended to the east to accommodate past growth and future development.

The eastern end of the Wadi el Hamam divides the northern section of the City. Interceptor B follows the wadi in this area, allowing areas both north and south of the wadi to be served. Although the proposed interceptor B route passes the industrial park, it is not practical to serve the industrial park by gravity since this area is 3 to 4 m lower than surface grade elevation along the interceptor route. Serving this area by gravity requires lowering interceptor B from the wastewater treatment plant to Hicma Street by 3 to 4 m. This is not economically feasible, and therefore a pump station and force main will be provided.

A small ejector station is required to serve future development in an area northeast of the proposed treatment plant. The ejector station is required because interceptor B is routed to flow into the upstream end of the wastewater treatment plant, permitting gravity flow through the plant. The area served by this ejector station is small and the flows are low. Ejector systems are frequently used for this type of application because of their nonclog characteristics at low flows.

5.3.2 Alternatives

In the development of the collection system plan, many alternatives were considered and the obviously unworkable or unfeasible alternatives were rejected. The remaining alternatives were evaluated for the following factors:

1. Cost.
2. Environmental impacts.
3. Implementation capability.
4. Energy use.
5. Reliability.

These alternatives are shown in Figure 5-3a and b, and are as follows:

5.3.2.1 Alternative 1.

Interceptor C in the 1969 report services only the central part of Irbid and future growth to the north. Review of the topography of the town center indicates that flow will drain in either of two directions, towards interceptor A or C. The C alternative, however, provides only minimal

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service in the first construction phase. Interceptor A can service the center of town without the capital expense of constructing an interceptor sewer in a slow growth area. Construction of interceptor C is more costly, on an annual cost basis. Thus, in the previous 1969 report, interceptor C was deleted because it was not cost effective, and alternative 1a was selected.

5.3.2.2 Alternative 2.

The routing of interceptor A around the El Bariha area to provide gravity flow, is through a very difficult construction area. Consideration was given to pumping the flow over the ridge line through the El Bariha area. A cost-effectiveness study of each alternative (2a, gravity, versus 2b, pumping) was made. The proposed route of interceptor A is along the north wall of Wadi Tariq Saum which is very steep and is in dense limestone. The construction is expected to be difficult, and it is estimated to be five times more costly than normal gravity sewer construction.

If a pump station is built it will be a custom-designed station because the interceptor design flow, 38,400 cu m/day, is more than usual package pump station capacities.

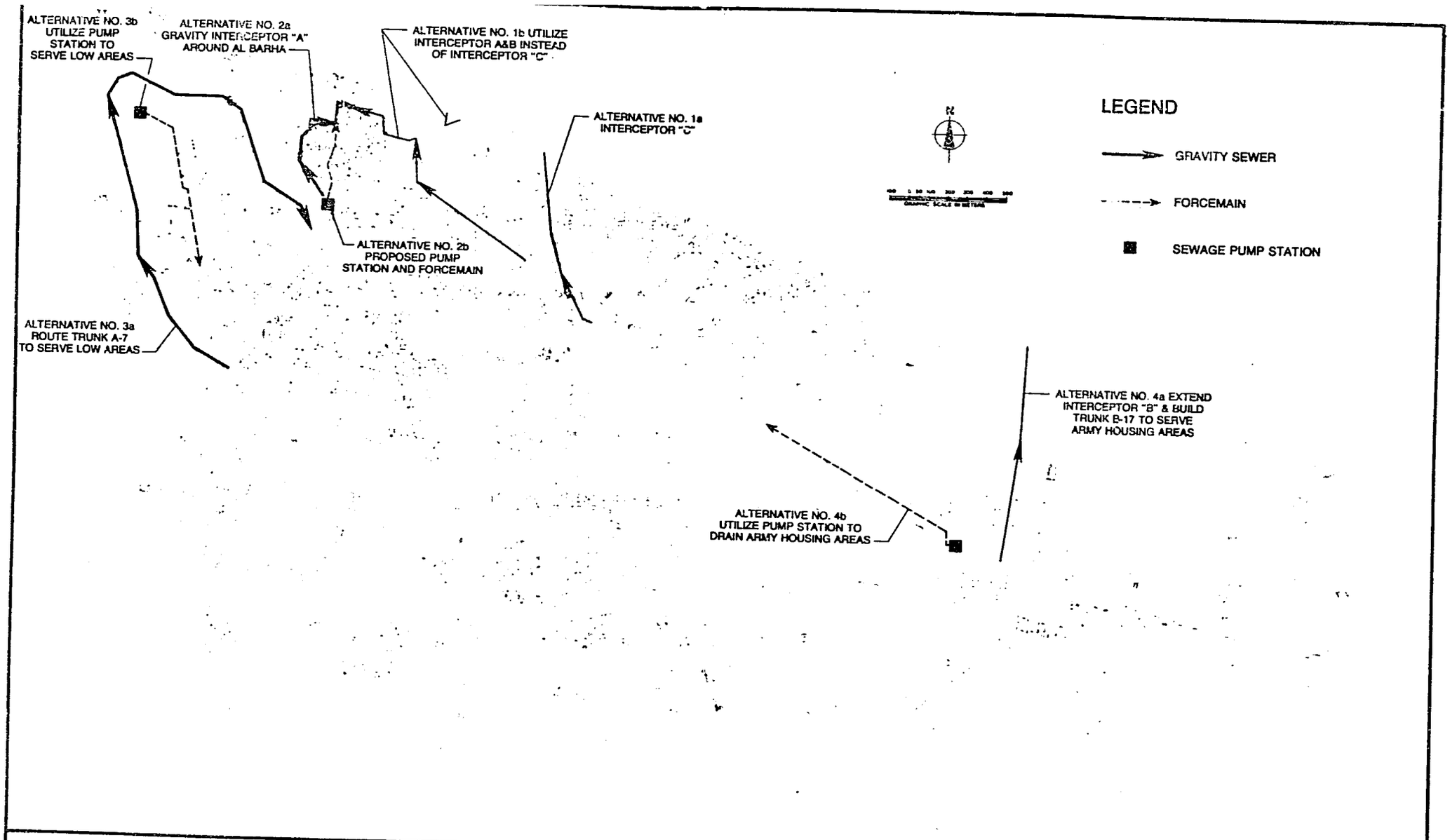
Even after allowing for increased construction costs, a comparison of annual capital and operating costs indicates the total annual costs of the gravity sewer will be only 55 percent of the cost of the pumping alternative. In addition, operation of a gravity sewer is more reliable than a pumping station and force main. In this instance, over 50 percent of the City's sewage flow is to be handled, and reliability is of utmost importance. Alternative 2a was selected because it is less costly and considered more reliable.

5.3.2.3 Alternative 3.

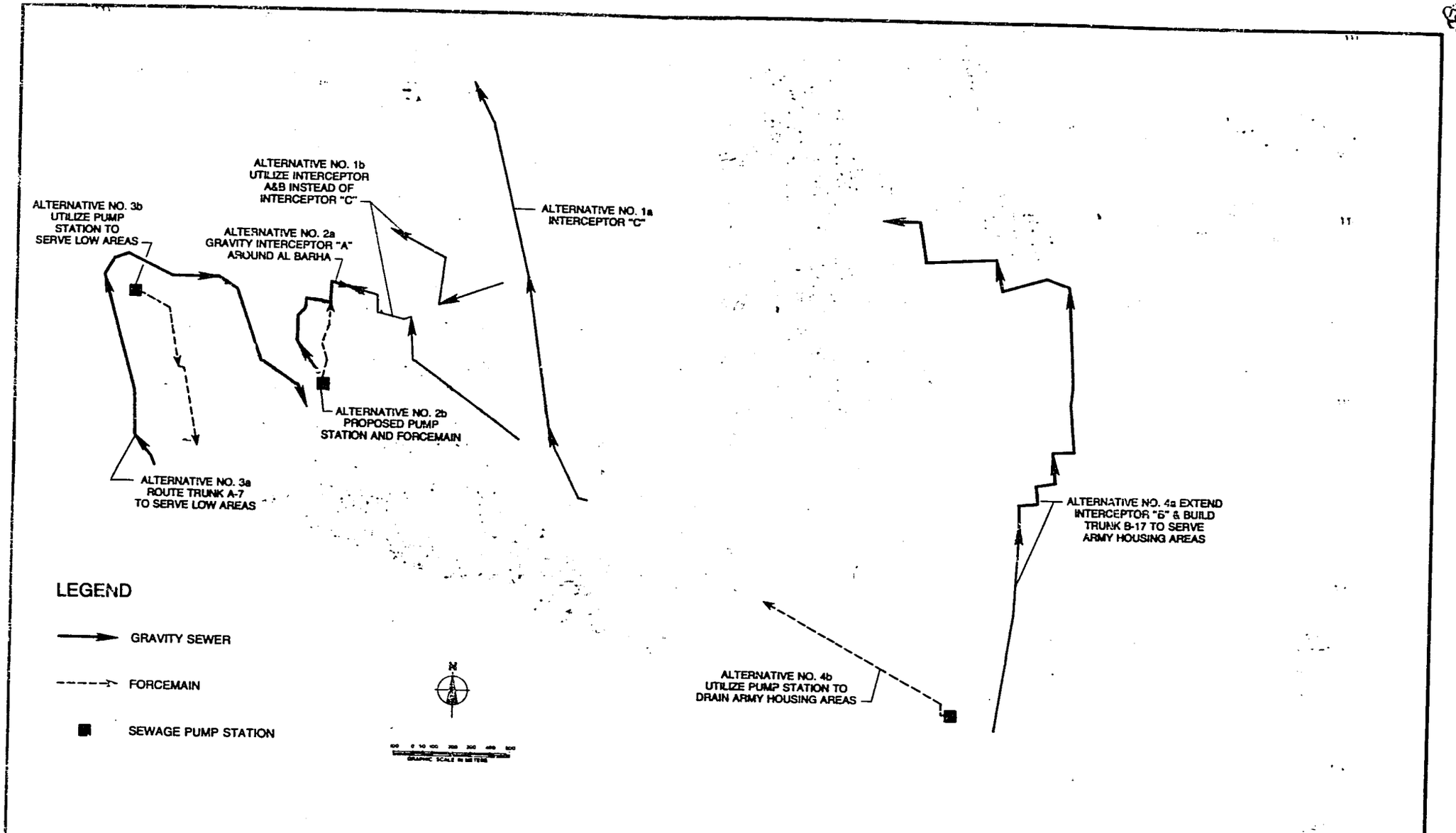
Alternative 3a routs trunk sewer A-7 at an elevation low enough to serve drainage area A-17 by gravity flow. To accomplish this, trunk sewer A-7, as well as much of interceptor A, will have to be lowered as much as 9 m. It is obvious that lowering a trunk line and interceptor by this depth is not cost-effective, particularly in this area since immediate growth is not projected. Trunk sewer A-7 is needed to serve other existing and potential growth areas. For these reasons, alternative 3b has been chosen; i.e., installation of a pumping station and force main to serve drainage area A-17.

5.3.2.4 Alternative 4.

The Army housing area can be served by either gravity sewers or by a package pump station and force main. Topography in the Army housing area indicates the natural drainage is in the northern direction, towards proposed interceptor B. In subsection 5.5.4, a phasing plan is addressed. Phase 1 construction requires that the Army housing area be served. Phase 1 construction of proposed interceptor B, however, stops near the



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	**IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT**	SEWAGE COLLECTION SYSTEM ALTERNATIVES	SHEET NO. FIGURE 5-3a DATE: SEPT. 1979 BY: F. RAHHAL CHKD: HALVENSLEBEN



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DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

SEWAGE COLLECTION SYSTEM
ALTERNATIVES

SHEET NO.
FIGURE 5-3b

DATE: SEPT. 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

western edge of the industrial park. This point of termination for interceptor B is approximately 3.0 km north of the Army housing area. The termination point of proposed interceptor A in Phase 1 is only 1.5 km west of the Army housing area. A pump station and force main are required to cross a ridge to the northwest to serve the housing area through interceptor A.

A cost-effective evaluation was conducted to determine if interceptor B should be extended to serve the Army housing area, or a pump station and force main should be constructed to interceptor A. From this evaluation, it was determined to be more economical to pump the flow into interceptor A. The total annual construction and operating cost of the pump station is only 25 percent of the annual cost of extending interceptor B 3 km to serve only the Army housing area. When interceptor B is completed in Phase 2, the pump station can be abandoned and the sewage flow from the housing area can be connected to interceptor B. At that time, additional development in the area will justify construction of this portion of the interceptor.

The relative ratings and the final rating of each alternative are given in Figure 5-4. The lower number indicates the more acceptable alternative.

Figure 5-5a and b shows the complete proposed wastewater collection system master plan for Irbid, with all pump stations, force mains, interceptors, and trunk sewers.

5.3.3 Construction Phasing

These wastewater collection studies are based on providing sewerage service to all residences in the study area by the year 2000. To implement this approach, a phased construction plan with two distinct construction phases is proposed.

Phase 1 of the sewer collection master plan is the largest and costliest phase. It will provide a solid base for future expansion, and will also provide immediate sewer collection service to the areas with the most urgent need. It includes construction of two major interceptor sewers, three pumping stations, 32 trunk sewers, and associated lateral sewers. The proposed Phase 1 collection system is shown on Figure 5-1a and b.

Interceptor A will serve the western and southern portions of the City. Figure 5-6a and b shows the proposed profile of this interceptor. Interceptor B will serve the northern and eastern sections of the City. During Phase 1, this interceptor will be constructed from the treatment plant to Hicma Street. The proposed profile of interceptor B is shown on Figure 7-7a and b.

The Phase 1 construction will provide sewer collection service for approximately 87 percent of the estimated 1990 population of the City of Irbid. The Phase 2 master plan, shown on Figure 5-2, will extend sewer collection service to the entire population expected to be located within the service area by the year 2000.

ITEM	ALTERNATIVES 1 A VS. B		2 A VS. B		3 A VS. B		4 A VS. B	
COST	4	2	1	3	4	1	4	1
ENVIRONMENTAL IMPACT	1	1	1	1	1	1	1	1
IMPLEMENTATION CAPABILITY	1	1	3	1	4	1	4	2
ENERGY USE	1	1	1	4	1	3	1	3
RELIABILITY	1	1	1	3	1	3	1	3
TOTALS	8	6	7	12	11	9	11	10

LOWEST TOTAL IS MOST ACCEPTABLE ALTERNATE

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ALTERNATIVE SEWER COLLECTION SYSTEM SCREENING MATRIX

FIGURE 5-4

DATE SEPT. 1979

BY A. TAYEH

CHECKED

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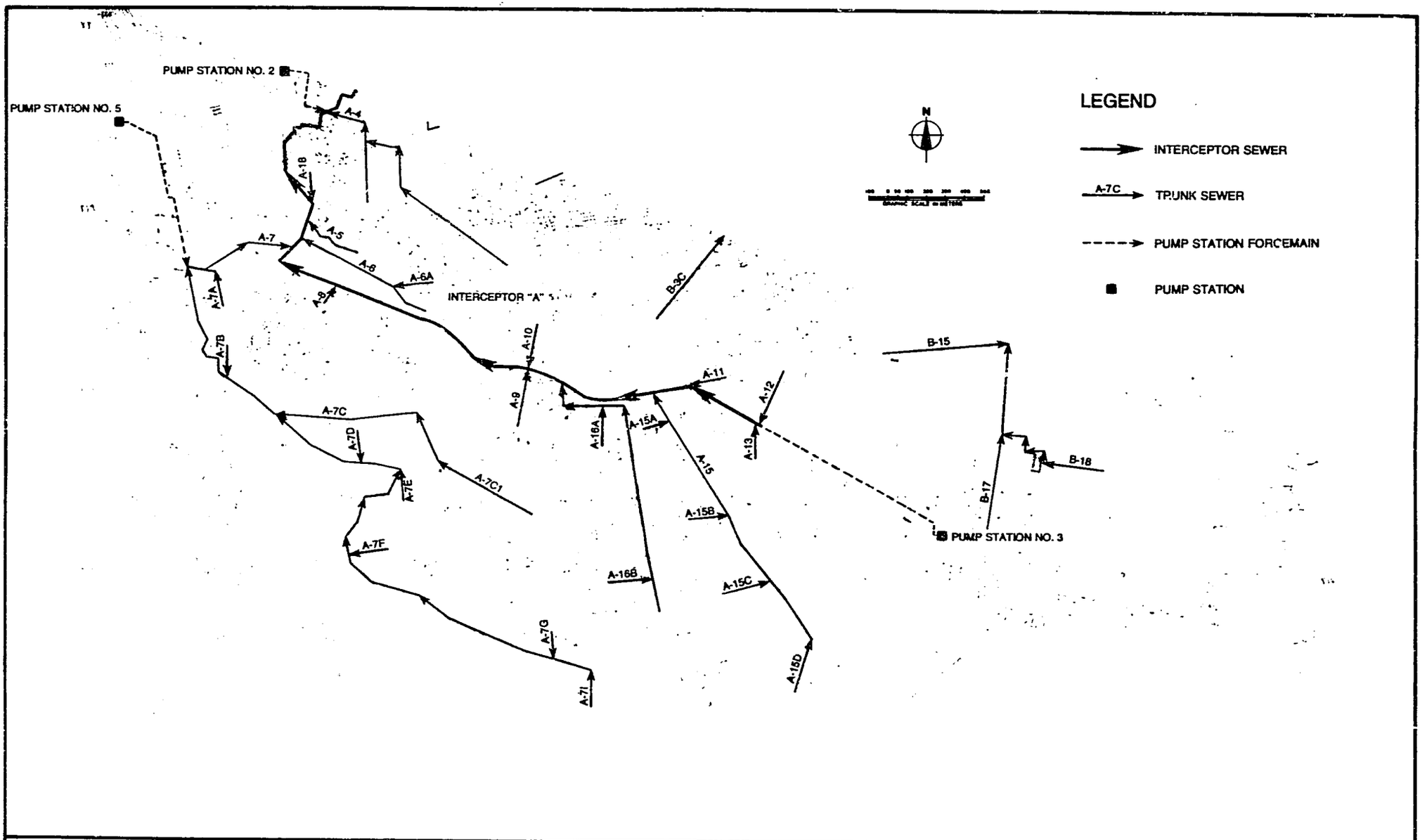

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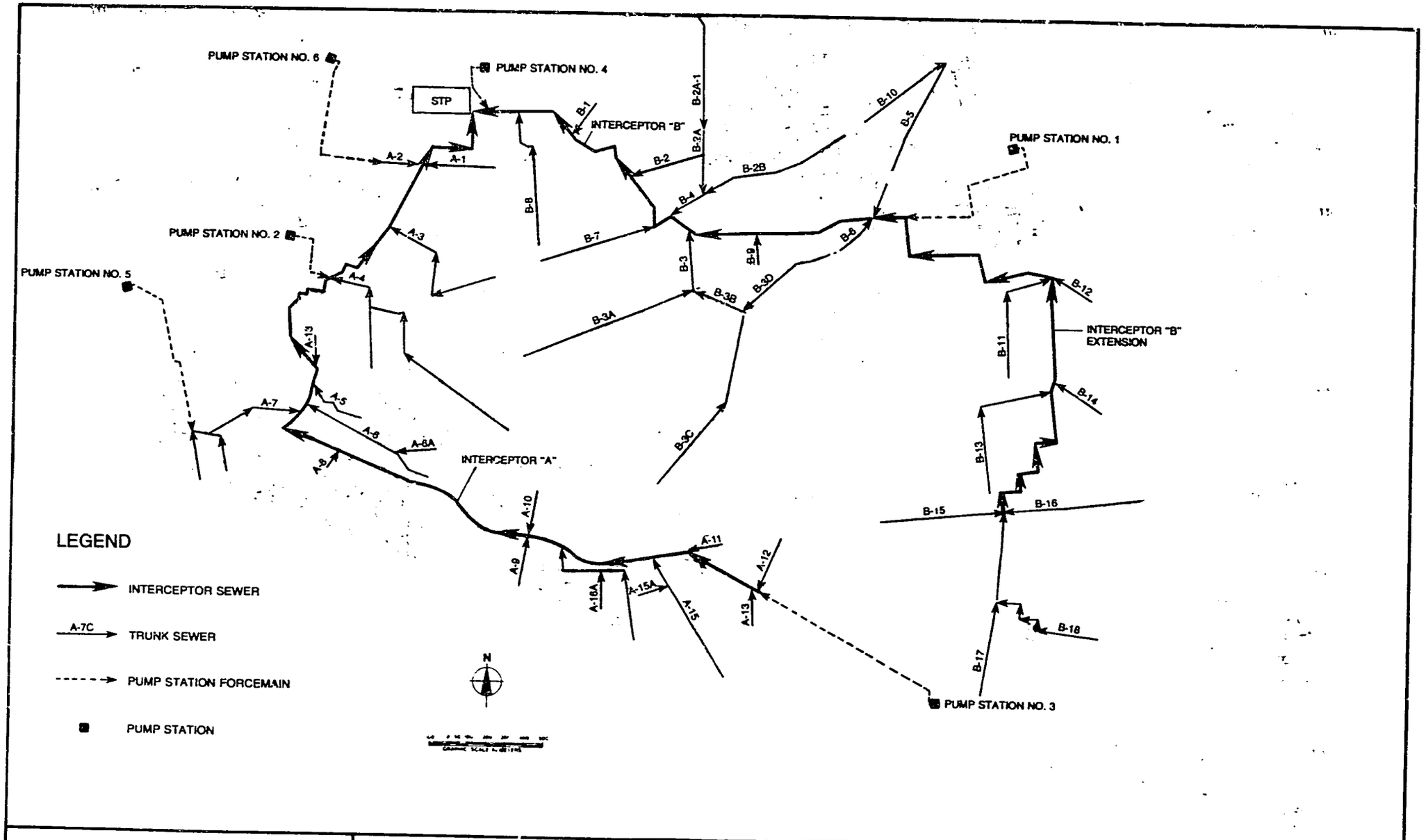

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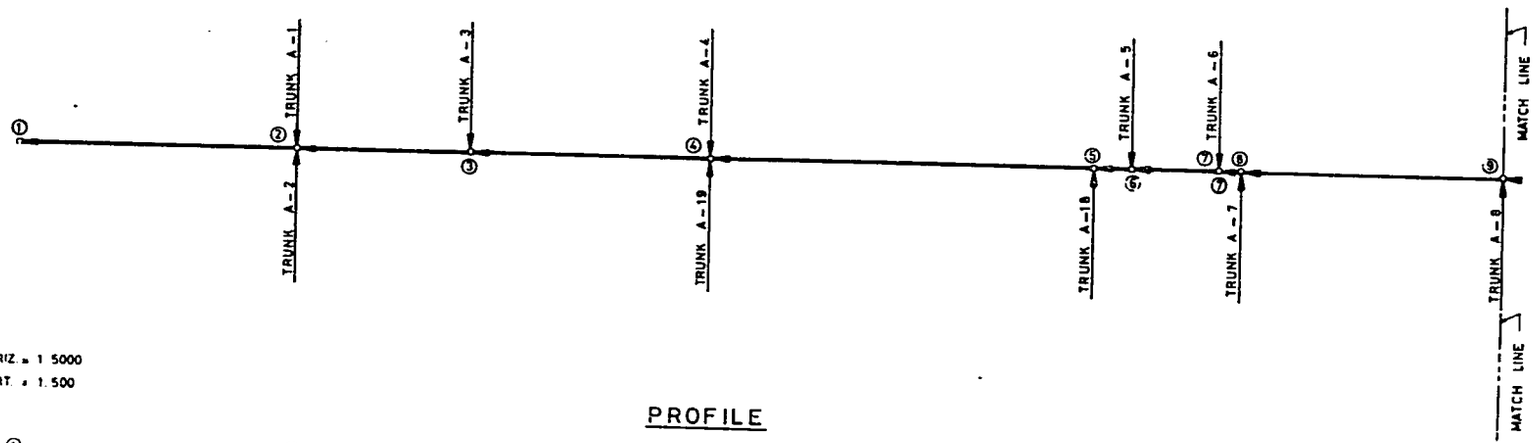
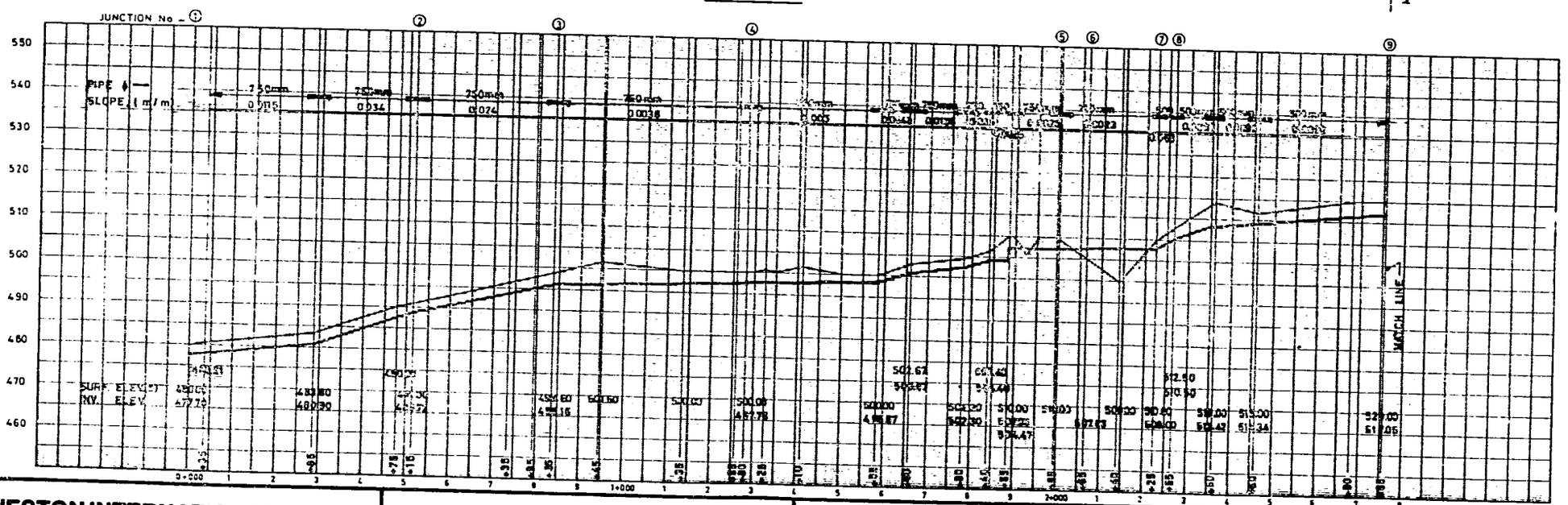
SCHEMATIC PLAN



SCALES: HORIZ. = 1 5000
VERT. = 1. 500

PROFILE



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INTERCEPTOR "A"
SCHEMATIC PLAN AND PROFILE

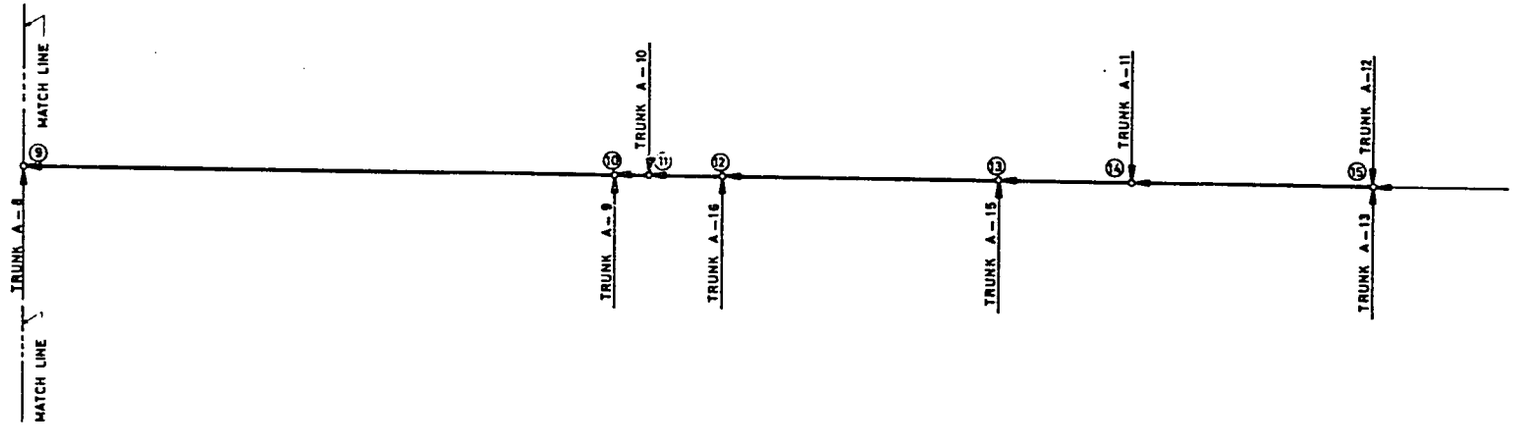
FIGURE 5-6a

DATE: SEPT. 1979

BY: F RAHHAL

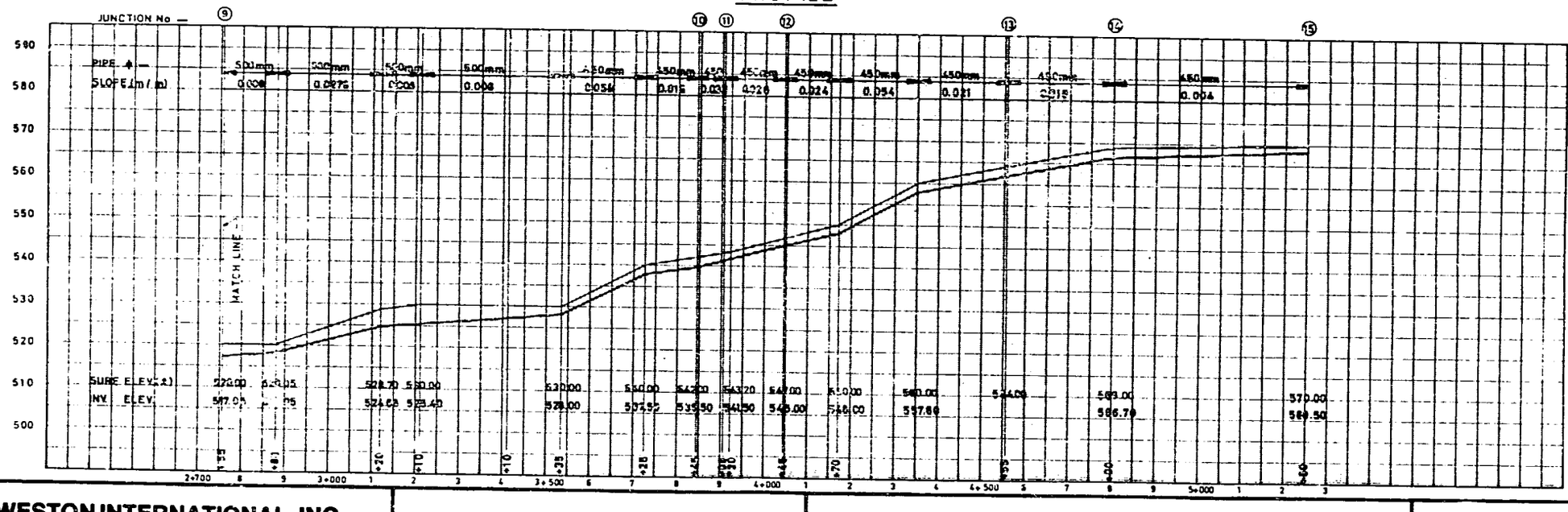
CHKD: HALVENSLEBEN

SCHEMATIC PLAN



SCALES: HORIZ. = 1:5000
VERT. = 1:500

PROFILE



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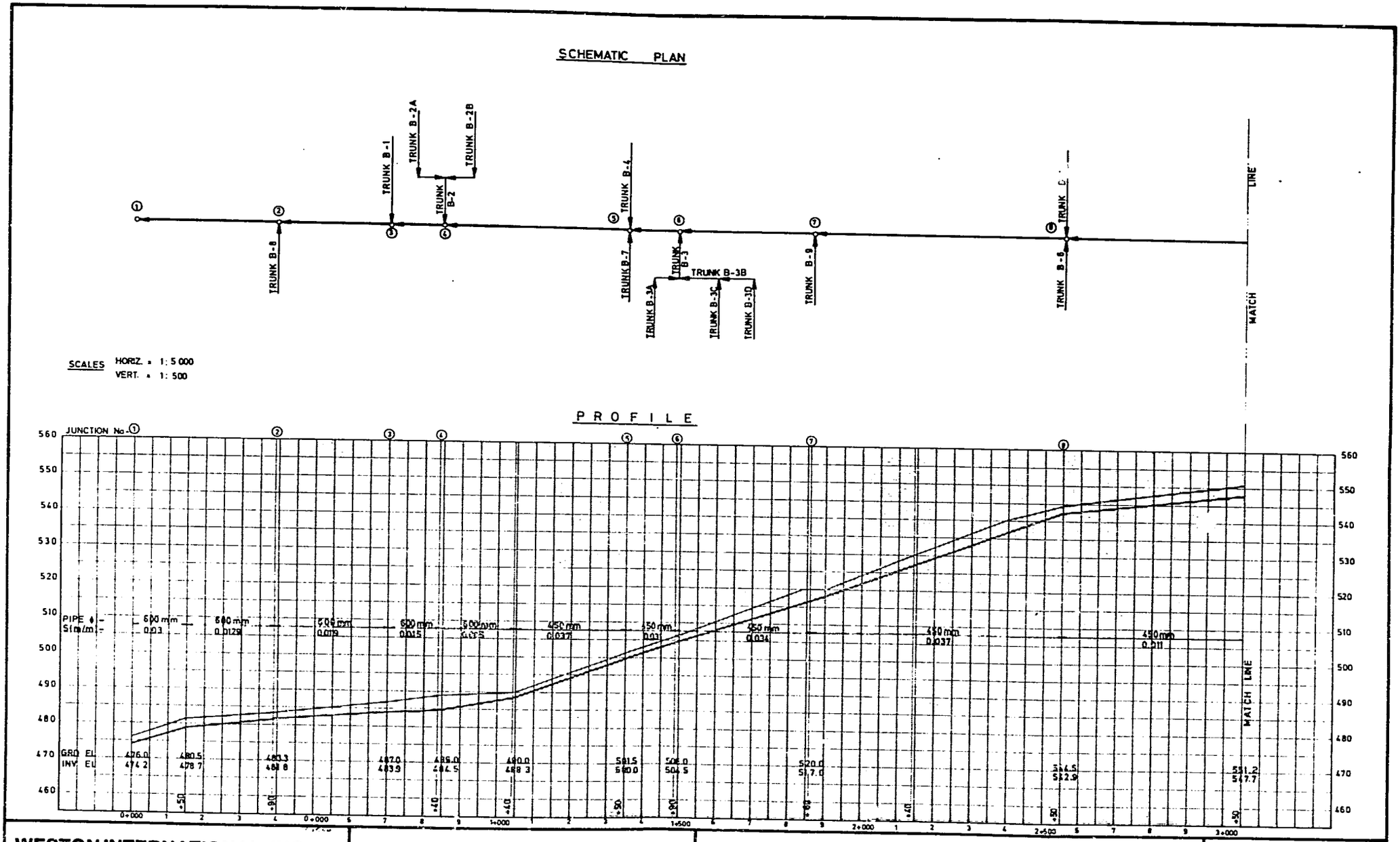
INTERCEPTOR "A"
SCHEMATIC PLAN AND PROFILE

FIGURE 5-6b

DATE: SEPT., 1979
BY: F. RAHHAL
CHKD: HALVENSLEBEN



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INTERCEPTOR "B"
SCHEMATIC PLAN AND PROFILE

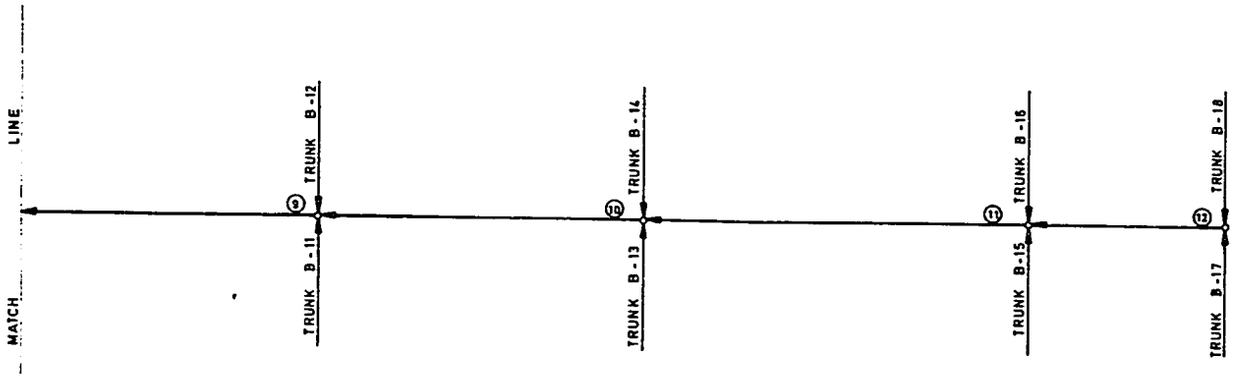
FIGURE 5 - 7a

DATE: SEPT, 1979

BY: A. TAYEH

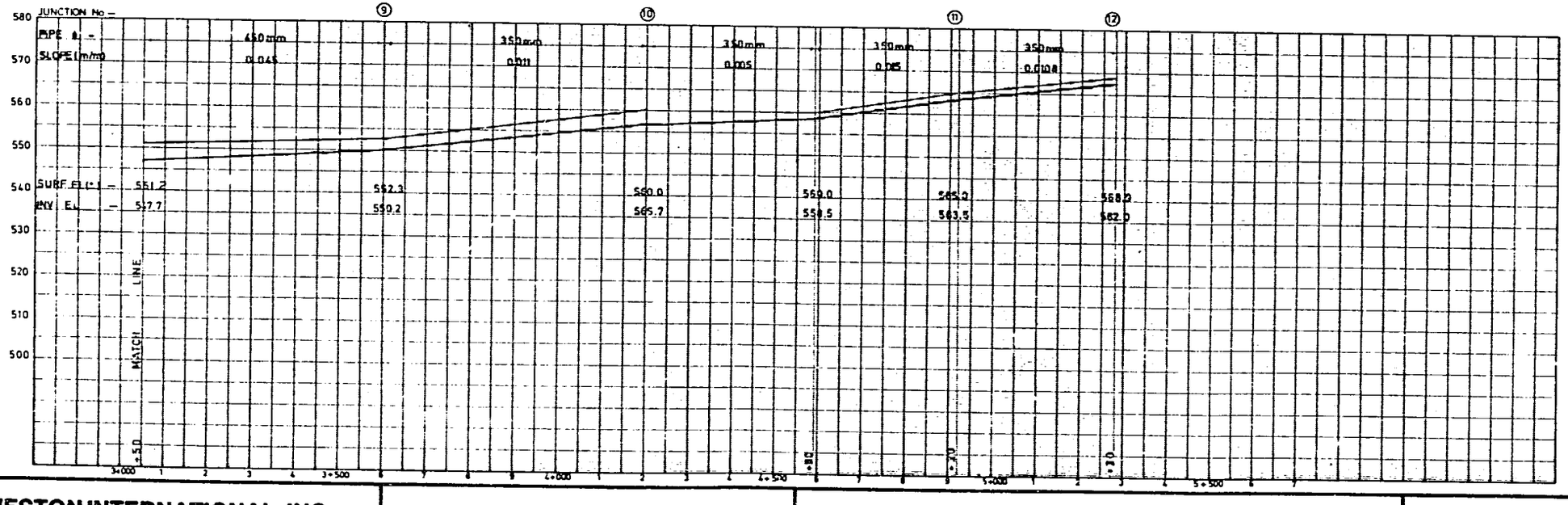
CHKD: HALVENSLEBEN

SCHEMATIC PLAN



SCALE: HORIZ. = 1:5 000
VERT. = 1 500

PROFILE



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INTERCEPTOR "B"
SCHEMATIC PLAN AND PROFILE

FIGURE 5 - 7b

DATE: SEPT., 1978

BY: A. TAYEH

CHKD: HALVENSLEBEN

In Phase 2, trunk and lateral sewers will be added to the interceptor A system, and interceptor B will be extended from Hicma Street to Buchra Street. New trunk lines and laterals will be connected to this system as required.

A construction schedule for the Phase 1 sewer collection system is developed and presented in Chapter 10, subsection 10.6.3, and Figure 10-7. This schedule provides for construction of the Phase 1 sewer collection system over a 27-month period, and suggests that nine sewer construction contracts be awarded during this period. The two interceptor contracts should be awarded first because the interceptors are required to transport wastewater to the treatment facilities. These contracts have the additional feature that they include trunk and lateral sewers required to serve the identified low income areas of the City.

5.3.4 Recommendations for Unsewered Areas

The sewerage system plan provides treatment capacity for septic tank septage from unsewered areas. Since some residences will be constructed in the study area outside of the sewer service area (especially during Phase 1 of the project), we have developed recommended septic tank construction standards for these areas. The construction standards are shown on Figures 5-8 and 5-9.

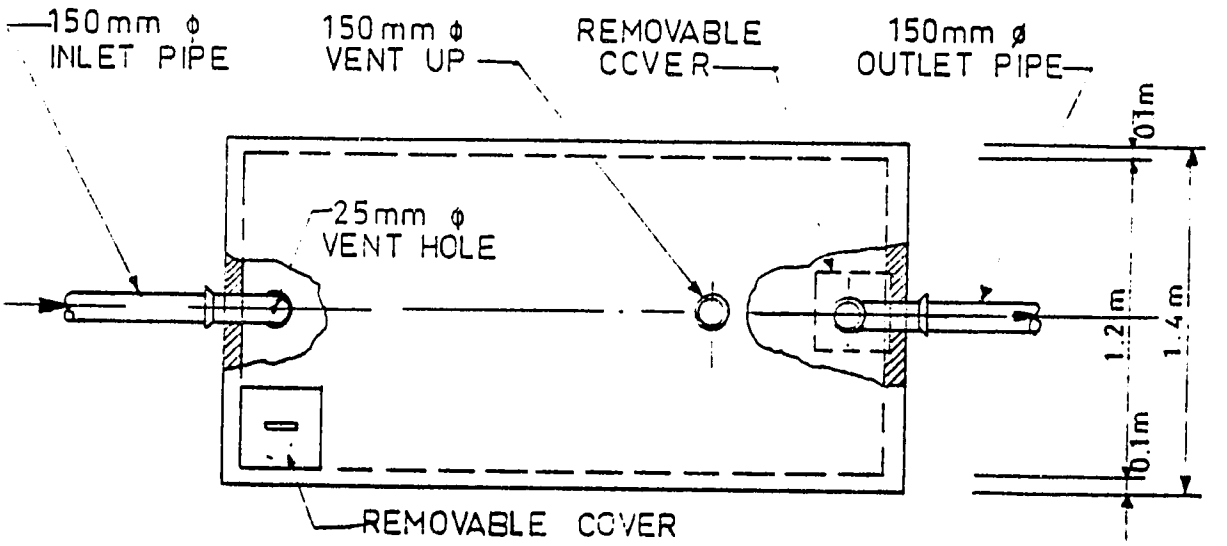
The septic tank and leaching systems can be expected to function satisfactorily as long as they are limited to areas of low density development. When development intensifies, collector sewers should be constructed and septic tanks and leaching systems filled with clean fill and abandoned.

5.3.5 Right-of-Way Requirements

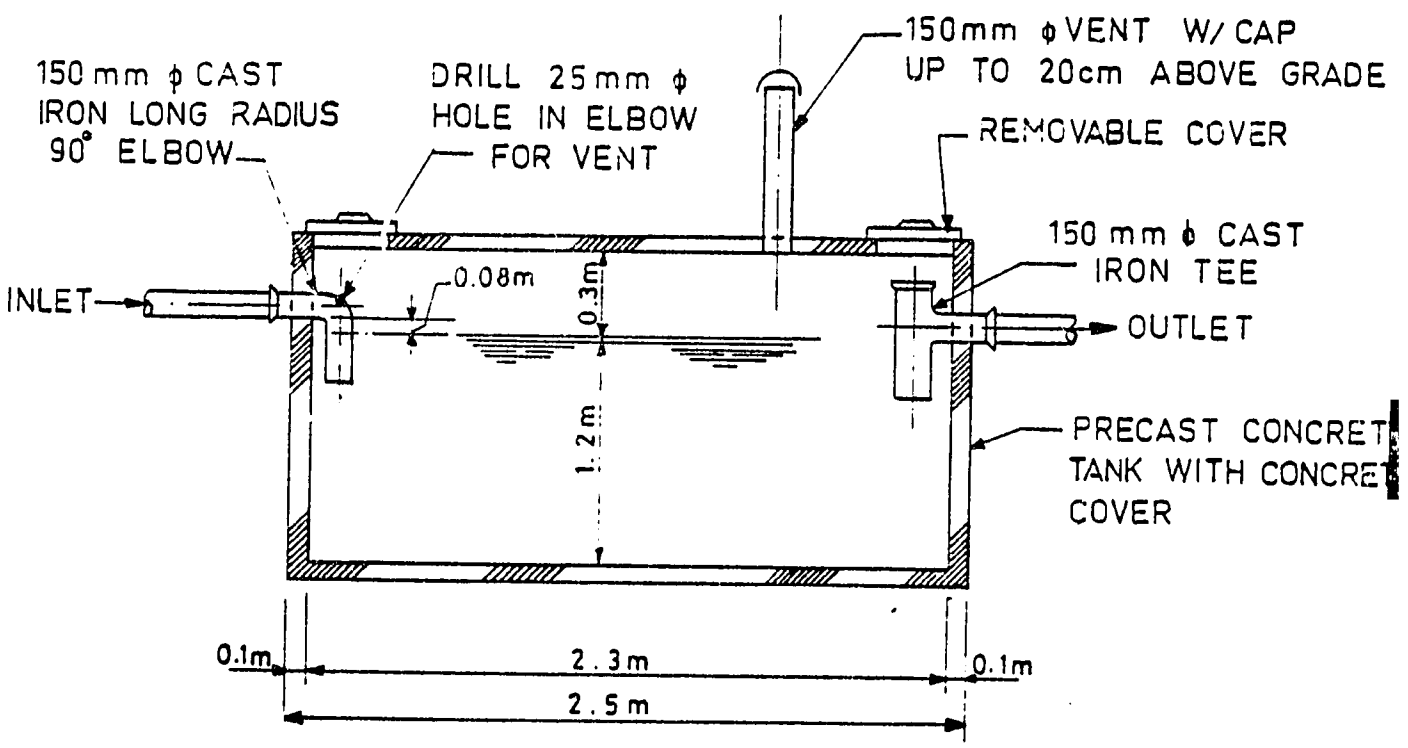
The sewage collection system master plan is laid out using existing street right-of-ways to the maximum possible extent. In some cases, trunk and interceptor sewers will have to be constructed in their own right-of-ways. In these areas, a 15- to 20-m permanent right-of-way should be obtained.

Some of the sewers to be constructed in Phase 1 will pass through existing undeveloped areas, but can be located within existing proposed street right-of-ways. If the street right-of-way can be finalized prior to the sewer construction, separate sewer right-of-ways will not be required in these areas.

The Phase 1 right-of-way requirements for the sewage collection system are identified on Figure 5-10a and b.



PLAN



SECTIONAL ELEVATION

NOTE: MAKE INLET AT LEAST 0.1m ABOV OUTLET

SEPTIC TANK ARRANGEMENT

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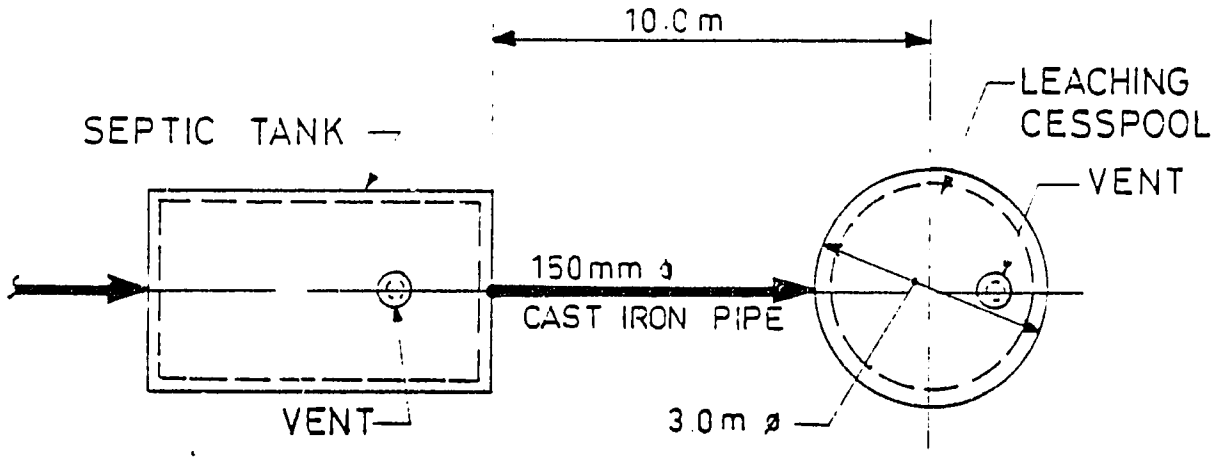
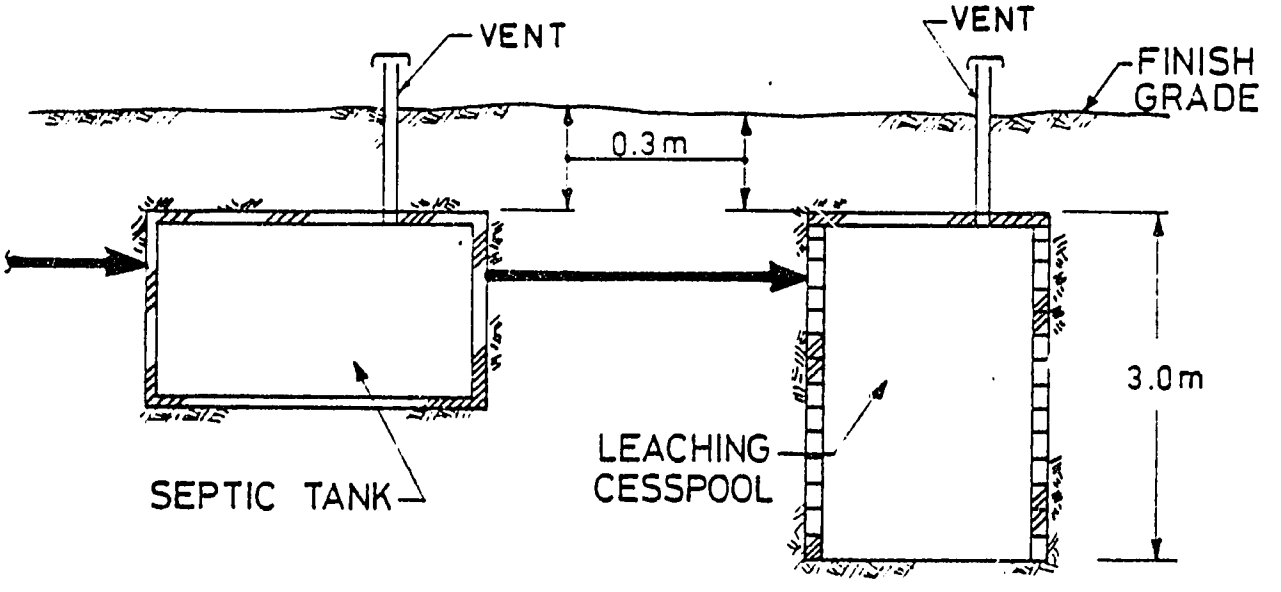


LEACHING CESSPOOL TO BE MADE OF CONCRETE BLOCK LAID-UP WITH OPEN JOINTS, DRY, AND WITH AN UNLINED BOTTOM

PLAN



SECTIONAL ELEVATION

SEPTIC TANK / LEACHING CESSPOOL ARRANGEMENT

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5.4 WASTEWATER TREATMENT

5.4.1 Introduction

To develop an effective wastewater treatment scheme, all feasible treatment alternatives which can comply with the criteria established in Chapter 3 of this report, should be considered. The treatment alternatives must also include compatible sludge handling and disposal systems. A primary consideration is the end use or disposal of the treated effluent (as well as residual solids). Other items of consideration in the selection process include the socioeconomic and environmental criteria. The initial analysis considers the following treated effluent final disposal alternatives:

1. Direct discharge to the Wadi Arab system.
2. Reuse of the treated effluent.
3. Direct land application (irrigation).

The residues (including grit, screenings, scum skimmings, and sludges must be concentrated and made innocuous prior to final disposal. Final residue disposal alternatives which are to be considered in the initial analysis include the following:

1. Disposal to sanitary landfill.

2. Direct application to the land.

3. Sludge composting and subsequent application to the land.

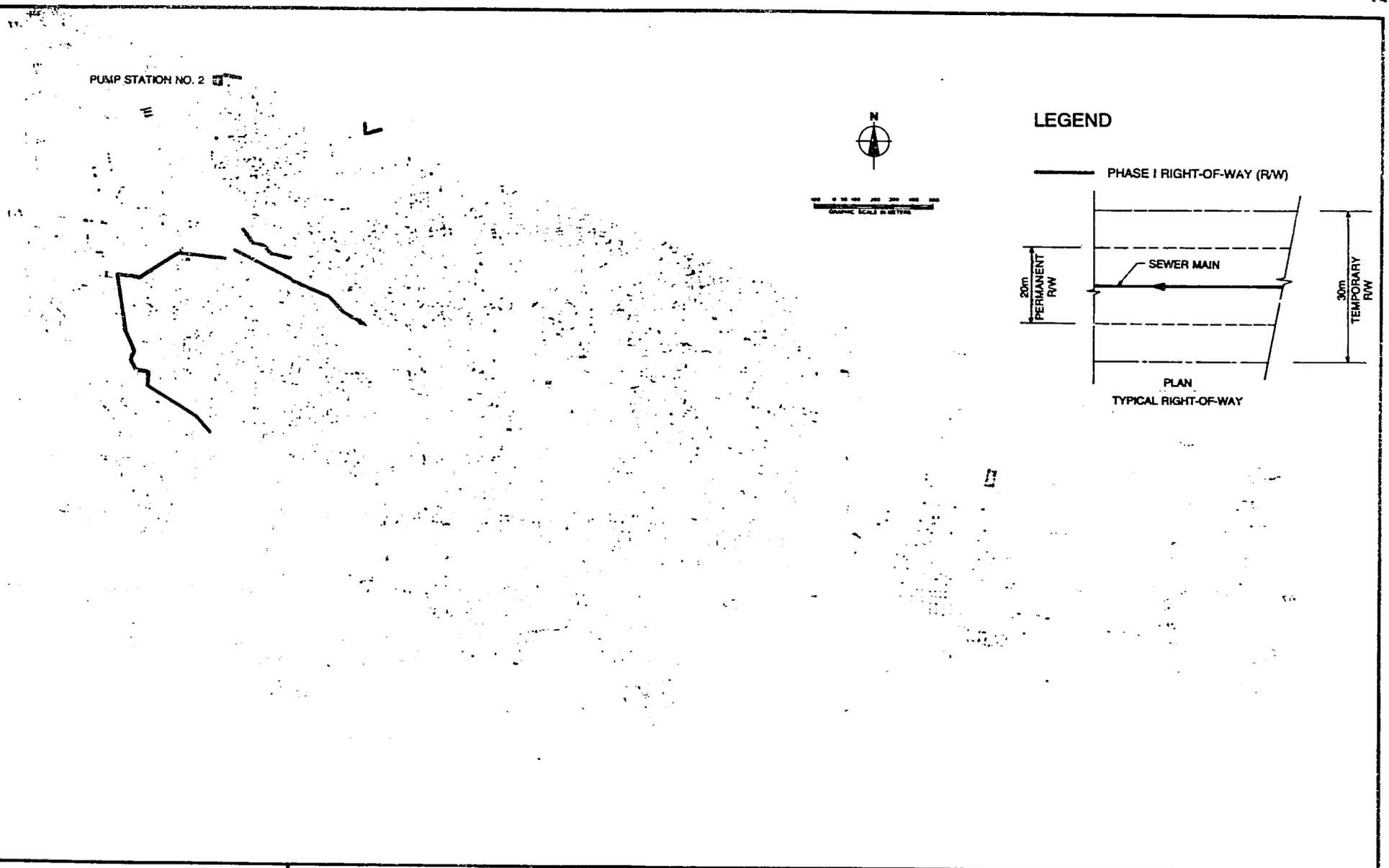
4. Sludge incineration, and burial of ash and grit in the sanitary landfill.

Each of these alternatives is discussed in an initial evaluation of effluent and residue disposal alternatives in the following subsections.

5.4.2 Effluent Disposal Alternatives

5.4.2.1 Direct Discharge to the Wadi Arab System.

There is a reservoir proposed on the Wadi Arab which will be used for storing water for irrigation purposes. The criteria for discharging to the Wadi Arab are discussed in subsection 3.3.3 of this report. With a set effluent quality, the selection of a treatment plant site can impact on the water quality of the Wadi Arab reservoir (site selection is discussed in subsection 5.4.3).



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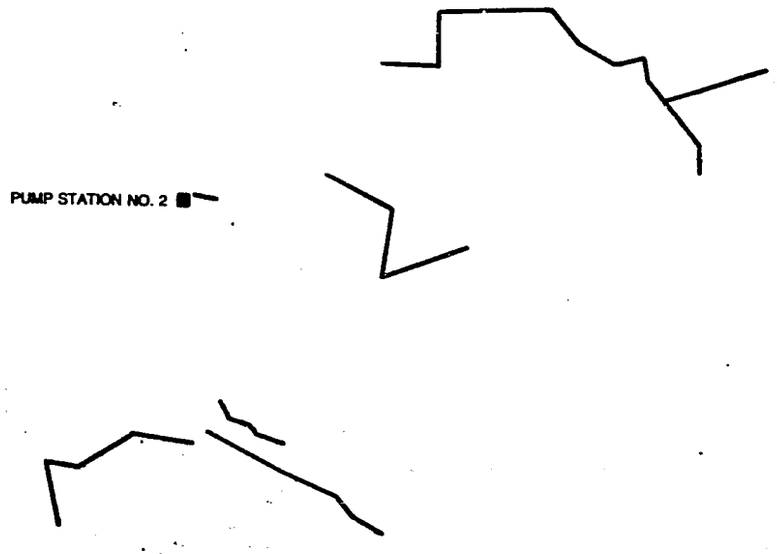
IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

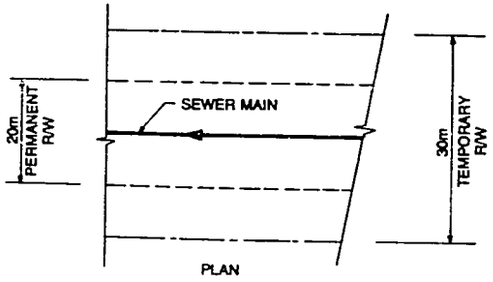
RIGHT-OF-WAY REQUIRED
PHASE I

SHEET NO. FIGURE 5-10a
DATE: SEPT. 1979
BY: F. RAHHAL
CHKD: HALVENSLEBEN

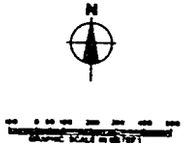


LEGEND

PHASE I RIGHT-OF-WAY (R/W)



PLAN
TYPICAL RIGHT-OF-WAY



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	RIGHT-OF-WAY REQUIRED PHASE I	SHEET NO. FIGURE 5-10b DATE: SEPT. 1979 BY: F. RAHHAL CHKD: HALVENSLEBEN

5.4.2.2 Reuse of Treated Effluent.

Reuse of the treated effluent from the proposed treatment plant can be considered a practical alternative to direct discharge of the treated effluent if the following situations apply:

1. Reuse does not constitute a health hazard.

2. Existing water sources and/or supply systems are inadequate to meet the projected future demands.

3. Treated effluent can be reused without further treatment, or with minimal additional treatment.

4. Reuse of treated effluent is more cost effective than developing new water supply systems.

5. Reuse does not interfere with other downstream uses.

Each of these situations is discussed in order of presentation.

1. Reuse -- Even in situations of relatively tight control, reuse inherently constitutes a potential health problem. If the reuse system involves a less controlled situation, (such as a domestic dual water system), the health hazard potential is greatly increased. In order to counteract the potential danger, it is necessary to institute a very concerted public information program. Even then, the hazards to the commuter population would still be high and the danger to the transient population is highest of all.

   Based on findings of this preliminary investigation, the reuse alternative could only be recommended in a case where tight control can be established, and where the risks are not inherently high (such as irrigation uses).

2. Existing water sources/supply systems inadequate -- A review of other sections of this report (especially Chapter 4), indicates future water supplies in Irbid will be inadequate for the project design period.

3. Reuse treated effluent without further treatment -- Depending on the intended use of treated effluent, there may or may not be a need to treat the effluent further.

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At present, there is no identified industry in the project area that could be considered a potential candidate for reuse of the treated effluent. This is not meant to infer that industrial reuse is not feasible or practical, but just that the uncertainty of future industrial development within the project area has not enabled us to identify a potential candidate for wastewater reuse.

4. Reuse of treated effluent more cost-effective than new supply system -- Even if a potential user is identified, the cost of a dedicated "reuse water system" must be cost effective when compared with using the existing potable water system. Included in the cost of the "reuse water system," is the liability due to occasional upsets in the wastewater treatment plant operation.

5. No interference with other downstream uses -- The Jordan Valley Authority has expressed a desire to maintain the effluent discharge in the Wadi Arab system. While it is true that most foreseeable reuse schemes would return the water through the treatment plant, the effects of reuse on salinity and trace element build-up must be thoroughly evaluated.

5.4.2.3 Direct Land Application (Irrigation).

Land application of wastewater is a form of treatment in itself. Therefore, the required degree of treatment for wastewater targeted for direct land application is considerably lessened. The application method can include: infiltration/percolation (groundwater recharge); overland flow; and spray, drip, or channel irrigation. In general, the topography, climate, and soils, as well as local farming practices around the project area, suggest that the channel or drip irrigation methods would be favored.

There are practical considerations to be reviewed if land application is proposed as a treatment process in lieu of direct discharge. As a minimum, these considerations include:

1. The wastewater must be used throughout the year. Some storage may be feasible to hold the effluent during periods of low utilization, but this increases costs.

2. The cost of pumping facilities, transmission, and distribution pumping should not exceed the savings realized by lower treatment requirements.

3. An adequate system for monitoring groundwater quality to check for contamination arising from the land application activity must be implemented.

4. The cost of treated wastewater should not be higher than the benefits of increased crop values.

5. The effluent quality (including salinity and trace metals concentrations) must be suitable for the intended application.

5.4.2.4 Summary.

Direct reuse of treated effluent is not proposed for this project at this time because of:

1. The controls that will be required to make the project function properly.

2. The lack of an identified potential industrial water user.

3. The expressed desire of the Jordan Valley Authority to have the water available for irrigation through the Wadi Arab system.

Similarly, direct land application is not considered for this study because:

1. Sufficient quantities of land suitable for land application of wastewater could not be identified.

2. Effluent used for land application will not be available for use through the Wadi Arab system.

Note that land used for effluent disposal should be available throughout the year, and effluent would be applied at the rate required for optimum wastewater renovation, not the rate required for optimum crop production. Crops produced for direct human consumption should not be considered in a land application system. This does not preclude direct application of effluent in the future. Construction of the second phase of the wastewater treatment plant, projected for the year 1990, could possibly be delayed or modified if effluent land application is viable at that time.

5.4.3 Wastewater Treatment Plant Site Selection

The topography of the project area slopes generally from the southeast to the north-northwest. This obvious flow gradient dictates that the proposed wastewater treatment plant be located on the north to northwesterly boundary of the project area. Four alternate treatment plant sites were considered. The first site is located in the vicinity of the site proposed in the preliminary report, "Sewerage and Drainage Scheme," prepared by Hydroconsult, Bratislava, Czechoslovakia (1969). The effluent discharge from this site is to Wadi el Hamam, 3.7 km above the confluence of Wadi el Ghafar. These wadis are headwater tributaries to Wadi Arab. (The approximate coordinates of the proposed discharge are 32° 34' 52" latitude by 35° 50' 00" longitude.)

The second potential site is located near the confluence of Wadi el Hamam and Wadi el Ghafar. This discharge point is located in Wadi el Ghafar. about 0.5 km above the confluence with Wadi el Hamam. (The approximate coordinates of this proposed discharge are 32° 34' 21" latitude by 35° 48' 48" longitude.)

Sites 1 and 2 contain sufficient area for development of the biological wastewater treatment alternatives described in subsection 5.4.4, but do not have sufficient area for development of the low technology, waste stabilization pond alternative. Two additional sites have been identified for the low technology alternatives. Both of these sites require pumping virtually all wastewater flows collected in the City of Irbid.

Site 3 is approximately 1 sq km north of site 1. This site is located between Wadi el Hamam and Wadi Dalham. Discharge would be to Wadi el Hamam at the same location as site 1. This site has numerous rock outcrops, and an approximately 20-m drop in elevation across the site from east to west.

Site 4 is located east of the proposed Irbid industrial park on the northeast side of Irbid. This site is flatter than site 3, and construction should be easier. The site is just to the east of the natural divide between Wadi Arab and the Yarmouk River drainage areas, however, flow could be returned to the Wadi el Hamam through approximately 500 m of effluent conduit. (The approximate coordinates of this proposed discharge are 32° 35' 00" latitude by 35° 52' 30" longitude.)

Because of the extensive pumping required to reach sites 3 and 4, these sites have not been considered for the conventional biological treatment alternatives. These sites are equivalent with respect to factors other than economics. The choice between the sites involves balancing the lower pumping costs required to reach site 3 against the lower construction costs (especially site preparation costs) required to develop site 4.

The suitability of alternative sites 1 and 2 were evaluated in accordance with the site selection criteria set forth in Chapter 3, as follows:

1. Evaluation and Relief -- Both sites are considered satisfactory. The main wastewater treatment flow stream can flow through each site by gravity.

2. Proximity and Access -- Site 2 is remote, located on a spit of land between Wadi el Ghafar and Wadi el Hamam. The only access is a road from the southeast. Site 1 is closer to the City and has better access to the alternative solid waste disposal sites.

3. Land Use -- Site 1 is surrounded by existing agricultural, industrial (slaughterhouse), and some residential land. Site 2 is in an agricultural area. Agriculture in the vicinity of site 1 is primarily field crops, while the agriculture in the vicinity of site 2 includes extensive orchards.

4. Expansion -- Both sites are suitable for future expansion.

5. Effluent Renovation -- Site 1 is approximately 3 km further upstream from the Wadi Arab reservoir than site 2. This will allow effluent from site 1 to receive additional stream reaeration and renovation because of increased travel time.

6. Land and Interceptor Sewer Costs -- Land cost for site 1 is estimated to be approximately 100,000 JD more than the land cost for site 2. This cost is more than offset by the increased sewer interceptor cost (approximately 250,000 to 300,000 JD) required to reach site 2. In addition, at least a portion of the flow from the northern part of the Irbid service area will require pumping to reach site 2.

7. Odor Potential -- Site 2 is remote from the City of Irbid, and odors generated at this site will not affect the City. Odors generated at site 1 could affect the northern portion of the City. Several points should be noted, however:

a. Existing development is very sparse in the vicinity of site 1.

b. Site is adjacent to the existing Irbid municipal slaughterhouse which is, in itself, a potential source of odors.

c. Odors are not normally generated by the biological treatment systems being considered in this study if the systems are operated properly. Odors are an indication that treatment is upset, and the design effluent standards are not being met.

Based on this evaluation, site 1 has been selected as the site for the biological wastewater treatment facilities.

5.4.4 Wastewater Treatment Alternatives

5.4.4.1 Low Technology Alternatives.

Waste stabilization ponds are an appropriate, low-technology wastewater treatment system. When suitable low cost land is available, properly-designed waste stabilization ponds can produce good quality effluent with minimum operating costs. Four treatment alternatives have been considered for site 3 and site 4, as follows:

1. Facultative waste stabilization ponds.
2. Anaerobic/aerobic stabilization ponds.
3. Aerated lagoons.
4. Anaerobic ponds/aerated lagoons.

These alternatives are described in the following paragraphs, and the cost analysis based on a comparison of annual costs is presented in Table 5-2.

1. Facultative Waste Stabilization Ponds.

Operation of waste stabilization ponds depends on a symbiotic relationship between bacterial degradation of organic matter and algal photosynthetic production of oxygen. Aerobic, facultative, and anaerobic bacteria are found in ponds. Properly-designed ponds in tropical areas do not require desludging until after 8 to 16 years of operation.

Waste stabilization ponds in the United States are commonly designed for a loading rate of 50 lbs BOD/acre/day (56.8 kg/hectare/day). In tropical areas, loading rates three to seven times the United States design

Table 5-2

Cost Analysis -- Low Technology Alternatives
(All Costs in JD x 1,000)

Alternative	1		2		3		4		5		6		7		8	
Description	Facultative Waste Stabilization Pond Site 3		Facultative Waste Stabilization Pond Site 4		Anaerobic/ Aerobic Stabilization Ponds Site 3		Anaerobic/ Aerobic Stabilization Ponds Site 4		Aerated Lagoons Site 3		Aerated Lagoons Site 4		Anaerobic Ponds/ Aerated Lagoons Site 3		Anaerobic Ponds/ Aerated Lagoons Site 4	
Design Year	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
Total Construction Cost	2,832	3,659	2,559	3,426	2,100	2,678	1,737	2,259	4,761	6,783	2,778	3,840	2,841	3,830	2,002	2,583
Land Acquisition	2,580	2,580	2,580	2,580	1,980	1,980	1,980	1,980	900	900	900	900	405	405	405	405
Contingencies	425	549	384	514	315	402	260	339	714	1,017	417	576	426	575	300	387
Administration, Engineering	425	549	384	514	315	402	260	339	714	1,017	417	576	426	575	300	387
Total Capital Cost--1979	6,262	7,337	5,907	7,034	4,710	5,462	4,237	4,917	7,089	9,717	4,512	5,892	4,098	5,385	3,007	3,762
Annual Capital Cost	733.9	790.6	692.3	751.7	552.0	591.7	497.8	533.7	830.8	969.4	528.8	601.6	480.3	669.5	352.4	392.2
Annual Operation and Maintenance Costs																
Materials	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0	8.0	10.0	8.0	10.0	8.0	10.0	8.0	10.0
Power	26.3	39.4	50.0	85.0	26.3	39.4	50.0	85.0	381.8	552.4	405.5	598.0	200.3	282.0	224.0	322.0
Labor	56.3	62.5	56.3	62.5	56.3	62.5	56.3	62.5	69.4	77.2	69.4	77.2	69.4	77.2	69.4	77.2
Chemicals	3.6	3.7	3.6	3.7	3.6	3.7	3.6	3.7	3.6	3.7	3.6	3.7	3.6	3.7	3.6	3.7
Sludge Disposal	--	--	--	--	5.0	7.0	5.0	7.0	8.0	11.1	8.0	11.1	6.3	8.7	6.3	8.7
Total Operation and Maintenance Costs	90.2	110.6	113.9	156.2	95.2	117.6	118.9	163.2	470.8	654.4	494.5	700.0	287.6	381.6	311.3	421.6
Total Annual Costs	824.1	901.2	806.2	907.9	647.2	709.3	616.7	696.9	1,301.6	1,623.8	1,023.3	1,301.6	767.9	1,051.1	663.7	813.8

rate have been used successfully. At loading rates of 200 lbs BOD/acre/day (227.3 kg/hectare/day), BOD removals greater than 90 percent have been achieved with minimal sludge build-up.

The combined domestic and commercial industrial/institutional BOD loads for Irbid are 21,164 kg/day and 32,530 kg/day in the years 1990 and 2000, respectively. At these loads, the effective waste stabilization pond areas for Irbid are 93 hectares in 1990 and 143 hectares in the year 2000. Allowing 20 percent additional area for dikes, service roads, operations area, and buffer capacity, the total site area required for waste stabilization ponds to serve Irbid through the study period is 172 hectares.

The large surface areas of waste stabilization ponds will cause large quantities of water to be removed via evaporation in the hot summer months.

Snails in waste stabilization ponds can act as vectors in the transmission of schistosomiasis. Pond detention time is important in this regard. In Mandarellis, Rhodesia, it has been found that snail vectors are not capable of survival for more than 10 weeks in a pond environment.

Mosquitoes can be a problem in ponds if routine maintenance is not carried out. Peripheral vegetation must be removed to achieve positive control.

The major operating and maintenance costs for waste stabilization ponds in Irbid are related to the influent pumping requirements.

2. Anaerobic/Aerobic Stabilization Ponds.

The organic loading to the stabilization ponds can be reduced if the wastewater is first treated in anaerobic ponds. This alternative considers that 50 percent of the organic load to the treatment facility is removed in deep anaerobic ponds. The effluent from these ponds is then treated in shallow aerobic ponds. The aerobic pond effluent is passed through slow sand filters, and disinfected prior to discharge to Wadi el Hamam.

The total Phase 1 and Phase 2 land requirement for this alternative is reduced from 172 hectares to 132 hectares.

3. Aerated Lagoons.

Land requirements can be further reduced if mechanical aerators are provided to maintain dissolved oxygen concentrations in the ponds. Aerobic/anaerobic lagoons have been considered for Irbid. In this alternative, aerators are provided of sufficient capacity to maintain uniform distribution of dissolved oxygen in the ponds, but not of sufficient capacity to maintain suspension of all settleable solids.

The operating and maintenance costs of this alternative are increased because of the mechanical aeration equipment required. Settling tanks are required to remove suspended solids, and chlorination is required for disinfection prior to discharging effluent to the wadi.

Approximately 60 hectares are required for this alternative.

4. Anaerobic Ponds/Aerated Lagoons.

The loading to aerated lagoons can be reduced approximately 50 percent if the lagoons are preceded by anaerobic ponds. Approximately 27 hectares are required for treatment in aerated lagoons preceded by anaerobic ponds.

Inspection of Table 5-2 shows the alternative requiring the lowest technology for Irbid is pretreatment in anaerobic ponds, followed by treatment in aerobic ponds.

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5.4.4.2 Other Biological Treatment Alternatives.

A number of biological treatment processes, as well as some more sophisticated chemical-physical processes can achieve the effluent criteria set out in Chapter 3. Generally, unless dictated by unique constraints, the biological processes will be more economical. Five biological wastewater treatment schemes have been selected and developed with appropriate sludge-handling schemes for additional investigation as follows:

1. Description.

   a. Rotating biological media (shown in Figure 5-11).

   b. Trickling filter - in stages, or in combination with another process (shown in Figure 5-11).

   c. Activated sludge - conventional design with single stage nitrification (shown in Figure 5-12).

   d. Extended aeration/activated sludge (shown in Figure 5-12).

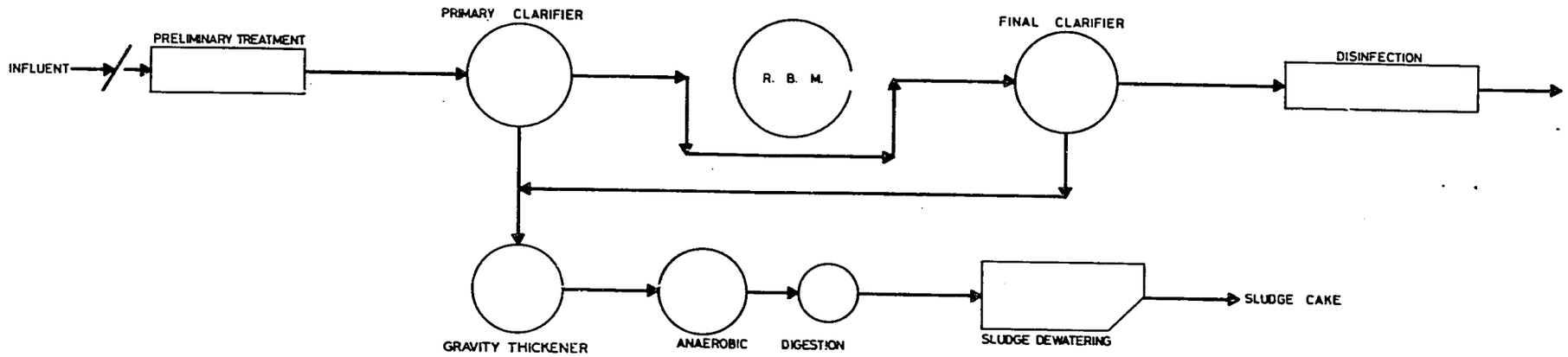
   e. Oxidation ditch/activated sludge (shown in Figure 5-13).

The features of these wastewater treatment schemes are described in the following paragraphs:

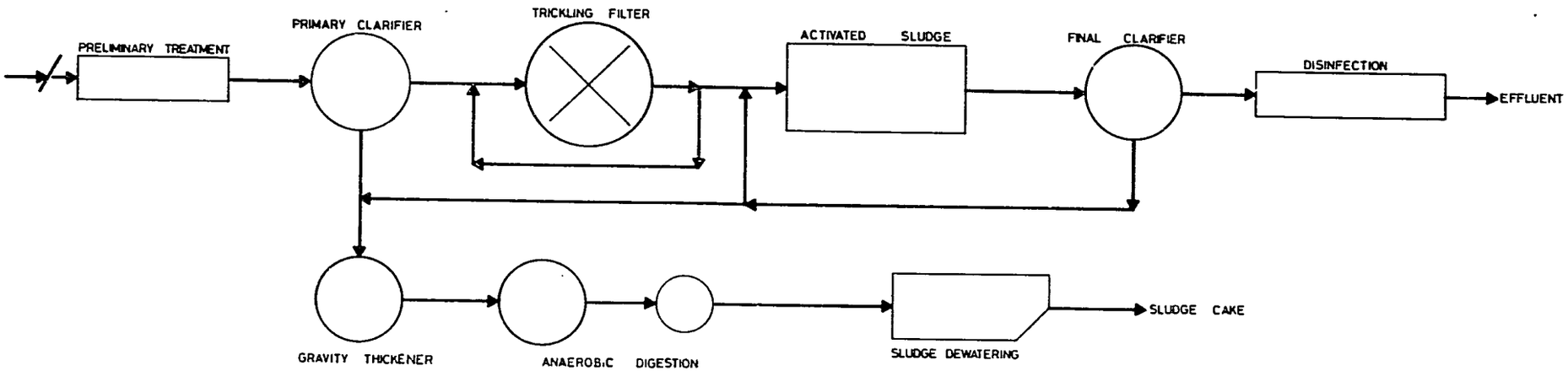
a. Alternative 1 -- Rotating Biological Media (See Figure 5-11)

- Preliminary Treatment -- Screening and aerated grit removal, as well as influent flow measurement via a standing wave-type flow element (Parshall flume). The aerated grit removal unit is oversized to provide preaeration of raw wastewater and septage to ensure efficient operation in the downstream primary clarifiers.

- Primary Treatment -- Provides removal of settleable materials and much of the floatable oil and grease and some debris. Primary clarification is a necessary treatment of wastewater prior to treatment by fixed film reactors, such as the rotating biological media (RBM) process. The clarifier is designed on the basis of a 30 cu m/day/sq m overflow rate, and is expected to remove 60 to 65 percent of the influent suspended solids and 35 to 40 percent of the influent BOD. Sludge pumps will transfer settled solids to gravity thickeners.



ALTERNATE No. 1



ALTERNATE No. 2

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WWTP ALTERNATE No:1- ROTATING BIOLOGICAL MEDIA (R.B.M)

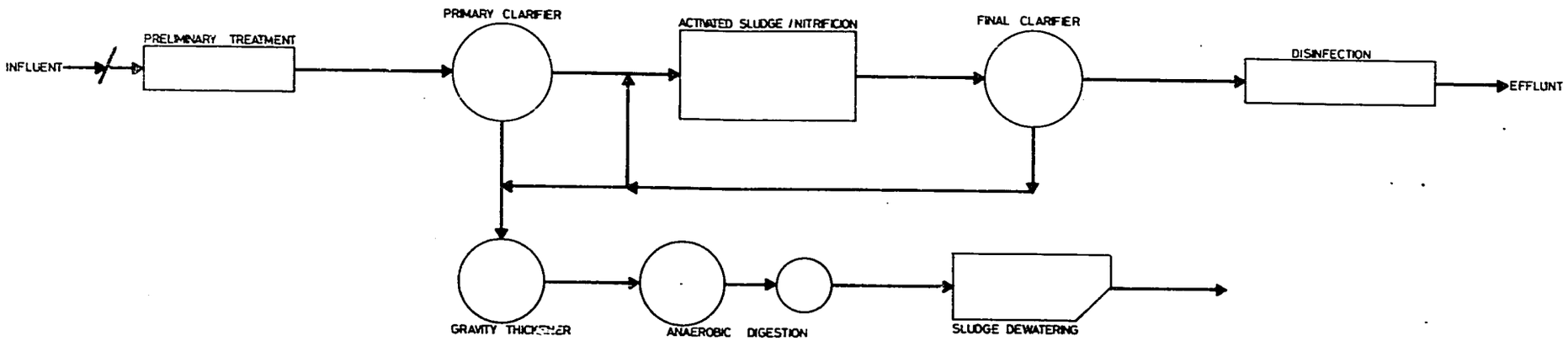
WWTP ALTERNATE No:2 TRICKLING FILTER - ACTIVATED SLUDGE

FIGURE 5-11

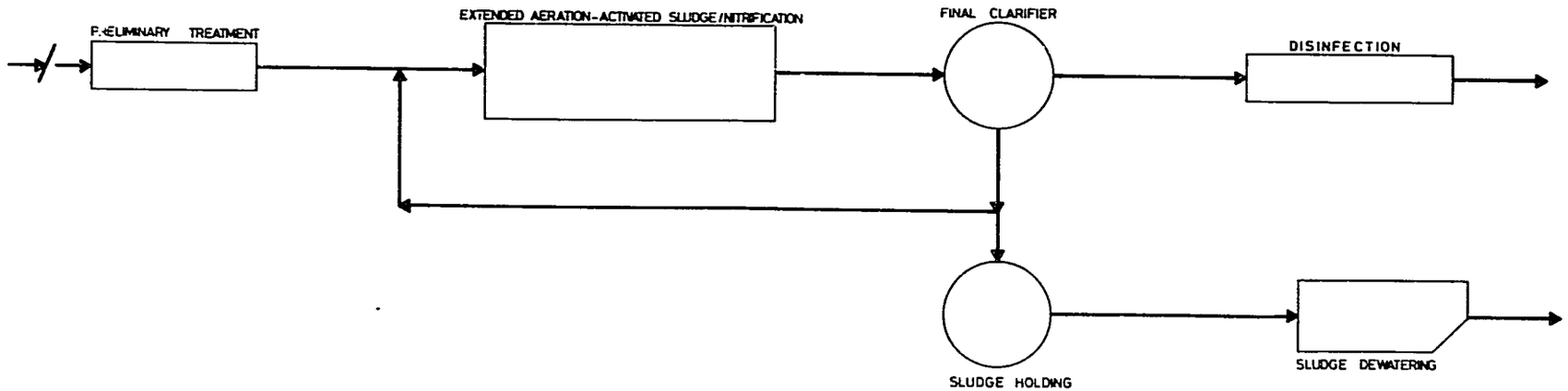
DATE: SEPT. 1979

BY: A. TAYEH

CHKD: HALVENSLEBEN

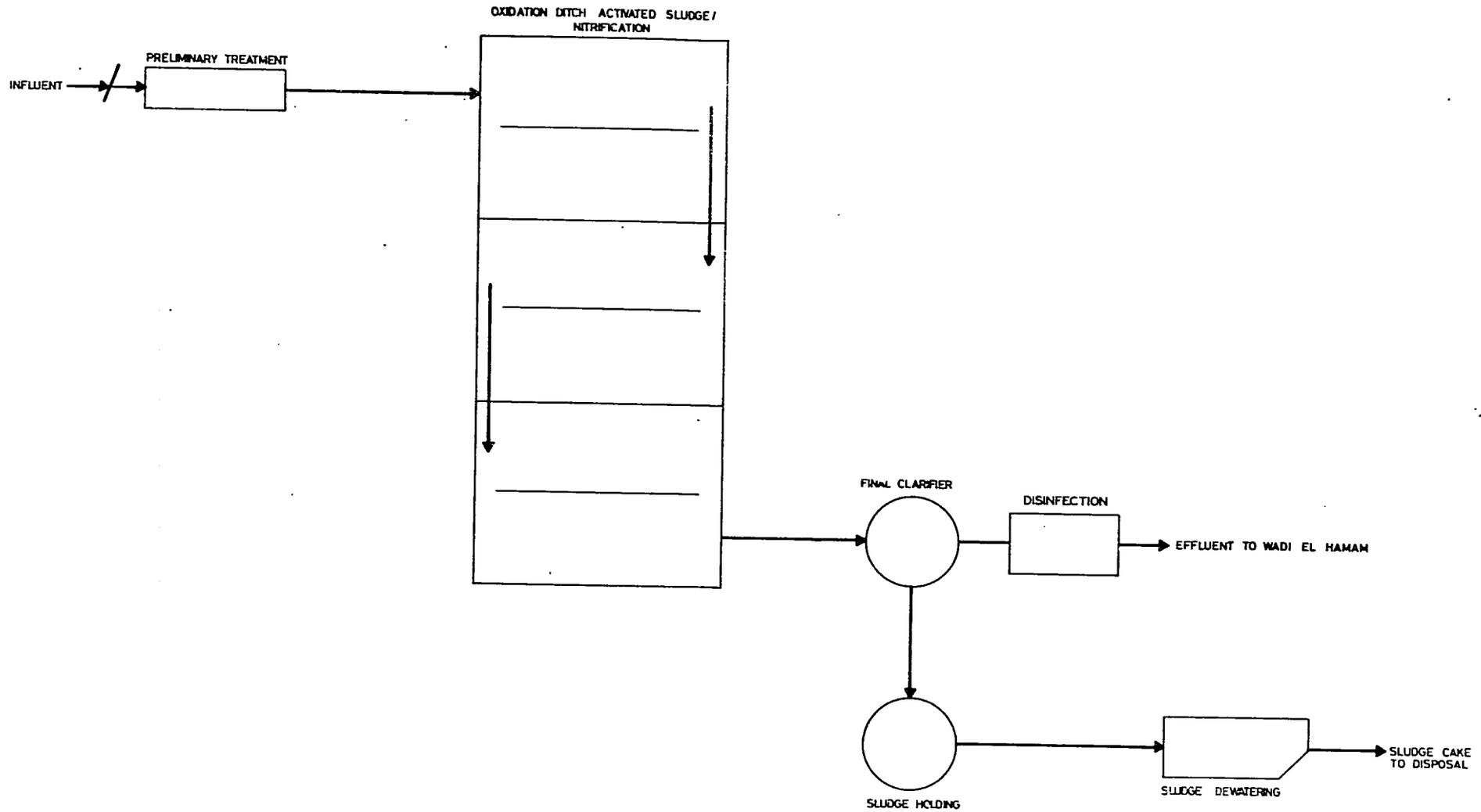


ALTERNATE No. 3



ALTERNATE No. 4

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	WWTP ALTERNATE No.:3 ACTIVATED SLUDGE NITRIFICATION (SINGLE CELL) WWTP ALTERNATE No.:4 EXTENDED AERATION ACTIVATED SLUDGE-NITRIFICATION (SINGLE CELL)	FIGURE 5-12 DATE: SEPT.1979 BY: A. TAYEH CHKD: HALVENSLEBEN



ALTERNATE No 5

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	**IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT**	WWTP ALTERNATE No.5 - OXIDATION DITCH ACTIVATED SLUDGE - NITRIFICATION (THREE CELL)	FIGURE 5-13 DATE: SEPT. 1979 BY: A. TAYEH CHKD: HALVENSLEBEN

- Rotating Biological Media (RBM) -- A biological treatment process which utilizes a fixed film of biological microorganisms. The organisms attach themselves to plastic disks which are mounted on a horizontal shaft. The disks are rotated slowly in the wastewater so that the organisms alternatively adsorb the wastewater pollutants and then adsorb oxygen directly from the atmosphere for biochemical oxidation. The required surface area of the RBM system is based on a hydraulic loading of 0.02 cu m/day/sq m to achieve a high degree of nitrification.

- Final Clarification -- Separates the microbial growth slimes which periodically slough off the RBM plastic media. The organic slimes are pumped directly to the gravity thickeners. The final clarifiers are designed for an average overflow rate of 15 cu m/day/sq m.

- Disinfection -- Disinfection of the treated effluent is accomplished via chemical oxidation with gaseous chlorine. The minimum contact time is 15 minutes at the maximum flow rate.

- Gravity Thickening -- Concentrates the sludges removed from the primary and final clarifiers and minimizes the size of the downstream anaerobic digesters. The thickener is designed on a solids loading basis of 70 kg/day/sq m. The thickener design is based on projected year 2000 loadings.

- Two-Stage Anaerobic Digesters -- Reduce the quantity and stabilize the primary and secondary sludges. The digesters are designed on a loading criteria of 2.5 kg solids/cu m/day, and will be adequate for the year 2000 requirements.

- Sludge Dewatering -- Accomplished via mechanical means (vacuum filtration or belt press) to reduce the volume of the sludge haul to the landfill. It is anticipated that the dewatering unit will operate around the clock on a four-shift basis for seven days/week at design load conditions in the year 2000. An extra dewatering unit would be provided as a standby.

b. Alternative 2 -- Trickling Filter/Activated Sludge (See Figure 5-11)

This scheme utilizes the following unit processes:

- Preliminary Treatment -- Identical to alternative 1.

- Primary Treatment -- Identical to alternative 1.

- Trickling Filter -- A fixed-film biological treatment process. Unlike the RBM which dips the media and attached culture into the waste, the trickling filter develops a biological culture on a fixed media (natural rock or synthetic media) which is periodically doused with wastewater. Oxygen is extracted from air which moves through the media by natural or forced draft. A high rate trickling filter (HRTF) is selected because of its ability to remove significant quantities of BOD in a relatively small area and volume. A 3.1 recycle rate is required to assist in providing sufficient contact time for the high organic loading. Because of the high organic and hydraulic loadings the biological culture continuously sloughs. The discharge from the HRTF is discharged directly to a downstream activated sludge process.

- Nitrification -- Nitrification (biological oxidation of ammonia to nitrates) is accomplished in aeration basins containing suspended biological culture.

- Final Clarification -- Required downstream of the activated sludge process to separate the biological organisms from the mixed liquor (ML) discharge from the aeration tank.

- Disinfection -- Identical to alternative 1.

- Gravity Thickening -- Identical to alternative 1.

- Two-Stage Anaerobic Digestion -- Identical to alternative 1.

- Sludge Dewatering -- Identical to alternative 1.

c. Alternative 3 -- Activated Sludge/Nitrification (See Figure 5-12)

- Preliminary Treatment -- Identical to alternative 1.

- Primary Treatment -- Identical to alternative 1, however, the intended purpose of the unit differs. In the previous alternatives, the purpose of the primary clarifiers was to protect the downstream biological fixed film type processes. For this application, the purpose of the primary clarifiers is to reduce the organic loading to the activated sludge process, thereby reducing the biological reactor volume requirements.

- Activated Sludge -- Utilizes a suspended biological culture in the wastewater. The suspended culture is referred to as mixed liquor (ML). Oxygen is introduced into the ML by either compressing air and distributing it throughout the bottom of the aeration basin, or by entraining air with surface aeration devices. Nitrification is maintained by controlling the age of the microbial culture. The age of the microbial culture is important in nitrification because the nitrifying organisms have a low rate of population growth.

- Final Clarification -- Provided downstream of the aeration tanks to separate the microorganisms from the mixed liquor. The microbes are collected at the bottom of the clarifiers and recycled back to the head end of the aeration basin to mix with the incoming wastewater. A smaller set of pumps diverts a small sidestream of sludge out of the cycle to be wasted with the primary sludge. Surface skimming ensures capture of organisms which may float due to the release of nitrogen gas from the clarifier sludge blanket.

- Disinfection -- Identical to alternative 1.

- Gravity Thickening -- Identical to alternative 1.

- Two-Stage Anaerobic Digestion -- Identical to alternative 1.

- Sludge Dewatering -- Identical to alternative 1.

d. Alternative 4 -- Extended Aeration/Activated Sludge (See Figure 5-12)

- Preliminary Treatment -- Differs from previous alternatives in that a velocity-controlled type grit chamber is employed in lieu of an aerated grit chamber. This design option is viable because there are no primary clarifiers to be protected. This option saves some power cost.

- Extended Aeration -- A suspended biological culture process similar to those used in alternatives 2 and 3. The size of the aeration basins is larger to accommodate the reduction of carbonaceous BOD removed in the primary clarifiers and/or the HRTF in the previous alternatives. It is intended that the aeration tank be designed for a "complete mix" mode of operation. The complete mix option and the larger volume of mixed liquor allows this process to absorb diurnal load variations, as well as shock loadings.

- Final Clarification -- Identical to alternative 1.

- Disinfection -- Identical to alternative 1.

- Sludge Holding -- Provides a reservoir of unwanted excess activated sludge for dewatering. Minimal power will be required to supply the endogenous oxygen requirements of the sludge and prevent odors. Very little sludge digestion occurs in this unit process because of the high sludge age maintained in the extended aeration process.

- Sludge Dewatering -- Similar to the previous alternatives. Lower surface loadings are necessary because of the dewatering characteristics of the sludge generated in this alternative.

e. Alternative 5 -- Oxidation Ditch/Activated Sludge (See Figure 5-13)

- Preliminary Treatment -- Identical to alternative 4.

- Oxidation Ditch -- Process is similiar to alternative 4. The oxidation ditch has some design advantages with regard to potential power savings. Because of the relatively high strength of the wastewater, the potential for power savings is offset by the larger volume required (necessary due to the oxygen transfer limitations of the anticipated aeration equipment for this design option) and the added rock excavation at the proposed site(s).

- Final Clarification -- Identical to alternatives 3 and 4.

- Disinfection -- Identical to alternative 1.

- Sludge Holding -- Identical to alternative 4.

- Sludge Dewatering -- Identical to alternative 4.

2. Biological Treatment Alternatives -- Technical Evaluation.

The selection of an optimum treatment scheme requires an evaluation of the reliable alternative treatment processes capable of achieving the discharge standards outlined in Chapter 3. Not only is the average effluent quality important, the extremes must be considered. Secondary processes which require the most operator attention are usually the most sensitive to upset conditions and will experience extremes in effluent quality. A comparison of operational and other technical characteristics of the alternative treatment systems is presented in Table 5-3. The technical evaluation presented in Table 5-3 is qualitative. Quantitative evaluation is possible via a review of effluent data from existing wastewater treatment plants.

Table 5-3

Qualitative Evaluation of Technical Aspects of Alternative Wastewater Treatment Processes

Technical Ranking Criteria	Alternatives: Rotating Biological Media	Trickling Filter/ Activated Sludge	Standard Activated Sludge with Nitrification	Extended Aeration/ Activated Sludge	Oxidation Ditch/ Activated Sludge
Reliability with Respect to:					
Basic process efficiency	1	3	2	1	1
Influent flow/load variations	3	3	2	1	1
Industrial shock loads	3	3	3	1	1
Subtotal	2	3	2	1	1
Operational Complexity	3	4	4	1	1
Expandability (modular features to meet future needs)	1	4	3	2	2
Overall Technical Ranking[1]	2	4	3	1	1

[1] Lower scores indicate increasing attractiveness.

The following evaluation is based on data obtained by the USEPA from many operating wastewater treatment plants:

Process	Maximum Effluent BOD_5 and Suspended Solids (mg/L) 50% of time	90% of time	Maximum Effluent NH_3-N (mg/L) 50% of time
Conventional activated Sludge	20	40	1
Extended aeration/ activated sludge	10	30	1
Oxidation ditch/ activated sludge	10	30	1
Trickling filter	30	40	3
Rotating biological media	20	40	3

Based on these technical observations, it would appear either the extended aeration or the oxidation ditch/ activated sludge processes are the optimum selections for further evaluation. It should be stated that the oxidation ditch is a specific layout configuration of an extended aeration/activated sludge process.

3. Wastewater Treatment Alternatives -- Socioeconomic and Environmental Considerations.

Each wastewater treatment plant alternative is evaluated against the existing socioeconomic and environmental elements of the project area, as well as impacted downstream areas.

Environmental and socioeconomic impacts are the changes which are bought about by the action or results contemplated by implementing each alternative. The impacts may be beneficial or adverse, as well as direct or indirect. Alternatives which have identified gross adverse impacts, either direct or indirect, can thereby be eliminated from further consideration.

The five biological treatment alternatives selected for consideration are basically equivalent in terms of their major impacts. Primarily, each alternative was developed to meet the criteria developed in Chapter 3 for direct discharge of treated effluent and its ability to satisfy each of the following socioeconomic/environmental factors:

a. Implementability -- Each alternative is equal, except with respect to cost differential, manpower, and training requirements.

b. Compatibility with other plans -- All alternatives have been sized and otherwise developed to be compatible with the development of the other critical utility services within the project area. There are some differences in the flexibility of each alternative to expand in modular fashion.

c. Public health -- Each alternative has been developed to protect the public health.

d. Public preferences, goals, values, and attitudes -- There are only slight differences among the five alternatives with respect to their overall public acceptance.

The alternatives to reuse or to apply treated effluent directly to the land were rejected for consideration in this study because of the apparent public reluctance to accept them at this time. The significant socioeconomic and environmental impact differences of the wastewater treatment plant alternatives are shown in Table 5-4.

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Table 5-4

Qualitative Evaluation of Socioeconomic and Environmental Aspects of Alternative Wastewater Treatment Processes

Socioeconomic and Environmental Ranking Criteria	Alternatives: Rotating Biological Media	Trickling Filter/ Activated Sludge	Standard Activated Sludge with Nitrification	Extended Aeration/ Activated Sludge	Oxidation Ditch/ Activated Sludge
Implementability	1	1	1	1	1
Environmental Effects with Respect to:					
Potential nuisance odors	5	5	3	1	1
Sludge generation	3	3	5	1	1
Subtotal	4	4	4	1	1
Energy Requirements	3	1	2	5	4
Compatibility with Respect to Other Plans	2	2	2	1	1
Public Preference, Goals, Values and Attitudes	1	1	1	1	1
Overall Socioeconomic and Environmental Ranking	2	2	2	1	1

4. Reliability and Safety.

A wastewater treatment plant's ability to perform its designated function without failure is a measure of its reliability. Design emphasis on process reliability has been a key factor in the selection of a treatment scheme in this study. Other facets of the facilities design, however, must be considered in order to ensure treatment plant reliability.

Major contributors to plant failure include:

a. Power failures.
b. Lack of unit bypass capability.
c. Lack of spare parts.
d. Poor layout and equipment inaccessibility.
e. Lack of laboratory and maintenance capability.
f. Lack of personnel training and motivation.

During the investigations conducted for this study, it was reported that the Irbid area is subject to frequent power outages and voltage drops. To ensure the reliability of the biological treatment process, stand-by emergency power generation facilities must be provided for the proposed treatment plant. They are proposed to be tied into the treatment plant electrical system via a manual interlock. The generator will be sized to maintain operation of equipment vital to the operation of the biological treatment process and maintaining the effluent quality.

The treatment plant reliability will be enhanced by providing a minimum of two units for every stage of treatment. In some cases, stand-by equipment may be necessary. The treatment plant phasing is such that two units or modules can meet the first phase requirements, and a third identical unit will provide the expanded capacity necessary to meet the Phase 2 requirements.

The equipment manufacturers and system suppliers will be directed to provide adequate spare parts, as well as materials for maintenance and major repairs. Equipment manuals, as well as on-site training, where required, will also be provided.

The life of the treatment plant structures is expected to exceed the equipment life. Although the project life has been designated as 20 years, buildings and major structures may be functional for a much longer period. Future expansions may require upsizing or adding equipment. During the useful life of a structure, personnel must have access to the equipment and be able to remove it from the building, if necessary. Accordingly, minimum aisle and passageways will be provided with adequate approach ramps and lifting equipment.

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A laboratory for performing the analyses necessary for monitoring the operation and performance of the plant will be provided. A maintenance shop for equipment repair will be provided commensurate with the treatment plant requirements.

Proper training and motivation of the staff is a most important consideration. Chapter 10 presents specific recommendations regarding staff training.

Safety considerations must be addressed in the design and operation of a treatment plant. Safety hazards are inherent in the operation of such a facility. They include explosive and toxic sewer gases, deep tanks filled with water, toxic chlorine gas, high electrical voltages, moving machinery, and potential occupational health hazards. The design will include maximum safeguards for staff protection. Protective equipment and its proper placement will be detailed in the proposed treatment plant construction specifications. Safety will be a major part of the staff training program.

5. Cost Analysis.

The selection of a wastewater treatment scheme is based on cost evaluation, as well as the other criteria just discussed.

Estimated capital and annual costs were developed for the five alternative treatment plant schemes, and are presented in Table 5-5.

Costs were developed for facilities constructed for the year 1990 and year 2000 requirements. Annual costs are based on a 20-year amortization at 10-percent interest. Annual power, chemical, and sludge disposal costs were estimated as an average annual cost using a uniform gradient series to indicate the increased usage of these commodities as wasteloads increase over the project life.

Table 5-5

Cost Analysis -- Wastewater Treatment Plant Alternatives
(All costs in JD x 1,000)

Alternative Number	1		2		3		4		5	
Description	Rotating Biological Media		Trickling Filter/ Activated Sludge		Activated Sludge/ Nitrification		Extended Aeration/ Activated Sludge		Oxidation Ditch/ Activated Sludge	
Design Year	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
Construction Cost	5,278	7,353	2,821	3,550	2,677	3,528	1,310	2,799	2,880	4,239
Land Acquisition	90	90	90	90	90	90	90	90	90	90
Contingency	792	1,103	423	532	402	529	272	420	432	636
Administration, Engineering	792	1,103	423	532	402	529	272	420	432	636
Total Capital Cost	6,952	9,649	3,757	4,704	3,571	4,676	2,444	3,729	3,834	5,601
Annual Capital Cost - 1979	816.6	938.7	441.3	484.2	419.4	469.4	287.1	345.3	450.3	530.
Annual Operation and Maintenance Costs										
Materials	24.5	35.5	39.6	53.9	48.3	62.0	40.1	52.3	40.1	52.
Power	34.9	44.0	48.5	58.5	82.7	100.6	89.8	98.0	81.6	89.
Labor	89.6	100.2	89.6	99.3	87.5	96.9	83.2	92.4	83.2	92.
Chemicals	6.0	6.2	6.0	6.2	6.0	6.2	17.6	19.5	17.6	19.
Sludge disposal	11.3	15.7	11.3	15.7	11.3	15.7	10.0	13.9	10.0	13.
Total Operation and Maintenance	166.3	201.6	195.0	233.6	235.8	281.4	240.7	276.1	232.5	267.
Total Annual Cost	982.9	1,140.3	636.3	717.8	655.2	750.8	527.8	621.4	628.8	797.

Notes: 1. Assume facilities required to expand treatment facilities to serve year 2000 requirements will be constructed in 1990.
2. Capital costs for year 2000 are total capital costs of facilities required for that year.

5.4.4.3 Residue Handling and Disposal Alternatives.

Residue or sludge handling generally includes two operations: dewatering, and final disposal. The purpose of sludge dewatering is to reduce the sludge moisture content to a degree which facilitates handling and ultimate disposal.

Alternative dewatering processes evaluated in detail for this project are mechanical dewatering, and sand-bed drying.

For mechanical dewatering a belt filter press was evaluated. The belt filter is a mechanical press in which sludge is fed on a continuous belt filter media through a series of rollers which squeeze water out of the sludge. It is fed with chemically-conditioned sludge thickened to one and one-half percent solids content. The solids content of the dewatered sludge is increased to approximately 28 percent. In this state, sludge is in a solid form and may be handled with conveyors, dump trucks, and earth-moving equipment.

Sand-drying beds usually consist of 10 to 20 cm of sand over 40 to 50 cm of graded gravel. Sludge is applied as a liquid at 20- to 30-cm depths. Water is removed initially by draining through the sand/gravel bed, and then by evaporation from the surface of the sludge cake. In this analysis, it was assumed that sludge could be thickened to 2.5 percent solids content prior to loading the sand-drying bed. A sludge-drying cycle includes the following four stages:

1. Loading the bed.
2. Drying.
3. Dried sludge removal.
4. Bed conditioning (maintenance).

The time required to complete a cycle depends upon weather and climatic conditions. In England, operators expect to get three drying cycles per year. In the northern United States, five cycles are expected. The Irbid facilities design was based on 13 cycles per year (four weeks per cycle).

Detailed capital and operating costs were developed for the two alternatives for both the 1990 and 2000 design requirements. These costs are as follows:

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	Costs in JD	
	Belt Filter Press	Sand-Drying Bed
Capital Costs (including land)		
Phase 1	109,000	250,900
Phase 2 (incremental cost)	35,000	35,800
Total Annual Operating Costs		
Phase 1	21,600	12,000
Phase 2	27,200	16,700
Total Annual Costs		
Phase 1	34,400	41,500
Phase 2	41,500	47,800

The Phase 1 and Phase 2 total annual costs for these alternatives are within 15 percent of each other. The estimated annual operating cost for the sand-drying bed alternative is 60 percent of the corresponding cost for the belt filter press. The sand-drying bed annual operating cost is primarily manual labor, while the belt filter press operating costs include equipment maintenance, power, and chemical costs. Operation of the sand-drying beds is felt to be more reliable. For this reason the sand-drying bed alternative is selected even though the total annual cost is slightly higher than the mechanical belt press total annual cost.

The sand-drying beds will require approximately 9.2 hectares of additional land. It is proposed to locate the drying beds north of the treatment plant site adjacent to the road between Irbid and the village of Tuqbul. This location is removed from proposed City of Irbid development. Odors generated at this site will not affect the City. Liquid sludge will be pumped to the drying bed site.

Four final sludge disposal alternatives have been evaluated:

1. Disposal to sanitary landfill.

2. Direct application of land.

3. Sludge composting and subsequent application to land.

4. Sludge incineration and disposal of ash and grit to a sanitary landfill.

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These alternatives are discussed in the following paragraphs.

1. Disposal to Sanitary Landfill.

This alternative requires concentration, stabilization, and dewatering of the sludges. Scum, screenings, and grit can be disposed of in a concentrated form. Generally speaking, this alternative is the most cost-effective (given that there are no major limiting constraints). The landfill alternative is compatible with the considered solid waste disposal alternative, and is discussed in Chapter 7.

2. Direct Application to Land.

This option is viable for both slurry and dewatered sludge. Scum, skimmings, and grit will still be disposed of in a landfill. The sludge must be stabilized and concentrated, thus reducing hauling costs. The sludge has some nutrient value as fertilizer for cropland, but its primary value is as a soil conditioner because it increases the organic content and moisture retention of the soil. Metal poisoning should not be a problem unless unanticipated concentrations of metals appear in the raw wastewater. There may be public resistance to direct application of sludge to land. In discussions with the Ministry of Agriculture, it was reported that commercial farmers may be inherently suspicious of sewer sludge in any form. During the cholera outbreak of 1977, crops planted in soil conditioned with "night soil" were plowed under as a precautionary measure. This would tend to reinforce already ingrained suspicions. Guidelines regarding sewage sludge application should be developed and implemented. Sludge application should not be universally used on all agricultural land, e.g., it should be prohibited where crops would come in contact with the soil.

3. Sludge Composting and Subsequent Application to the Land.

This alternative utilizes the composting process to stabilize the sludge. It is possible to compost certain wastewater treatment plant sludges along (with a bulking agent) or in combination with municipal refuse. Suitable bulking agents (chips, paper, leaves, etc.), are not readily available in Jordan. Sludges are readily compostable with municipal refuse. Certain technical problems must be overcome, and these are discussed in more detail in Chapter 7.

The attractiveness of the compost product is dependent in large measure on the type of composting process employed (aerobic or anaerobic). The aerobic product is normally more attractive and is usually more sought after for home gardens and landscaping needs around institutional facilities. Process controls, however, particularly moisture control, may be a difficult obstacle in this region.

Screenings and grit could be included in the compost process, but scum should be incinerated, sold, or landfilled.

4. Sludge Incineration and Disposal of Ash and Grit to a Sanitary Landfill.

Sludges, scum skimmings and screenings can be incinerated. This alternative reduces residuals to the lowest possible volume and quantity, but at great cost. To reduce cost, it is necessary to dewater the sludges to the greatest possible extent. It will still be necessary to dispose of ash residue and grit in a sanitary landfill.

Because of its exceedingly high cost, it is concluded that incineration could only be justified by the most severe constraints on the other available options. Since these constraints do not exist, this alternative is not considered viable for this study.

5.4.4.4 Best Apparent Alternative Wastewater Treatment System.

The wastewater treatment systems have been evaluated on the basis of technical, socioeconomic, environmental, reliability, safety, and cost factors. The anaerobic/aerobic pond alternative is the least cost, acceptable low-technology alternative, while the extended aeration alternative is the least cost, acceptable conventional biological treatment alternative. The costs for these two alternatives, given in Tables 5-2 and 5-5, are reproduced in Table 5-6.

The Phase 1 and Phase 2 total annual costs for the extended aeration alternative are approximately 16.8 and 12.1 percent, respectively, less than the total annual costs for the anaerobic/aerobic pond alternative. The extended aeration scheme was the recommended alternative on the basis of this cost differential.

A site plan for this selected alternative has been prepared and is presented in Figure 5-14. The site plan is based on gravity flow for all forward flow through the plant. Pumping will be required for recycling and waste sludge flows.

A list of major process equipment for the recommended treatment alternative has been prepared and is presented in Appendix A.

5.4.4.5 Phasing Plan.

A 27-month construction period is projected for the wastewater treatment plant contract. This construction period is coordinated with the other project elements, and is presented in Chapter 10, subsection 10.6.3, Figure 10-7.

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Table 5-6

Cost Comparison Extended Aeration Activated Sludge - Anaerobic/Aerobic Stabilization Ponds
(Costs in JD x 1,000)

Design Year	Extended Aeration/ Activated Sludge 1990	Extended Aeration/ Activated Sludge 2000	Anaerobic/Aerobic Stabilization Ponds 1990	Anaerobic/Aerobic Stabilization Ponds 2000
Construction Cost	1,810	2,799	1,737	2,259
Land Acquisition	90	90	1,980	1,980
Contingency	272	420	260	339
Administration, Engineering	272	420	260	339
Total Capital Cost	2,444	3,729	4,237	4,917
Annual Cost	287.1	345.3	497.8	533.7
Annual Operation and Maintenance Costs				
Materials	40.1	52.3	4.0	5.0
Power	89.8	98.0	50.0	85.0
Labor	83.2	92.4	56.3	62.5
Chemicals	17.6	19.4	3.6	3.7
Sludge disposal	10.0	13.9	5.0	7.0
Total Operation and Maintenance Costs	240.7	276.1	118.9	163.2
Total Annual Cost	527.8	621.4	616.7	696.9

No. [illegible]

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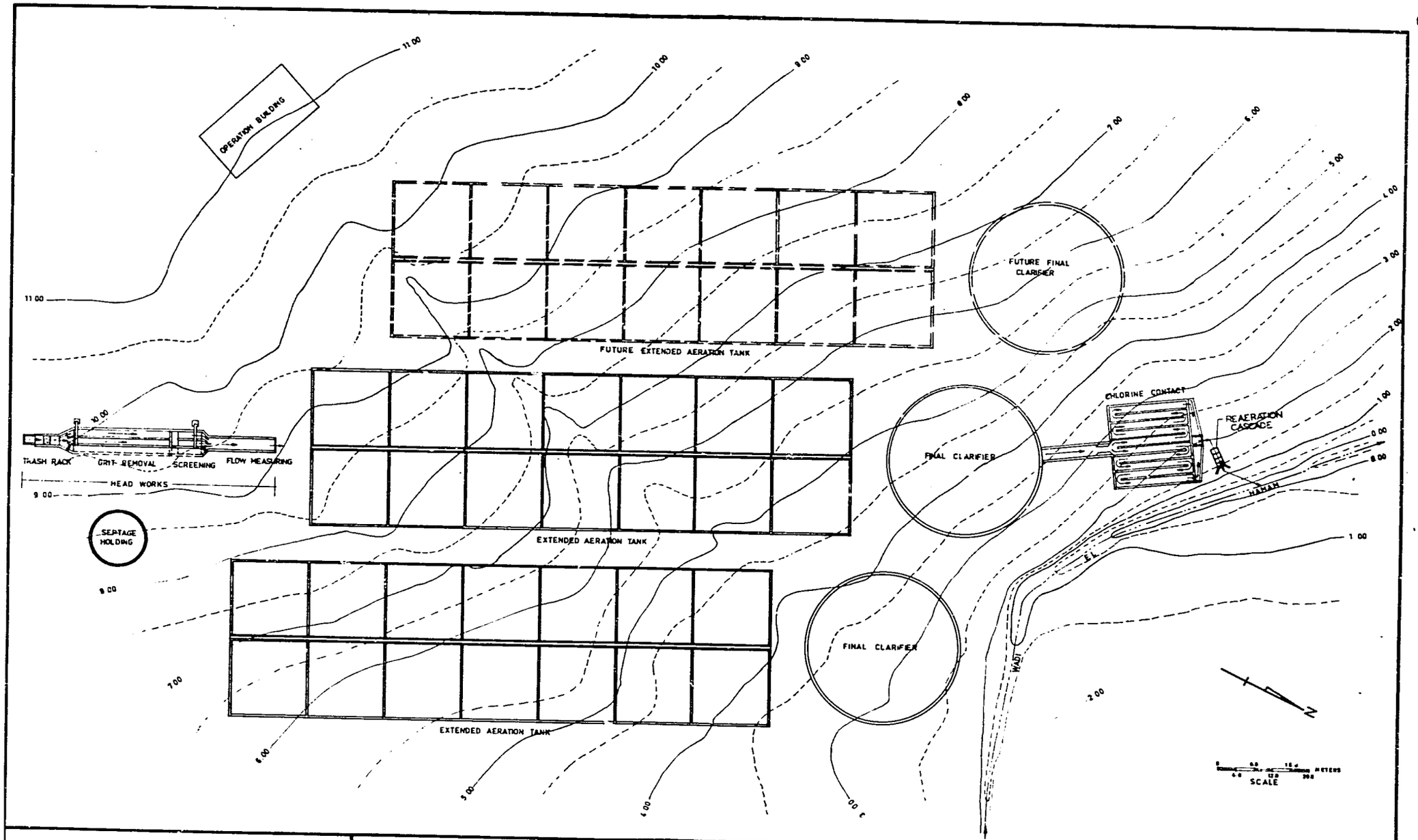

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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

LAYOUT OF PROPOSED EXTENDED AERATION ACTIVATED SLUDGE WWTP IRBID JORDAN

FIGURE 5 -14

DATE: SEPT, 1979

BY: F RAHHAL

CHKD: HALVENSLEBEN

The Phase 1 wastewater treatment facilities are sized to serve approximately 87 percent of the estimated 1990 population in the City of Irbid. The treatment facilities are laid out so they can be easily expanded after 1990 to serve the entire population expected to be located within the service area by the year 2000.

Major treatment units are sized so that each unit provides approximately one-third of the total required treatment capacity. This approach ensures minimum disruption of treatment plant operations and performance during the Phase 2 construction.

5.5 OPERATION AND MAINTENANCE

Proper operation and maintenance of the wastewater collection and treatment systems is essential to ensure consistent and long-term compliance with the discharge criteria outlined in Chapter 3 of this report. A detailed operations and maintenance manual should be developed prior to start-up of the facilities. The manual should be prepared to meet the unique requirements of the proposed facility. It should reflect the personnel qualifications, the equipment complexity, as well as the specific functions to be performed.

The manual will be an operative tool. Accordingly, it will be concise, indexed by function, and bound so that it may be updated periodically.

The proposed wastewater treatment plant staffing and organization is diagrammed in Figure 5-15. Staffing requirements for the treatment plant and collection systems operations departments are given in Chapter 10. It is anticipated that four separate operating shifts will each be headed by a senior operator. It is anticipated that each shift will operate the plant 42 hours/week. Security will be maintained around-the-clock. The majority of the remaining staff will work the day shift.

Efficient operation and maintenance requires a trained staff. A proposed training program is outlined in Chapter 10.

5.6 ESTIMATED COSTS

Estimated capital costs for Phase 1 and Phase 2 are presented in the following tabulation. Costs are expressed as 1979 Jordanian dinars (JD).

Sewer construction costs include construction of building sewers from the lateral sewer in the street to individual property lines.

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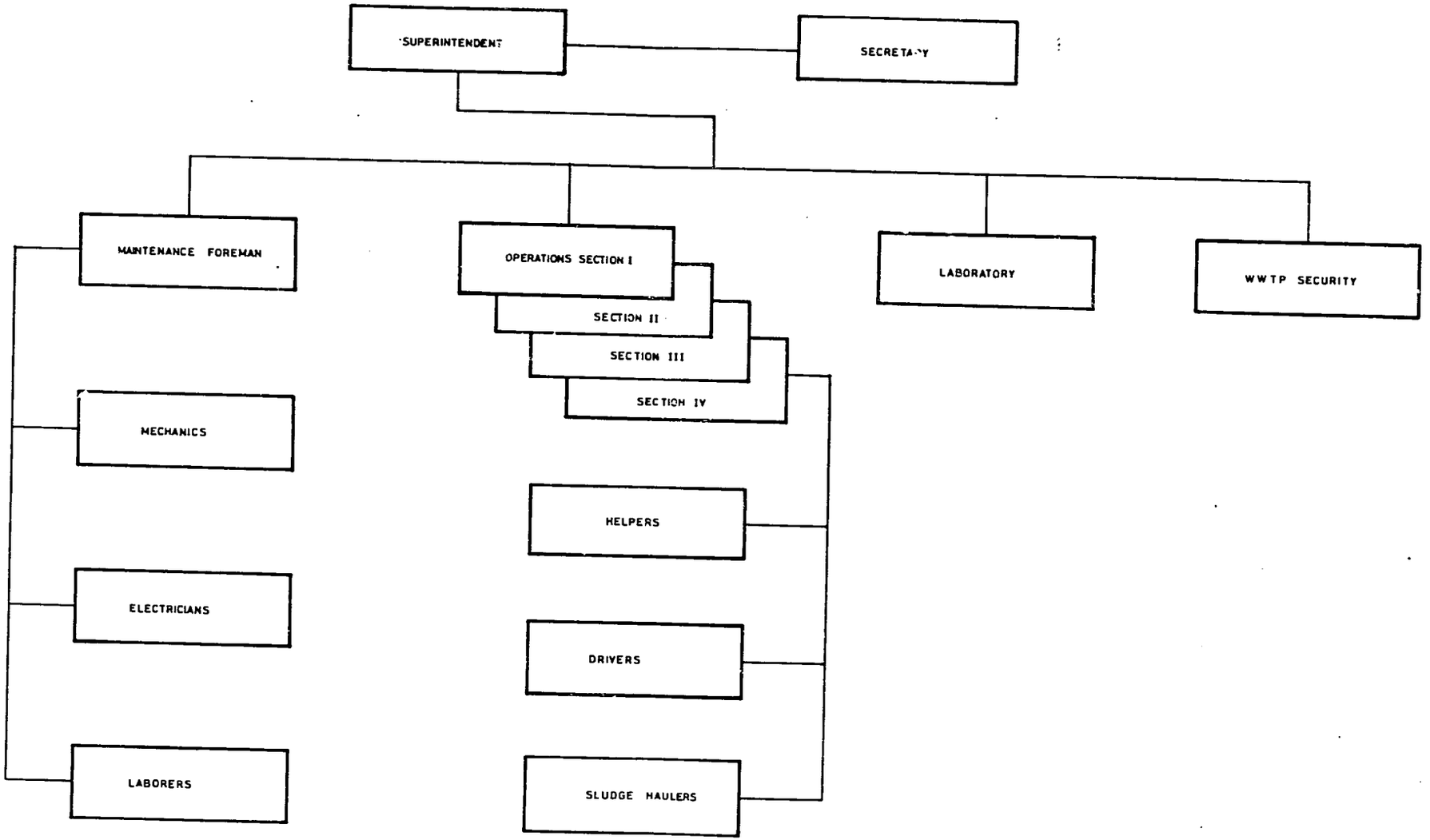
Description	Cost JD x 1,000 Local	Foreign	Total
Phase 1 Costs			
Wastewater treatment plant	1,001	860	1,871
Sewer construction	3,159	1,050	4,209
Probable construction cost	4,170	1,910	6,080
Contingency	625	345	970
Engineering and administration	625	345	970
Total Project Cost -- Phase 1	5,420	2,600	8,020
Phase 2 Costs			
Wastewater treatment plant	475	514	989
Sewer construction	2,550	853	3,403
Probable construction cost	3,025	1,367	4,392
Contingency	454	205	659
Engineering and administration	454	205	659
Total Project Cost -- Phase 2	3,933	1,777	5,710



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

PROPOSED WASTEWATER TREATMENT PLANT STAFF ORGANIZATION

FIGURE 5-15

DATE: SEPT, 1979

BY: F. RAHHAL

CHKD: HALVENSLEBEN

CHAPTER 6

STORMWATER DRAINAGE SYSTEM STUDIES

As shown on Figure 6-1a and b, there are two hydrologic basins with stormwater drainage networks serving the Municipality of Irbid. Both are in the upper watersheds of the Wadis el Hamam and Tariq Saum. Structural elements of the Irbid stormwater collection system have been in existence for about 20 years. The existing network in Wadi Tariq Saum flows east to west, and is located along and just south of the Palestine Road. As urbanization of Irbid has occurred, these systems have been extended. The latter half of the 1960's brought about construction of piecemeal drainage structures in Wadi el Hamam, which generally flows in a south to northwesterly direction.

Recent expansion of the municipal stormwater collection system has included a major extension of the Wadi Tariq Saum network to the downstream City boundary, and a consolidation of the lower network in Wadi el Hamam. Large parts of these networks receive sanitary wastewater flows.

This chapter evaluates the existing system and develops extensions of, and additions to, the usable portion of the existing system to provide adequate surface drainage to the population of the study area.

6.1 PREVIOUS PLANNING AND DESIGN EFFORTS

The only previous study of Irbid's stormwater drainage problems and needs consisted of a plan and design by a Czechoslovakian firm which was completed in 1971. Proposals made were for a major collector system network in both the el Hamam and Tariq Saum basins. A separate stormwater system was designed based upon a two-year frequency storm using the rational formula method. The existing system was utilized as an integral part of the proposed network. Drainage districts were developed according to the projected town plan layout of streets. The design was based on the metric system with circular and box conduits ranging in cross-sectional area from 0.03 to 5.2 sq m. Proposed appurtenances included:

1. Curb and gutter inlets with catch basins located on both sides (one side for narrow streets) of the street, placed at maximum intervals of 40 meters.

2. Manholes located at junctions, changes in gradient, alignment and pipe size, or at maximum intervals of 50 meters for pipe diameters under 150 cm.

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6.2 IDENTIFICATION OF DRAINAGE DISTRICTS

6.2.1 Delineation of Districts

6.2.1.1 Topographic Limits.

Figure 6-1 displays the drainage basins within the project area. Two major hydrologic basins drain the Irbid study area, with the drainage divide between these basins running north-south close to the eastern City boundary. Most of the run-off from the study area drains to the west to the Wadi el Arab, which in turn drains to the River Jordan. Drainage to the east is by way of the Wadi esh Shallala to the River Yarmouk. Study area drainage to this eastern hydrologic basin is minimal.

Within the upper limits of the Wadi el Arab are three smaller wadis which serve to drain Irbid; these are from north to south:

1. Wadi el Hamam
2. Wadi Tariq Saum
3. Wadi Zabda

Wadi Zabda drains only a small portion of the City. Wadi el Hamam and Wadi Tariq Saum drain most of the urbanized area of Irbid. Wadi Tariq Saum's pear-shaped basin is a well-defined valley that extends through the center of the City, with the broad upper area elevations in the southeast draining to the northwest. Elevations in the Wadi Tariq Saum basin range from about 600 m above sea level to 450 m near the western City boundary. Palestine Road, which traverses the central business district, has an average elevation of about 550 m in the center of the City.

Wadi el Hamam drains in a south to north direction. For the study, this basin will be segregated into two drainage districts: the western district, which drains the more urbanized area including the refugee camp; and the eastern district. The eastern drainage district of the Wadi el Hamam basin drains an urbanized area along the southern half of the district to a cultivated area in the northern half. The terrain slopes uniformly from the south to the north.

6.2.1.2 Extent of Existing and Planned Development.

As seen from Figure 6-1, the area drained by the Wadi Tariq Saum and Wadi el Hamam drainage networks have almost reached "saturated" development as defined by the socioeconomic studies section of this report. As such, provision for new drainage structures to augment any existing deficiencies or to relieve flooding problem areas would be for a completely-developed basin.

The other hydrologic basins within the planning boundary are relatively undeveloped. These areas are also at the upper edges of the drainage

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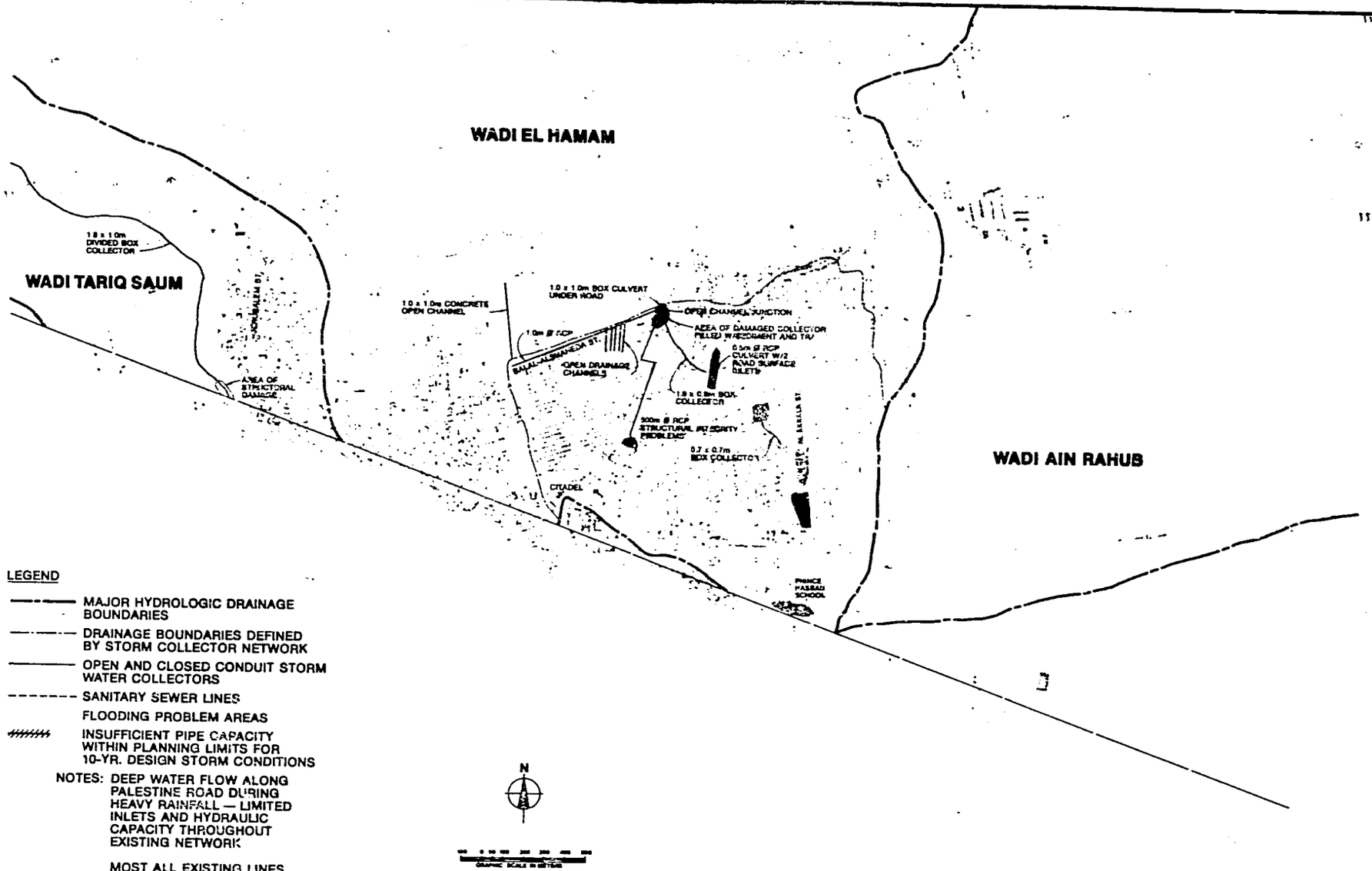


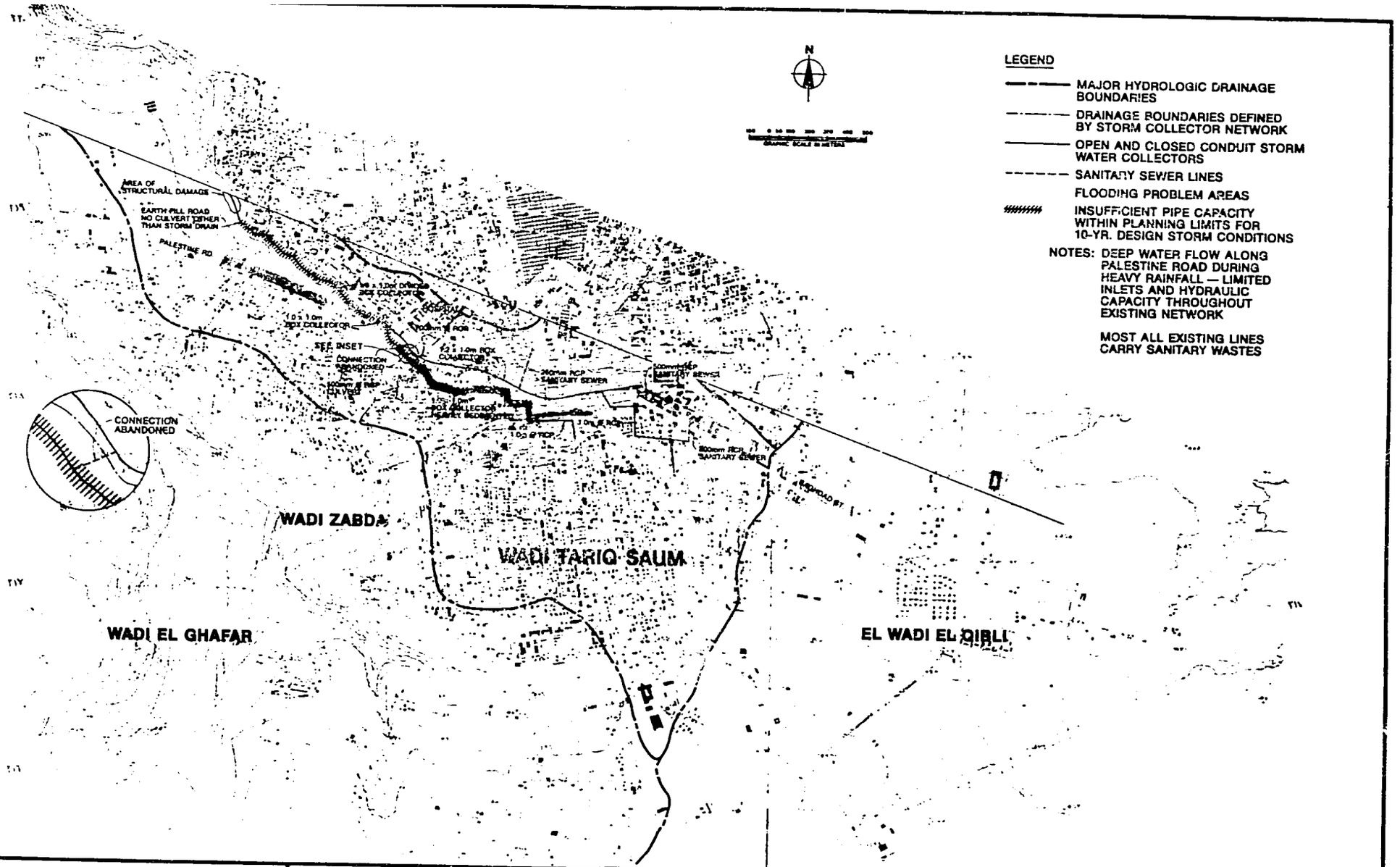
LEGEND

- MAJOR HYDROLOGIC DRAINAGE BOUNDARIES
- DRAINAGE BOUNDARIES DEFINED BY STORM COLLECTOR NETWORK
- OPEN AND CLOSED CONDUIT STORM WATER COLLECTORS
- SANITARY SEWER LINES
- FLOODING PROBLEM AREAS
- INSUFFICIENT PIPE CAPACITY WITHIN PLANNING LIMITS FOR 10-YR. DESIGN STORM CONDITIONS

NOTES: DEEP WATER FLOW ALONG PALESTINE ROAD DURING HEAVY RAINFALL — LIMITED INLETS AND HYDRAULIC CAPACITY THROUGHOUT EXISTING NETWORK

MOST ALL EXISTING LINES CARRY SANITARY WASTES

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	EXISTING DRAINAGE SYSTEMS	SHEET NO. FIGURE 6-1a DATE: BY: CHKD:



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EXISTING DRAINAGE SYSTEMS

SHEET NO.
FIGURE 6-1b

DATE:
BY:
CHKD:

basins. All stormwater run-off from these areas would flow radially from the City's center. For the projected development it is not anticipated that any drainage network will be required for these other basins.

6.2.2 District Characteristics

Terrain characteristics of the two major drainage areas are bowl-like basins with even sloping sides. There are few, if any, rolling hills. Ground cover may be divided into three major categories:

1. Streets and sidewalks.
2. Rooftops.
3. Bare ground.

There is very little vegetation in the area. Olive trees and grape vines are predominant and are typically scattered; they are usually backyard orchards.

The soil is predominantly sandy-clay in nature with much rock. The higher elevations have deep soil layers before reaching impermeable rock surfaces; in the bottom of the basin, the rock layer is close (within 1 to 2 m) to the ground surface. During the dry season the bare ground consists of a fine dust with sand and an aggregate-type surface. There is no evidence of a hardpan layer. In many places, thin deep fissures were noted. On steep slopes within the wadi, the bare surface was either rock or a sandy-clay soil with much broken rock mixed with the soil. Despite the steep slopes, erosion should not be significant. The sandy-clay rocky soils appear to be quite cohesive and are not subject to a great deal of erosion.

Rooftops are typically flat; the majority are constructed of concrete or metal. In high density areas, buildings are constructed side-by-side with little, if any, bare ground between roofs and streets. The opposite condition occurs in the less dense residential areas, where often houses are surrounded by enclosed (concrete or brick-type walls) gardens. These gardens usually have a layer of topsoil above the natural ground surface.

Sidewalks are concrete and street surfaces are bituminous. There are some streets in the planning area that are still dirt roads, but all have plans for bituminous surfacing. Most alleys and footpaths are bare ground with a hardpan-type dusty surface. Run-off characteristics for these different ground cover categories have been identified in the appropriate criteria section of this report (see Section 3.4).

6.3 EXISTING FACILITIES AND CONDITIONS

6.3.1 Type and Location of Facilities

The location of major stormwater drainage structures are shown on Figure 6-1, indicating size, direction of flow, condition, capacity deficiencies, and flooding problem areas. Structures utilized for stormwater conveyance are constructed of reinforced concrete materials.

6.3.1.1 Inlets.

Inlets to the stormwater collection system are typically located directly above the conduit, having no catchment volume for sand or grit. Inlet covers are of two types: one for summer and one for winter. Since there is little or no precipitation in summer, the covers are solid, keeping trash and sand out of the collection system. During the wet season, the solid covers are replaced with perforated ones. Inlets are small and few in number, and are a limiting factor in the hydraulics of the existing system.

6.3.1.2 Culverts.

In the Wadi Tariq Saum basin, two 0.5-m diameter reinforced concrete pipe culverts are located at road crossings of the natural drainage pathways (Figure 6-1). Trash and sediment have accumulated at the entrances to these structures.

Jerusalem Street is a new road (under construction) that crosses Wadi Tariq Saum, and is on the western boundary of the planning area. The final elevation of this earthen embankment road, as it crosses the wadi, was unknown at the time of this study. Presently, there is no culvert through this road. The embankment will act as a dam to run-off not intercepted by the existing stormwater collection system.

Two street culverts are located in the Wadi el Hamam basin. The one crossing Heckma Street (0.5-m diameter RCP) drains the low point along that street. Two manhole inlets, one on each side of the street median, provide entrance to this culvert. The discharge of this culvert flows in a northwesterly direction towards an inlet to a concrete box collector.

The second culvert in the Wadi el Hamam basin conveys the stormwater collected by the existing network in this basin under the road bordering the north edge of the refugee camp.

6.3.1.3 Enclosed Conduits.

Stormwater conveyance conduits include circular pipe, open and closed box channels, and twin box channels. The majority of the existing structures are of the enclosed box channel type, having a cross-sectional area of about 1 sq m or greater. All such conduits are of reinforced concrete construction. Locations of the major transport conduits are shown in Figure 6-1.

The Wadi Tariq Saum basin network is the oldest with portions in the center of the City having been constructed in the late 1950's. The two major collectors constructed during this period the collector along

Palestine Road, and the collector parallel to Palestine Road and south of it; hence, termed South Palestine Road collector. The two lines joined and terminated at the S-curve just south of Palestine Road and due south of the hospital. Expansions in the 1960's extended the Palestine Road line eastward to the intersection with Baghdad Street. The combined Palestine/South Palestine line was extended westward, paralleling the south and then north sides of Palestine Road before terminating due east of the hospital.

More recent expansions in the 1970's have produced the system as it exists today. The connection between the Palestine and South Palestine lines, as constructed in the 1950's, no longer exists. The recent extension of the Palestine Road line to the west connecting to the South Palestine line north of this road eliminated the need for the earlier road crossing.

Field investigations have documented that the South Palestine Road collector is heavily silted with material having a tar-like consistency (mazutes). City personnel attributed this condition to earlier unpaved roads and lack of maintenance. The build-up of mazutes is also attributed to the conveyance of wastewater flows.

Early development in the urban center occurred without regard to obstruction of natural drainage courses. As flooding problems occurred, they were resolved by diverting run-off flows around the opposing structure.

The South Palestine Road collector was constructed (the top of the box at grade) in a zigzag fashion along the lowest path through the basin. Since the 1950's, numerous houses and buildings have been constructed over this line. Because of its age and sediment problems it is believed that the South Palestine Road collector will probably have some structural damage, such as cave-ins. Despite existing conditions, it is believed this line can be cleaned and structurally refurbished to function in the drainage network at a somewhat reduced capacity. When clean, the gradient of this collector is sufficient to maintain cleansing velocities with a moderate size rain.

The Palestine Road collector is clean, and also has a gradient that will produce high cleansing velocities from moderate storm run-off conditions. As previously noted, a major problem in removing run-off water from the streets at these lower elevations in the basin is due to the lack of inlets to the storm system. City personnel have identified Palestine Road Street as having deep flows due to large storm run-off events.

There are three lines that are strictly sanitary sewers in the Wadi Tariq Saum basin which are connected to the Palestine Road collector. From west to east, these three lines collect wastewater from a mosque, the electric company, and a bank.

The twin box collector, which begins east of the hospital, was constructed with a plan and profile equivalent to the lowest drainage path down the basin. The top of this box collector is at the grade of the ground surface (that portion of the line within the planning boundary).

The existing drainage network in the Wadi el Hamam basin is a piecemeal system constructed in the late 1960's and early 1970's. Wastewater flows and run-off from the refugee camp drain in open channels between dwelling units, and are collected by a 1-m diameter reinforced concrete pipe along the northern edge of the camp which drains in a easterly direction along the south side of Balal-Alshaheda Street. Discharge is to an open channel which flows through a box culvert under this road.

Paralleling the east side of the refugee camp is a 0.5-m diameter RCP pipe which also empties into the open channel and flows under Balal-Alshaheda Street. City personnel indicated that this line is structurally unsound and has hydraulic flow problems during run-off conditions. Their recommendation was to replace this line.

The short section of the 0.7-m square reinforced concrete box collector in the southeastern portion of the basin was constructed to relieve flooding problems in the immediate upstream area. In turn, this line has created a flooding problem at the downstream end of the line. The upstream end of the box collector starts at the street curb with the invert at street level. There are no sanitary flows in this line.

The 1.0 x 0.8-m reinforced concrete box collector beginning just east of Heckma Street was constructed in the early 1970's along a fairly undeveloped drainage pathway. This line is supposed to collect run-off which discharges from a low point along Heckma Street via a culvert under this road. The line then traverses the drainage basin in a semicircular fashion to ultimately discharge into a drainage ditch which flows through the culvert under Balal-Alshaheda Street. As with the South Palestine Road collector, houses have been constructed over this box collector. The lower end of this line has several structurally-damaged sections, and is filled with sediment, trash, and rubbish with wastewater meandering through all of this. It is doubtful the lower portion of this line can be restored.

6.3.1.4 Maintained Ditches.

There are no "maintained ditches" within the planning area for the conveyance of stormwater flows. As previously discussed, the existing conveyance systems are enclosed conduits, which were developed as a result of urbanization. The basic drainage concept may be divided into three stages of stormwater conveyance:

1. Street and gutter flow.
2. Pipe flow.
3. Channel or wadi flow.

The third stage usually occurs outside the planning area or is within an undeveloped region on the outskirts of the planning area. The average gradient through the basins is high, and increases with distance from the City's center. Street flow capacities from the basin extremities to the center of the basin (where existing storm collectors are located) are sufficient, not requiring storm collector laterals. Thus, the problem is moving the accumulated run-off from the center of the City to the outskirts of urban development. Once outside the urbanized area, the natural drainage capabilities are well beyond that needed.

6.3.1.5 Typical Street Sections.

Streets are constructed with a base course of clay and aggregate, and a bituminous road surface. Most street surfaces appeared to be flat, without crown or concave configurations. Curbs are constructed of either rock or precast concrete rectangularly-shaped slabs. Major roads are divided by raised medians, which in many instances dictate drainage flow patterns. Existing storm collectors are typically within 1 m of the street surface with manhole inlets directly above the storm collector.

6.3.2 Use of Combined Storm and Sanitary Sewers

The majority of the stormwater collection network also serves to collect sanitary wastewater flows. City personnel indicated that there may be 200 to 300 sanitary connections to the storm collector system. The three sanitary sewers identified on Figure 6-1 are connected to the stormwater network. Untreated sanitary wastewater discharges from the stormwater system into both Wadi Tariq Saum and Wadi el Hamam. In the Wadi el Hamam basin, the ditch and storm collector just east of the refugee camp is filled with trash, rubbish, and a meandering wastewater stream, creating a public health hazard in this populated area. The four-inch (10 cm) water supply main from Khreiba traverses this area. Recommendations of this study are to provide a separate sanitary sewer and stormwater collection system (refer to Chapter 5).

6.3.3 Present Expansion Efforts

Most recent stormwater collector system expansion efforts have been to extend the Wadi Tariq Saum basin outfall. This line presently serves as a combined sewer. As seen on Figure 6-1, wastewater is carried by this line far outside the planning area. Without wastewater flows, a stormwater discharge at the planning boundary would be sufficient to meet the stated objectives. Therefore, the collector outside the planning boundary will not be considered further. Construction of this formed in-place reinforced concrete twin box conduit follows the bottom of the wadi.

6.3.4 Capacity of Facilities

Slopes of the existing storm collectors were obtained from previous design efforts or from field surveys. Static, full-flowing line capacities were determined for each section of unique size, gradient, and shape of conduit. Manning's formula with an "n" value of 0.015 was used, and the conduits were assumed to be clean.

The South Palestine Road collector, because of its sediment problem, was analyzed as a clean conduit and then reduced to 75 percent of full capacity. The efficiency of the existing network in the Wadi Tariq Saum basin was evaluated with respect to run-off from a 10-year storm for the effective area. The hydraulic analysis for this evaluation is presented in the following section. Figure 6-1 shows those lines which are not capable of carrying run-off from the 10-year design storm. This analysis also assumed that the inlet constraint that now exists would be eliminated. The twin box collector outside the planning boundary was not evaluated, as an overflow from this line can be constructed to relieve run-off flows from larger storms.

An evaluation of the efficiency of the Wadi el Hamam system was not conducted since the network in this basin is incomplete and cannot be analyzed properly for the design storm.

6.3.5 Identification of Flooding Problems

Discussions with City personnel identified areas of the City with poor drainage characteristics. These areas are indicated on Figure 6-1. Flooding problems are principally due to poor storm collector inlet conditions, blockages to natural drainage pathways, and insufficient line capacities. In the course of analyzing the run-off characteristics of the drainage basins and developing stormwater control facilities, special attention is given to these problem areas. Modification of the existing collector system, providing increased hydraulic capabilities of the inlets, is also considered.

6.3.6 Obstacles to Natural Drainage

As described in the previous section, many flooding problems are caused by urbanization within the natural drainage pathways of the basin. There are no drainage ordinances which prohibit construction in these areas. As a result, drainage has been altered to suit the development of the City. With increased urbanization and run-off, the winding drainage network with poor hydraulic characteristics has had its capacity exceeded. In addition, construction over existing storm collectors causes an access problem for maintenance and inhibits expansion efforts. In particular, the South Palestine storm collector network is plagued by this problem.

Several places in the City have had improvements, such as the installation of street curbs, which have isolated or blocked natural drainage courses. The result is street flooding or ponding in a residential area. Without identification of right-of-way zones for natural drainage, these types of urbanization problems will occur. The piecemeal construction of the collection network in the Wadi el Hamam basin has also contributed to local flooding problems.

6.4 STORMWATER FACILITIES EVALUATION

Assessment of stormwater drainage needs in Irbid begins with an examination of the condition and available capacity of the existing system. There are two types of drainage problems that will require evaluation:

1. Areas that are prone to flooding due to rainfall/run-off occurrences.

2. Deficiencies in the existing system.

In some cases, the second may be the cause of the first problem. Once the potential capacity of the existing system has been determined, the deficit between the upgraded system and the desired level of protection is used as a basis in formulating options to meet projected stormwater control needs.

6.4.1 Existing System Analysis

Evaluation of the existing network begins with an examination of drainage districts within the basin. Figure 6-2a and b shows the subdivision of the entire drainage basin into smaller districts based upon selected key inlets to the existing network. As discussed in the previous section, the hydraulics of the existing collectors are inlet-constrained (too few and improperly placed to capture run-off), and in some cases obstructed by debris and grit accumulations. In this hydraulic analysis, it is assumed that the obstructions have been cleared and the inlet constraint has been relieved. Further details of existing network rehabilitation are presented in the following subsections.

6.4.1.1 El Hamam Network.

A hydraulic evaluation of the Wadi el Hamam network would be a useless exercise because of its piecemeal nature and inadequate collectors. The collector serving the refugee camp is a separate unit by itself, built by funds from the United Nations. This area has a combined

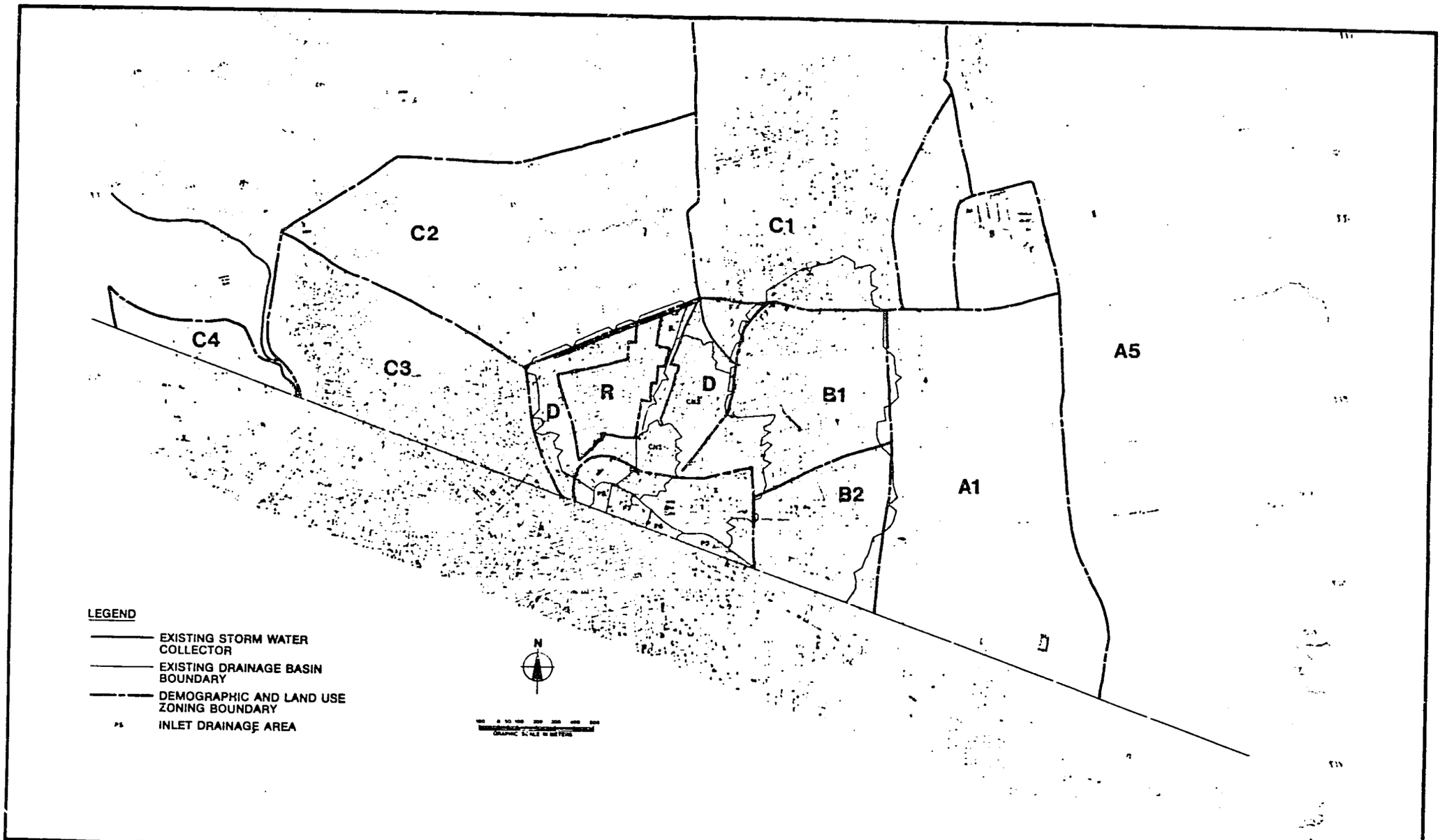
sewerage and drainage system, and will be discussed as one unit. The terminal point of this system will be treated as an inlet to the Wadi el Hamam network. Sewerage control structures for this system are detailed in Chapter 5. The collector extending from the existing outfall towards the Citadel is documented as being structurally unsound, and is recommended for replacement by City engineers. Thus, an evaluation of this line is not necessary. The remaining two collectors have separate outfalls, both along the same drainage course. These two lines will be made an integral part of a new network for the el Hamam basin.

6.4.1.2 Tariq Saum Network.

Unlike the el Hamam, the Tariq Saum network is a complete or continuous system. Run-off coefficients were determined for each population/land use zone, and subsequently for each drainage district as displayed on Figure 6-2a and b. Pipe and overland flow times and rainfall intensity were determined as described in Section 3.4 The rational formula method of design was then applied to this network. It was recognized that the entire drainage area of this system would not contribute to the peak rate of run-off. Thus, an effective area was determined to analyze the hydraulic capabilities of the existing network. The effective area is the portion of the drainage area, which combined with its time of flow and rainfall intensity, yields the greatest amount of run-off. Using more of the drainage basin than the effective area would only contribute to the descending portion of the peak run-off hydrograph.

A summary of the rational formula method of design for the existing Tariq Saum network is displayed schematically on Figure 6-3. As anticipated, the South Palestine Road collector is not capable of handling the run-off flows from the 10-year design storm. Location of the deficient lines are also shown graphically on Figure 6-1.

Again, it should be mentioned that the analysis represented by Figure 6-3 assumed clean lines and new inlet structures. The hydraulic analysis also considered the use of the maximum attainable hydraulic profile (surcharged conditions). Along the South Palestine collector, this was not beneficial because in most places the conduit top is at the ground surface. The collector downstream of the confluence of the two main lines, however, could realize a substantial increase in hydraulic capacity by allowing it to flow under pressure. Even under this condition, the collector was found to be undersized for the 10-year design storm.



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EXISTING NETWORK INLET DRAINAGE AREAS

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FIGURE 6-2a
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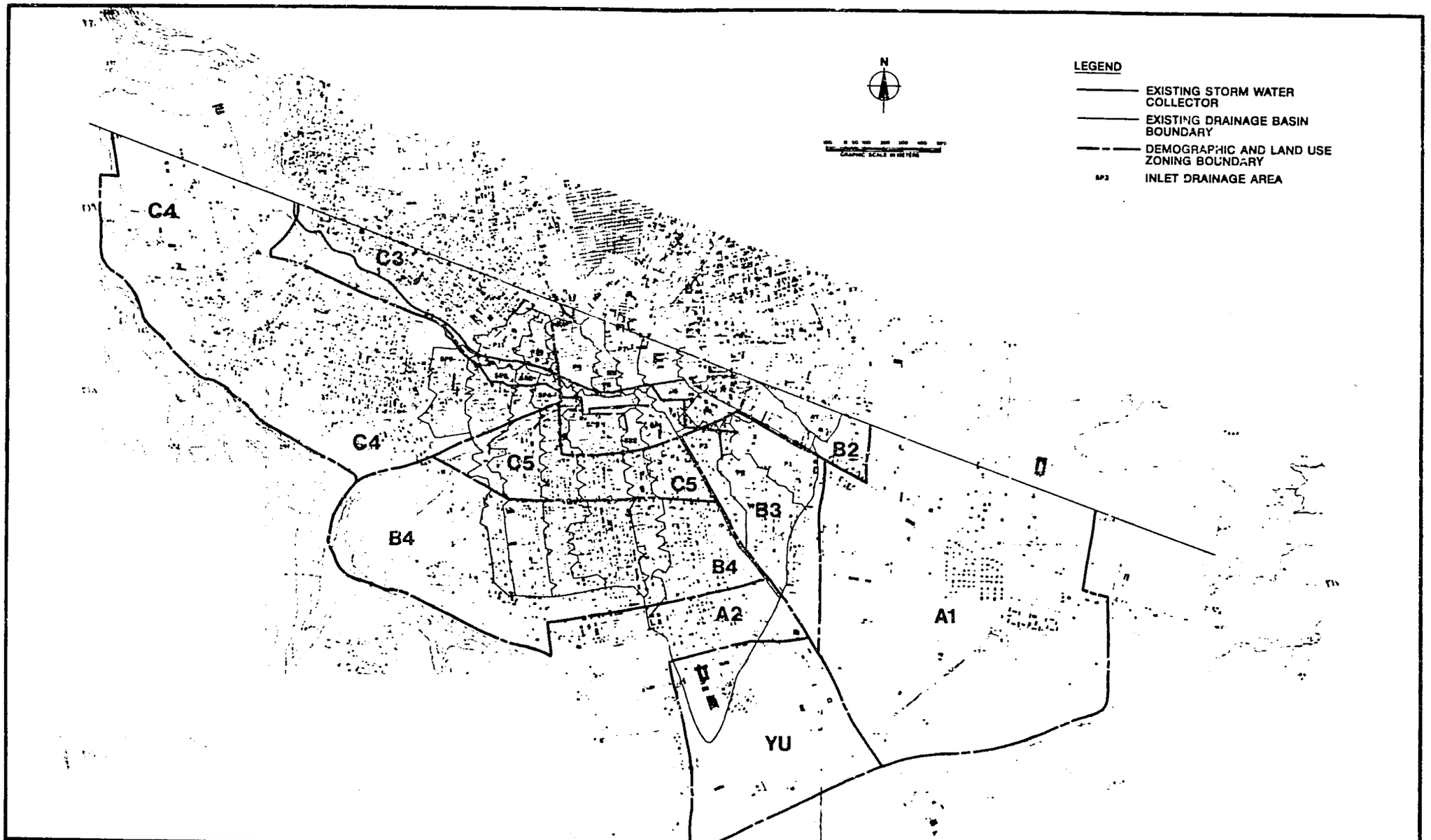

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EXISTING NETWORK INLET DRAINAGE AREAS

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FIGURE 6-2b

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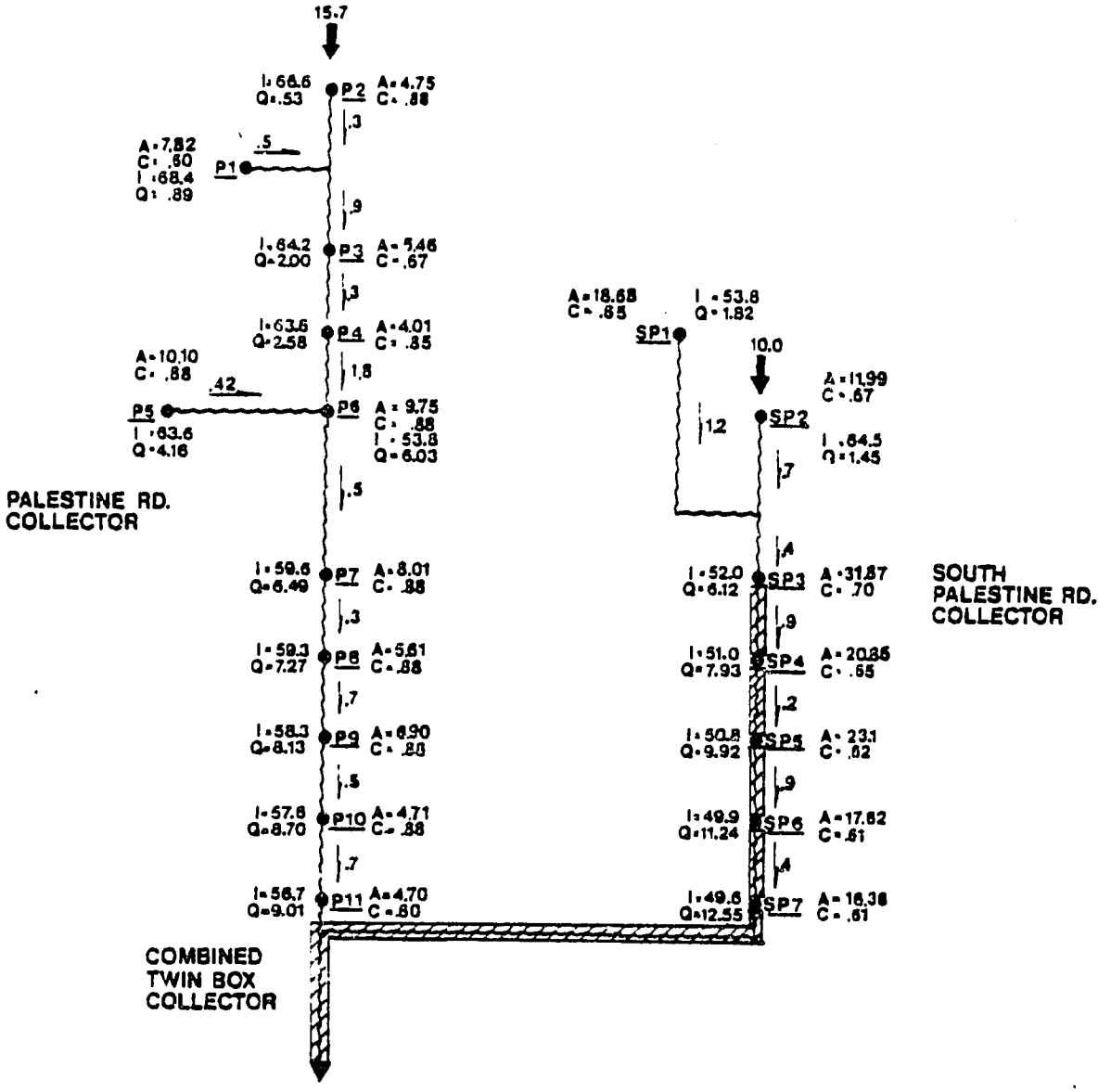


LEGEND

NI-Drainage subdivision inlet code name

A -Drainage subdivision area (hectares)

C -Drainage subdivision weighted runoff coefficient

I -10 Yr. storm rainfall intensity used at point in network (mm/hr)

tc-Time of concentration at point in network

-Maximum overland flow to inlet of major drainage network (minutes)

-Travel time between inlets (minutes)

Q-Computed flow at point in network (m^3/sec)

-Major collector drainage data summary

-Existing network collectors deficient in capacity for 10 yr. storm flows indicated

EXISTING DRAINAGE NETWORK — TARIQ SAUM BASIN
HYDROLOGIC ANALYSIS

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 6-3 DATE: SEPT.1979 BY: CHECKED:

6.4.2 Control Options

6.4.2.1 Definition of Needs.

From interviews, on-site investigations, and the hydraulic evaluation of the existing networks, three categories of drainage needs can be defined:

1. Rehabilitation of the existing networks.
2. Drainage of flooding problem areas.
3. Augmentation of existing drainage networks.

6.4.2.2 Upgrading Existing Network.

Rehabilitation of the existing networks includes construction of new inlets, conduit cleaning, and structural restoration. Plugging existing sanitary connections is also included. From initial reconnaissance, types and numbers of existing inlets were noted. The approach taken to resolve the inlet constraint problem was to:

1. Determine the best apparent inlet arrangements for the types of street plans and sections along the network.

2. Lay out such inlets on the plan.

3. Field verify to ensure best type and layout of inlet.

The physical shape of the street sections, including the use of medians, dictated the use of channel inlets in key places. Curbs and manhole inlets were also used where practical. Manhole interior inspections identified large accumulations of grit with tarlike consistency in much of the South Palestine Road collector. Accumulations of grit and debris were also found in the Wadi el Hamam basin collector which originates west of Heckma Street. These collectors have slopes that are sufficiently capable of maintaining clean conduit with precipitation and run-off events much smaller than the design storm condition. Because of this fact and the fact that these lines, especially the South Palestine Road collector, are along the lowest elevations of the drainage course, it is desirable to keep these conduits in service.

Cleaning of the existing conduits will also include a certain degree of structural restoration. It is likely that the grit accumulations are a result of blockages due to structural damage to the conduit. The degree of such problems is not evident at this time and can only be clarified during the cleaning process.

6.4.2.3 Flood Problem Areas

Areas that were documented to be flood-prone are displayed graphically on Figure 6-1. The area along the South Palestine Road collector will be somewhat relieved when this conduit is rehabilitated and additional inlets constructed. Other problem areas will require additional storm collectors or laterals to relieve the flooding problems.

As seen on Figure 6-1, flooding problems occur along the major drainage course in the el Hamam basin. This network was developed by construction of storm drainage structures where needed at the time, but as urbanization continued the segmented structures caused flooding problems downstream. The most efficient approach to adequately relieve the flooding problems and drain this basin properly would be to provide a new primary collector. This collector would be routed southwest from the existing outfall along the main drainage course. An additional line, which would junction with the primary collector at the existing culvert on Heckma Street, would run along this street to the southwest. This collector would relieve the heavy flow to the inlet at the low point on Heckma Street, where a large flooding problem now exists. The Heckma Street collector to the southwest would also intercept much of the flood causing run-off that normally crosses this street.

There is another area (long relatively flat area) along Heckma Street northeast of the refugee camp. This area receives and traps run-off from the high relief area southeast of this road. An extension from the primary collector on the same street will relieve this ponding problem, and will intercept run-off problems to the northwest of this street.

Still in the el Hamam basin, there are two other ponding areas, one along Al Akkala Street and the other on the south side of the Prince Hassan school football field. Both of these problems are situated along the main drainage pathway, and will be remedied by the primary collector.

The flooding problem that exists along Palestine Road in the Tariq Saum basin is a result of development of the high area to the south of this road. Because this road follows the terrain, the run-off is intercepted and trapped by the road curbing. Drainage of the low point along this road would relieve this problem. This would be accomplished best by a lateral that could be tied into the existing conduit along the wadi bottom. Because of the steep banks from the road down to the wadi bottom, an enclosed conduit must be provided to transport the run-off. In addition to this lateral, a collector along Palestine Road would drain the slow-moving water that would tend to build up quickly along the road from the high area to the south.

The flooding problem shown north of the two small culverts in the Tariq Saum basin is due to run-off from the south which has nowhere to go when discharged from these culverts. Extending a lateral from one of the major collectors to the culvert discharges would solve this problem.

The ponding problem in a relatively flat area along the road to Azraq can be relieved by extending a line from the existing collector on Palestine Road. The other two ponding areas shown on the south side of the existing network can be relieved by a new auxiliary collector that intercepts run-off from the large southern portion of the drainage basin. This portion of the basin overtaxes the South Palestine line at present. With the continuing development of the basin, this situation will worsen.

6.4.2.4 Augmenting Existing Network.

Additional collectors are required to augment the existing network where it is deficient in controlling the design storm run-off. In the Wadi Tariq Saum basin, this will require an additional collector to relieve the South Palestine Road collector and the line below the convergence of the two major collectors.

As previously stated, the South Palestine Road collector follows the bottom of the drainage course, which does not coincide with public property (roadway). It traverses a heavily populated low income area, and has many structures built over the top of the conduit. To abandon this line would require a larger new line, and the new line would require extensions in order to drain areas lower than its location. One alternative would be to use the existing line as the extensions. This alternative would require a number of connections with the existing collector and would cause the new line to zigzag through the streets along the bottom of the basin. The new line would still be sized to carry the entire design flow.

A more desirable alternative would be to route a new line to the south of the existing line. This would reduce the size of the new line and would leave the existing line to drain only the lower area. In this alternative, the new line routing would minimize the number of large bends, sharp, steep grades, and right-of-way land acquisition. Most important to the routing was to provide a new line to carry only the deficit capacity. Although the existing line is recommended for rehabilitation, it is not anticipated that its full capacity will be obtained. Because of the high cost of land, it is also of prime importance to route the new line within public right-of-way. Connection to the existing line would be made where the new line crosses it.

Augmenting the existing line north of Palestine Road would require a new line parallel to the existing one as it proceeds down the wadi.

Right-of-way would be required along this route since there is no road to follow.

Augmenting the collector in the el Hamam basin would be accomplished best by constructing a new line to carry all the flow. The capacity of the existing line is unknown and has been documented as being structurally unsound. Routing of this line would parallel the existing line, but would be shifted to the west in order to drain run-off that will tend to pond the streets just to the east of the refugee camp. This route would also decrease the drainage flowing into the camp.

6.4.2.5 Extent of Development.

The need for new collector construction is based upon present and planned development. In the Wadi el Hamam basin it is not anticipated that the land to the north of the refugee camp will be developed until after 1990. At this time, the network proposed as immediate (Phase 1 project) should be constructed. The future extension (Phase 2 project) of this system would be accomplished best by routing a closed conduit along the drainage course and ending it just outside the projected planned development. The drainage course presently follows a dirt road. It is suggested that this road be included in the Town Plan. The Phase 2 extension would thus be along public right-of-way.

Similarly, it is not anticipated that the Wadi Tariq Saum basin will be developed in the lower wadi area along the existing collector just upstream of its crossing under Jerusalem Street. It is recommended that an outfall or overflow at some point upstream in the wadi from Jerusalem Street (planning boundary) be constructed on the existing collector. This point would also be the termination point of the new line discussed previously. At the overflow point, flow above the capacity of the existing downstream line would overflow into the natural drainage course.

Future extension (Phase 2) of the new line would be programmed as this part of the drainage basin is developed. The extension would include a closed conduit to transport the overflows from the Phase 1 terminal point to Jerusalem Street and outside the planning area.

Right-of-way for Phase 2 extensions should be obtained under Phase 1. In this manner, development along these routes will not occur prior to construction of the projects themselves.

6.4.2.6 Major Culverts.

A major culvert is proposed in the Wadi Tariq Saum basin for Jerusalem Street. There is presently no culvert through this road, other than the existing stormwater collector. This culvert will allow run-off not collected by the proposed network to flow out of the planning area. Overflow from the proposed Phase 1 structures will also exit through this culvert.

6.4.3 Proposed Network Analysis

Layouts of proposed networks, augmenting existing collectors and relieving flooding problem areas, are displayed on Figure 6-4a and b, showing the new disaggregation of drainage districts.

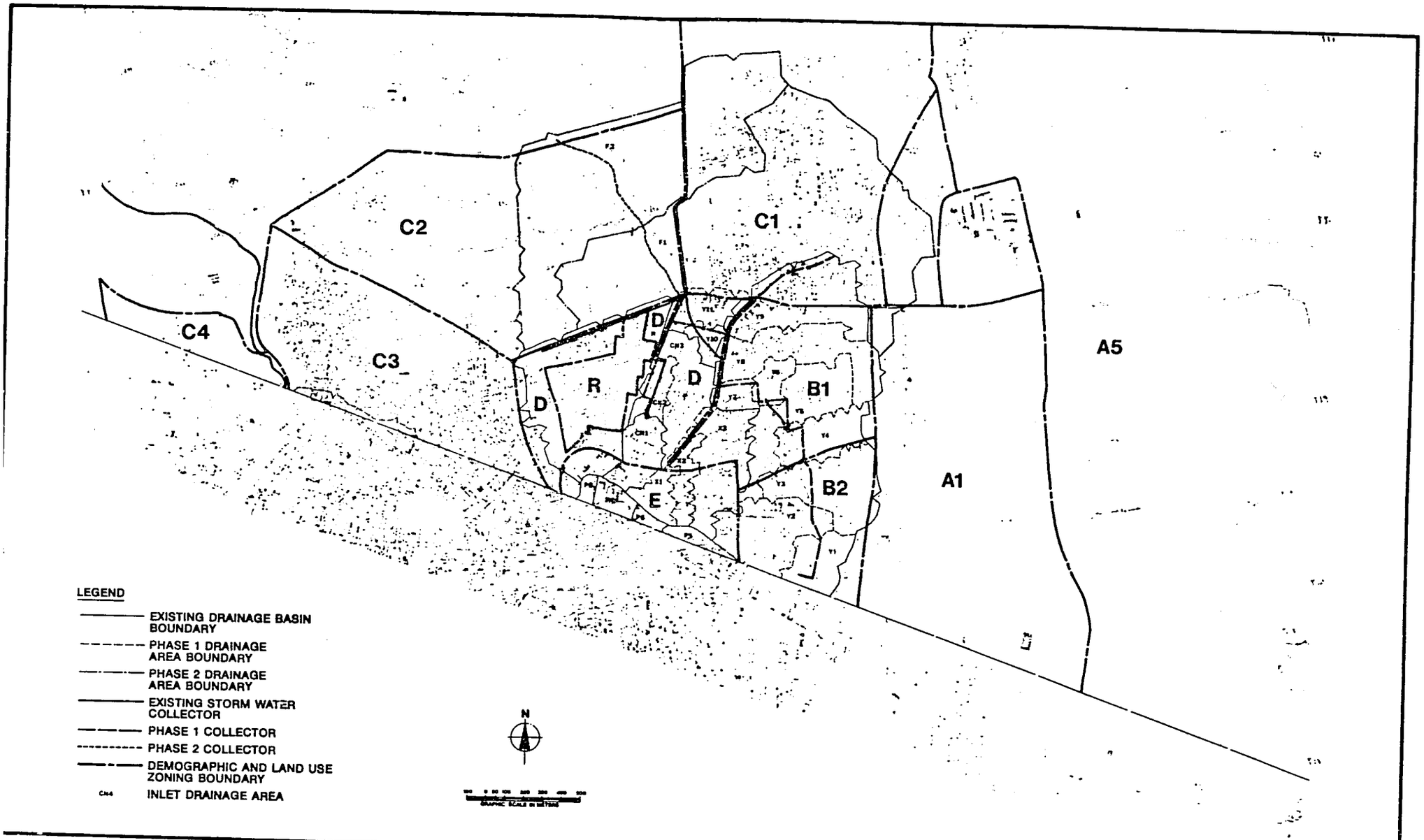
Weighted run-off coefficients and travel times were determined for the new drainage districts. The rational formula was then applied to the networks as shown on Figure 6-4. Again, it was recognized that an effective area existed, i.e., a reduced area would give a greater flow because of increased values of rainfall intensity and weighted run-off coefficients.

Boundaries of equivalent times of concentration for the proposed network outlets were determined from pipe and overland flow time computations. Figure 6-5a and b displays this analysis for the proposed networks. The effective area was then determined by eliminating outer areas, one boundary at a time, from the rational formula analysis until the peak rate of run-off was obtained. The resultant "effective areas," shown on Figure 6-5 produced calculated flows 40 to 60 percent greater than when using the entire drainage areas.

The effective area was then used in the hydraulic analysis to size storm drainage facilities for the proposed layout. Schematic diagrams representing the hydraulic analyses for the Tariq Saum and el Hamam networks are presented on Figures 6-6 and 6-7, respectively. Drainage district areas and run-off coefficient values, as well as flow times, represent those at the effective area boundary shown on Figure 6-5.

Sizing of new storm collectors and appurtenant structures was a result of an iterative procedure. Ground profile and pipe crown were plotted with minimum cover criteria (1 m) for all proposed collectors. For this profile, pipe sizes were determined assuming maximum conduit capacity at full flowing conditions and no decrease in downstream pipe sizes. Profile sections with high velocities (above 5 to 6 m per second) were reevaluated, placing drop structures at key points to reduce the velocity. Once the final profile was obtained, an evaluation using the ground profile to maximize the hydraulic gradient was performed to minimize the pipe size. In many places, this process considerably reduced the cost of the facilities. Figures 6-8 and 6-9 schematically display the results of the hydraulic analysis showing proposed and future pipe sizes and lengths for the Tariq Saum and el Hamam networks, respectively.

With the characteristics of the proposed network defined, a cost comparative analysis was conducted. Equivalent sizes for the collection network were determined for each conduit material. The equivalent conduit size for a given stormwater flow was based upon hydraulic slope and the roughness coefficient of the material considered.



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PROPOSED NETWORK INLET DRAINAGE AREAS

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FIGURE 6-4a

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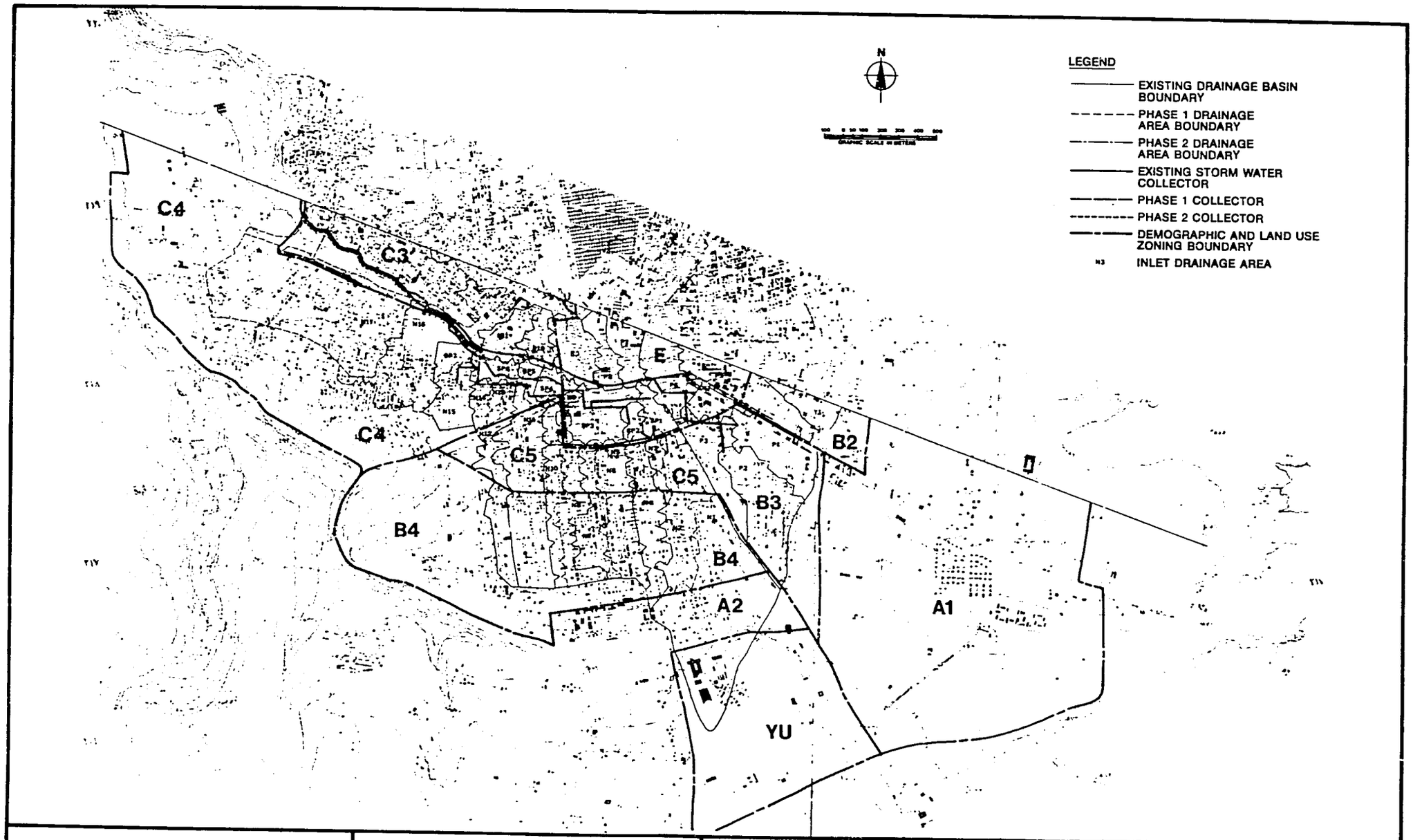

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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

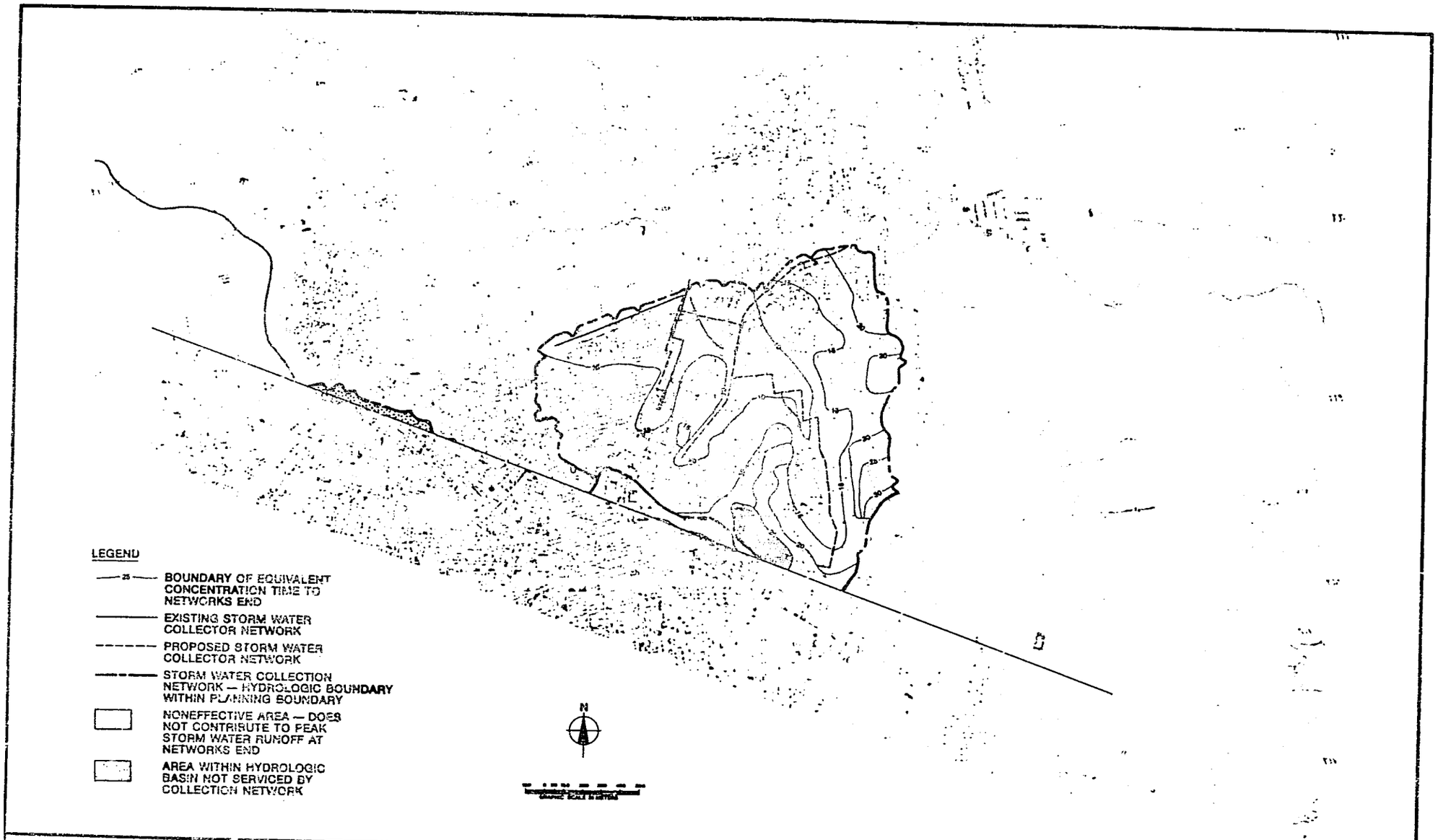
PROPOSED NETWORK INLET DRAINAGE AREAS

SHEET NO. FIGURE 6-4b

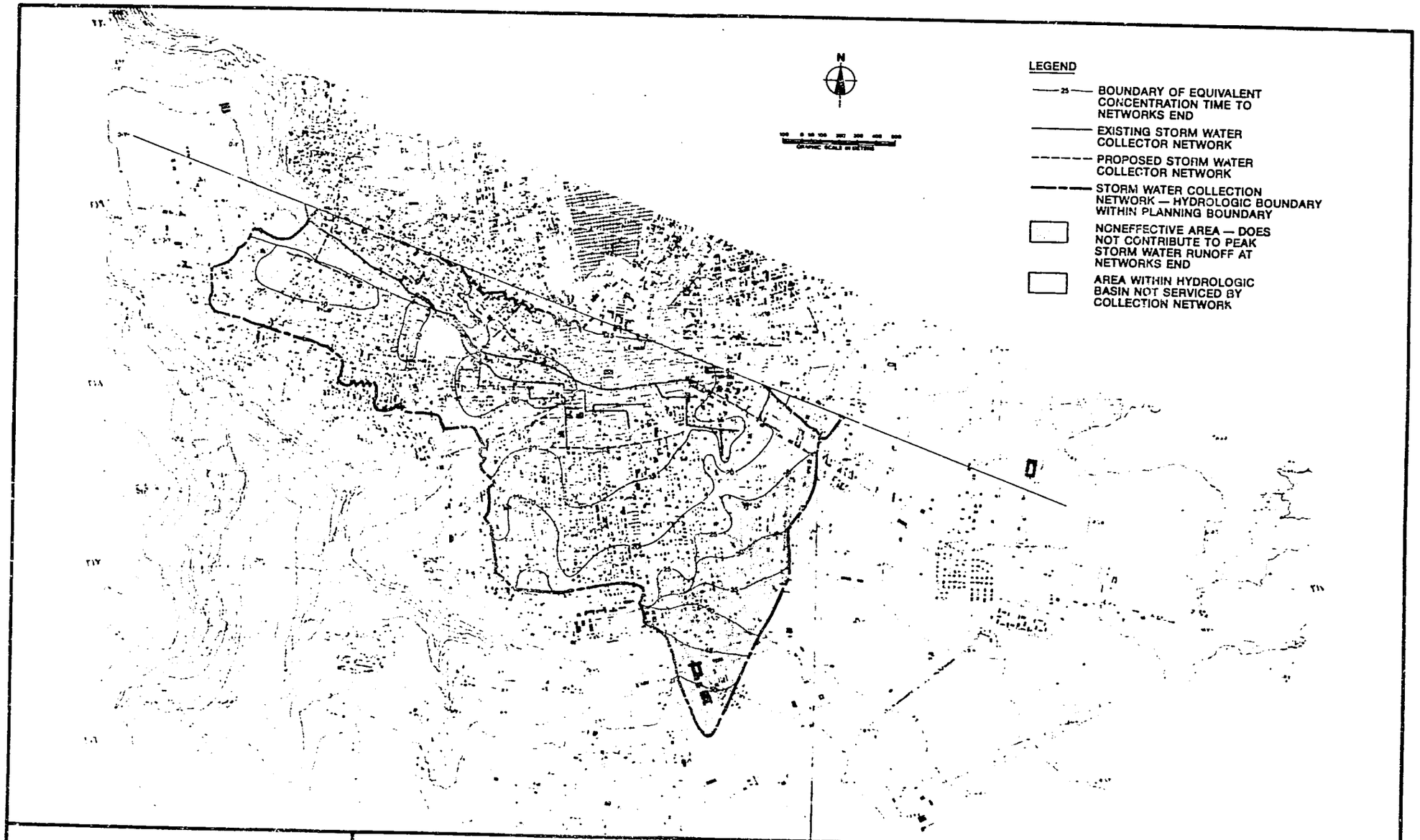
DATE:

BY:

CHKD:



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MPM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	EFFECTIVE DRAINAGE AREA PROPOSED NETWORK	SHEET NO. FIGURE 8-5a DATE: BY: CHKD:



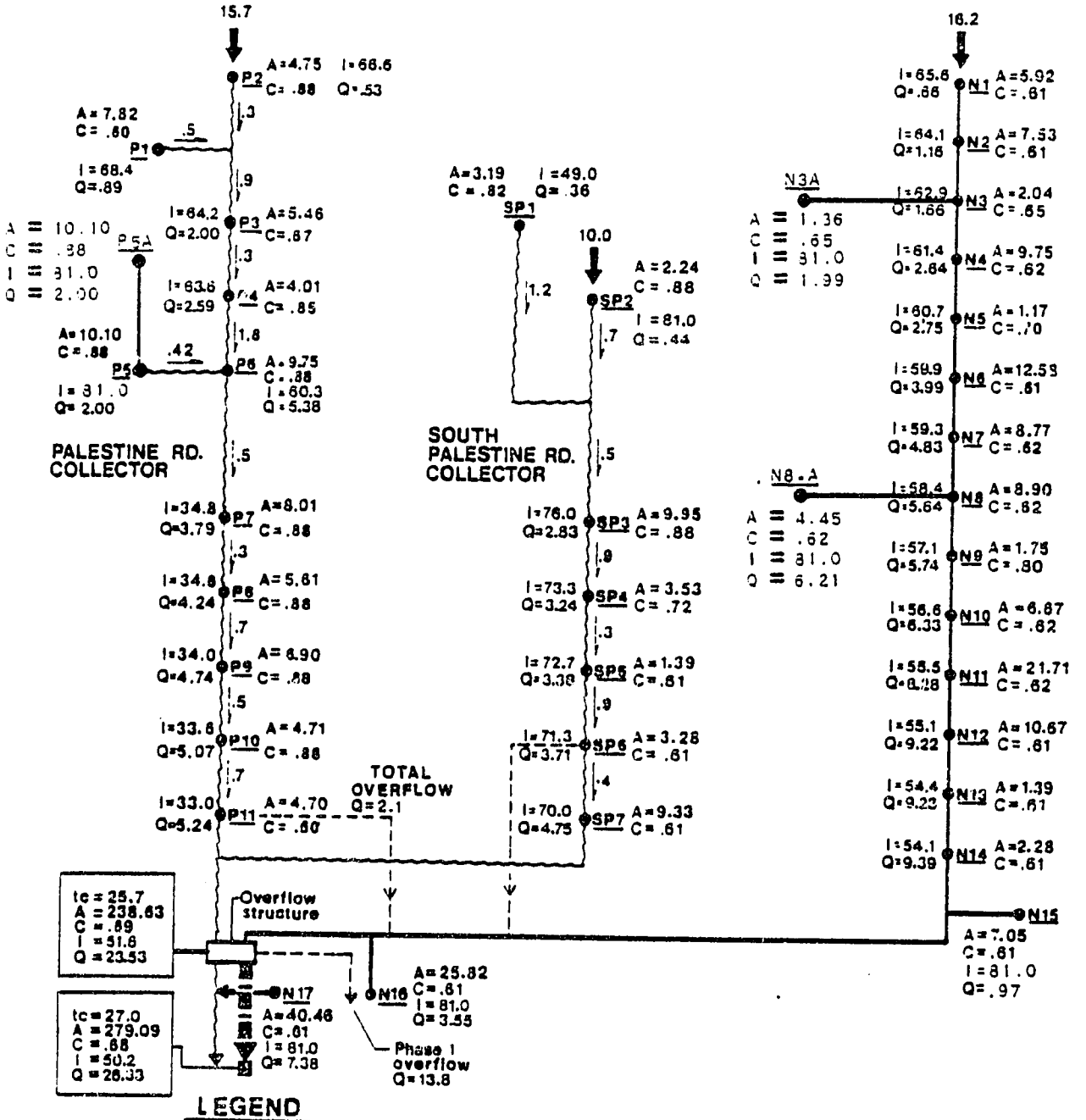
WESTON INTERNATIONAL, INC.
IN ASSOCIATION WITH STANLEY CONSULTANTS, INC.,
SIGMA CONSULTING ENGINEERS
MRM CONSULTING ENGINEERS CO., LTD

MIRIND WATER SUPPLY, SEWERAGE, STORM
DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

EFFECTIVE DRAINAGE AREA
PROPOSED NETWORK

SHEET NO.
FIGURE 6-5b

DATE:
BY:
CHKD:



LEGEND

NI-Drainage subdivision inlet code name

A - Drainage subdivision area (hectares)

C - Drainage subdivision weighted runoff coefficient

I - 10 Yr. storm rainfall intensity used at point in network (mm/hr)

tc-Time of concentration at point in network

--- Overflow for 10 yr. storm

~~ Existing network

▬ Phase 1 network

■■ Phase 2 network

↓ - Maximum overland flow to inlet of major drainage network (minutes)

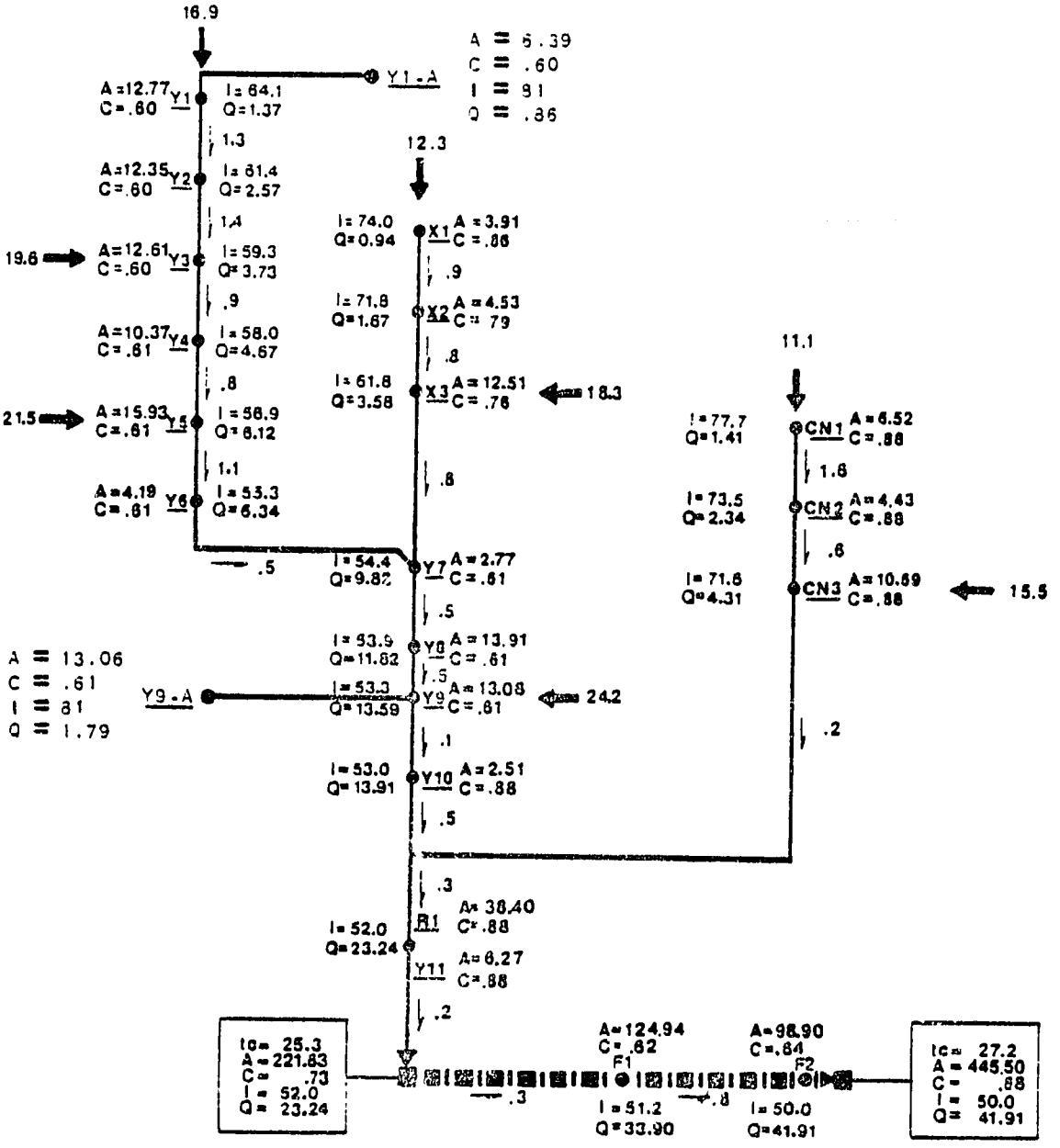
| - Travel time between inlets (minutes)

Q - Computed flow at point in network (m^3/sec)

■ - Major collector drainage data summary

PROPOSED DRAINAGE NETWORK — TARIQ SAUM BASIN
HYDROLOGIC ANALYSIS

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 6-6 DATE: BY: CHECKED: 310



LEGEND

Y1-Drainage subdivision inlet code name

A -Drainage subdivision area (hectares)

C -Drainage subdivision weighted runoff coefficient

I -10 Yr. storm rainfall intensity used at point in network (mm/hr)

tc-Time of concentration at point in network

— Phase I network

▩ Phase 2 network

↓-Maximum overland flow to inlet of major drainage network (minutes)

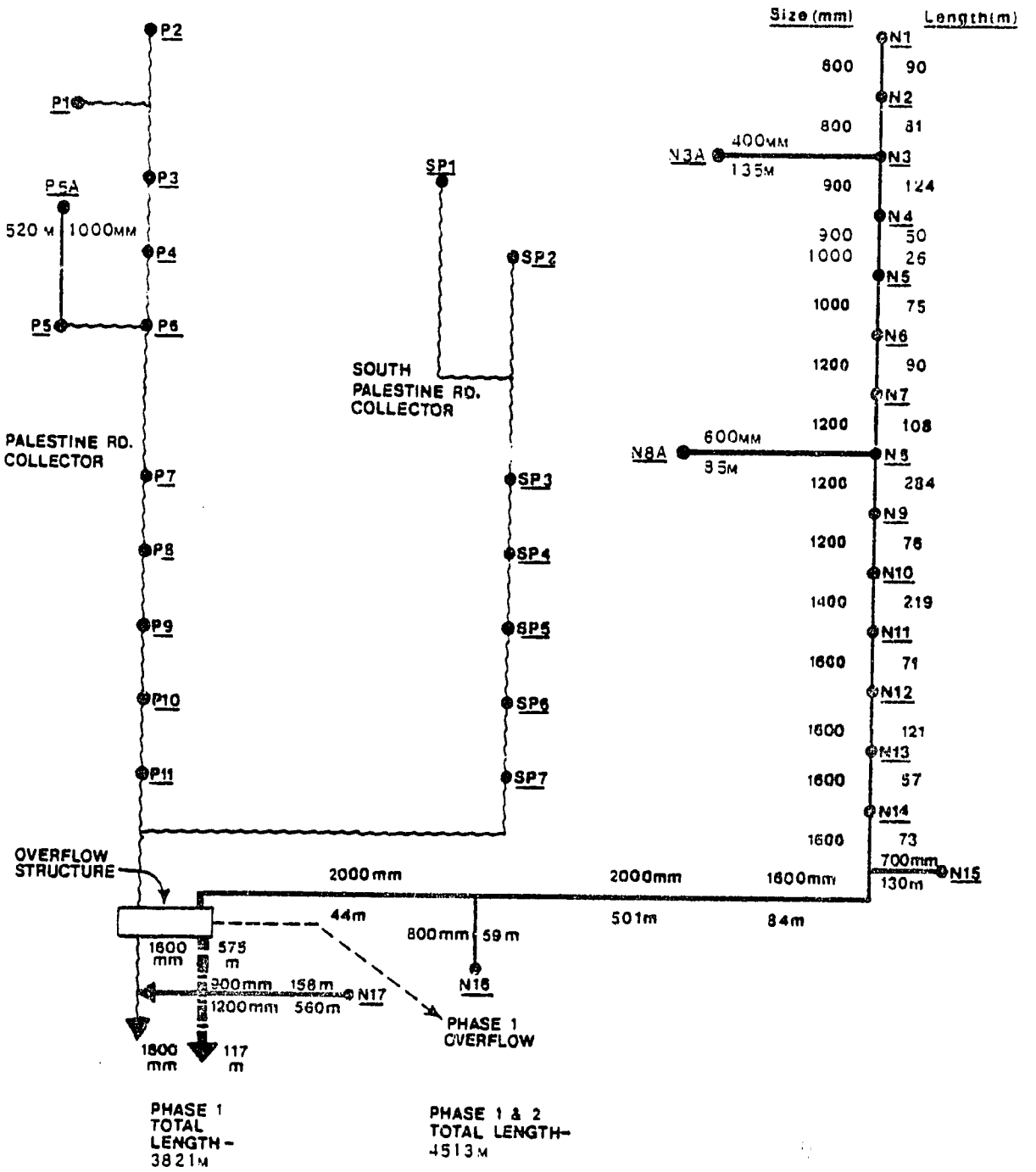
|-Travel time between inlets (minutes)

Q-Computed flow at point in network (m^3/sec)

▩-Major collector drainage data summary

PROPOSED DRAINAGE NETWORK — EL HAMAM BASIN
HYDROLOGIC ANALYSIS

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 6-7 DATE: 3/1 BY: CHECKED:



LEGEND

P5 - Drainage subdivision inlet code name

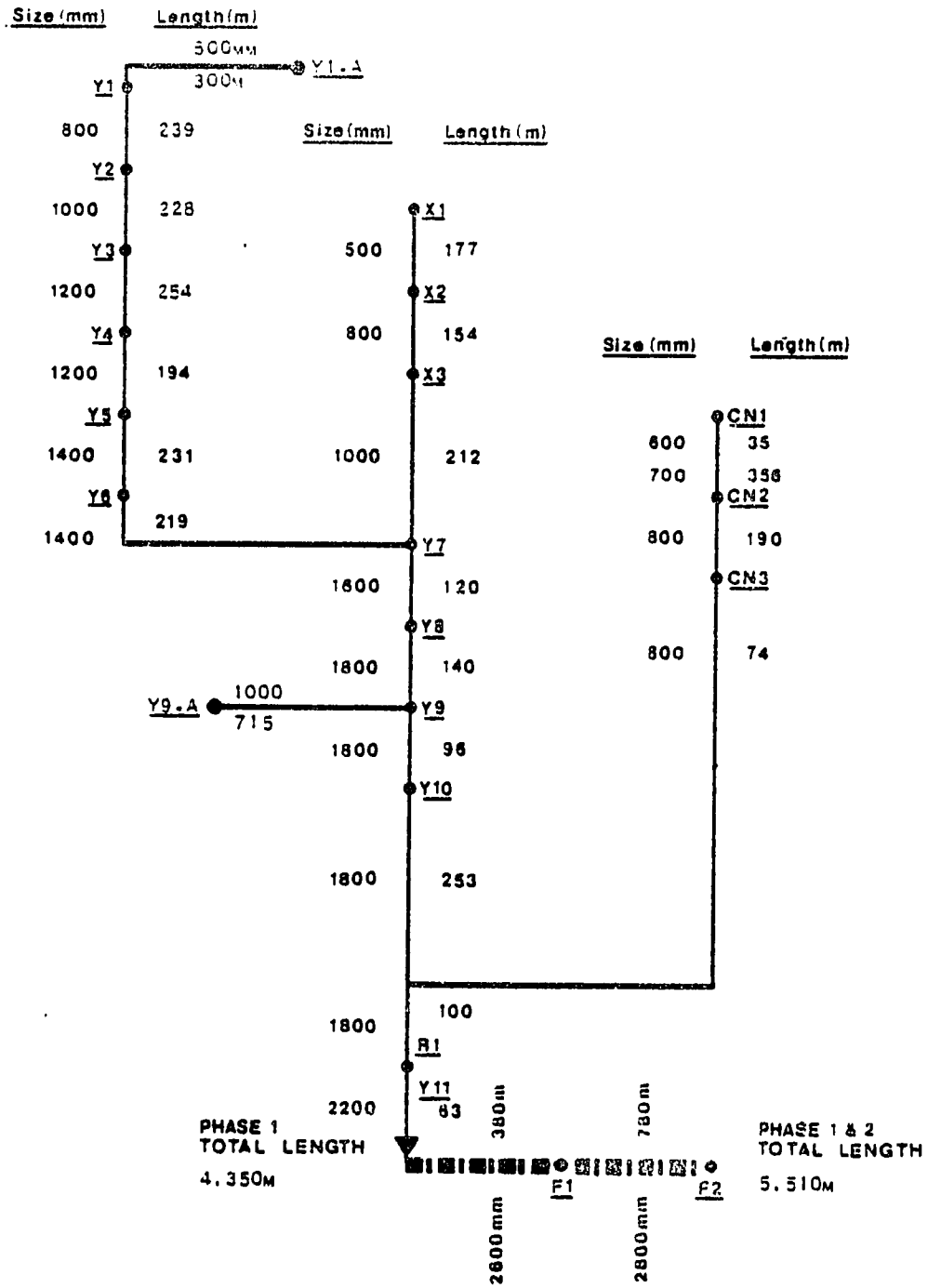
Existing network

Phase I network

Phase 2 network

PROPOSED DRAINAGE NETWORK — TARIQ SAUM BASIN
HYDRAULIC ANALYSIS RESULTS

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 6-8 DATE: 3/12 BY: CHECKED:



LEGEND

NI - Drainage subdivision inlet code name

—— Phase I Network

▩▩ Phase 2 Network

PROPOSED DRAINAGE NETWORK — EL HAMAM BASIN
HYDRAULIC ANALYSIS RESULTS

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co.Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 6-9 DATE: 3/3 BY: CHECKED:

Table 6-2 presents equivalent sizes and costs for the three conduit materials. Comparing the costs of these equivalent sizes reveals that reinforced concrete pipe is the most economical of all the conduit materials, and is also available locally. Thus, it was concluded that concrete pipe was the best material for the project.

6.4.4 Definition of System Characteristics

6.4.4.1 Existing Network Improvements.

Improvements to the existing network consist of provisions for increased inlet capacity, and cleaning and structural rehabilitation of conduits where appropriate. All existing sanitary connections will be plugged. The number of sanitary connections was estimated by the City at 200. New inlets to the existing collectors will include channel collectors (two lengths), curb inlets, and manhole inlets. System details are shown on Figure 6-10. Locations of inlets proposed for the existing collector system are shown on Figure 6-11a and b. The proposed number of each inlet type and manholes for each basin are listed in Table 6-1.

Table 6-1

Proposed Inlets to Existing Networks

Tariq Saum Network	
Channel Inlet (23-m street)	9
Channel Inlet (12-m street)	8
Curb Inlet	9
Manholes	43
El Hamam Network	
Channel Inlet (23-m street)	1
Manholes	8

Source: Stanley Consultants

Cleaning of existing conduits will be accomplished by a winch-pulled bucket cleaner, followed by a hydraulic jet cleaner. The cleaning process will be labor intensive and slow due to the condition of the lines. The South Palestine Road collector in the Wadi Tariq Saum basin and the collector beginning at Heckma Street in the Wadi el Hamam basin, are scheduled for cleaning during Phase 1.

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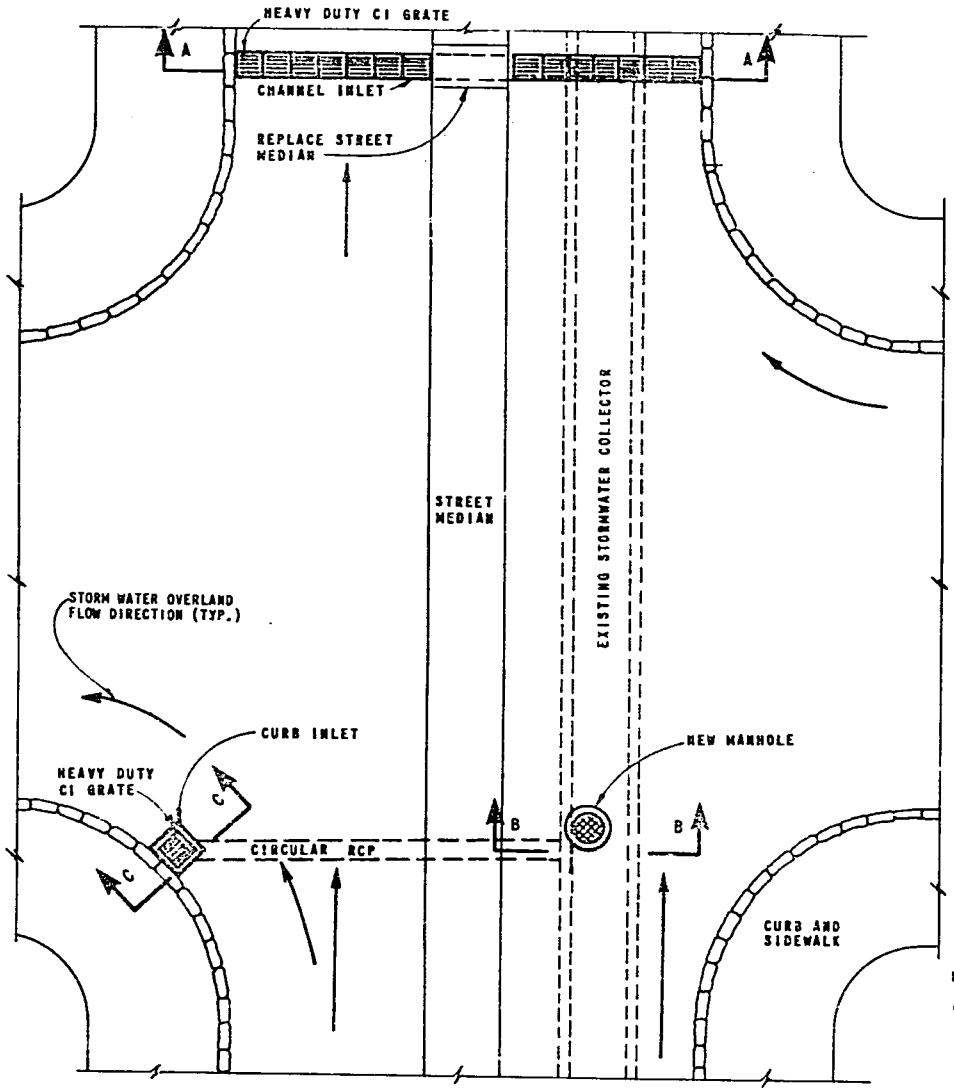
Table 6-2

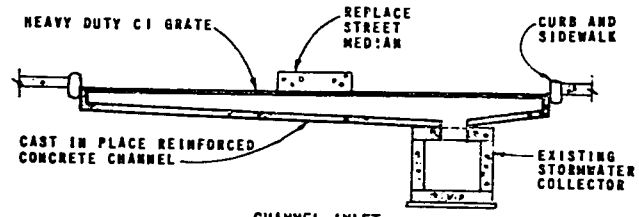
Equivalent Size and Cost of Materials
Cost Comparison Analysis

Reinforced Concrete Pipe		Corrugated Steel Pipe		Cast-in-Place Concrete Box	
Required Diameter (mm)	Cost (JD/m)	Required Diameter (mm)	Cost (JD/m)	Required Diameter (mm)	Cost (JD/m)
500- 600	16- 19	700- 800	40- 49	540- 620	91.3- 99.0
600- 800	19- 25	800-1,000	49- 58	620- 810	99.0-117.3
800-1,000	25- 36	1,000-1,400	58- 89	810-1,050	117.3-140.3
1,000-1,200	36- 53	1,400-1,600	89-105	1,050-1,230	140.3-157.6
1,200-1,400	53- 75	1,600-1,800	105-123	1,230-1,400	157.6-173.9
1,400-1,600	75- 97	1,800-2,000	123-139	1,400-1,630	173.9-196.0
1,600-1,800	97-126	2,000-2,400	139-228	1,630-1,880	196.0-220.0
1,800-2,000	126-156	2,400-2,600	228-255	1,880-2,030	220.0-234
2,000-2,200	156-204	2,600-2,800	255-282	2,030-2,290	234 -259.4
2,200-2,400	204-246	2,800-3,000	282-314	2,290-2,430	259.4-273

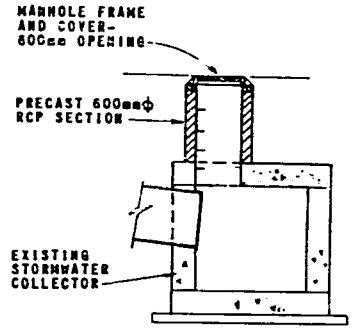
Source: Stanley Consultants and Weston International



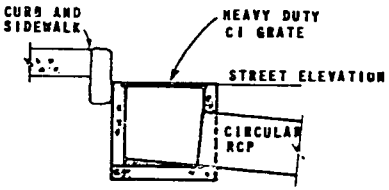
STREET INTERSECTION PLAN



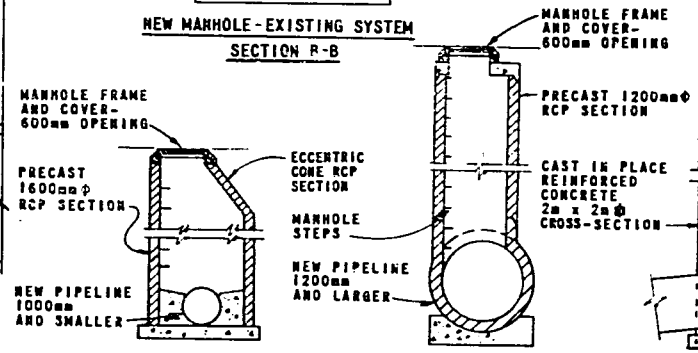
CHANNEL INLET
SECTION A-A



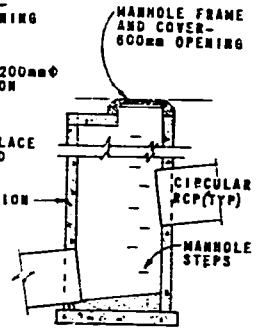
NEW MANHOLE-EXISTING SYSTEM
SECTION B-B



CURB INLET
SECTION C-C

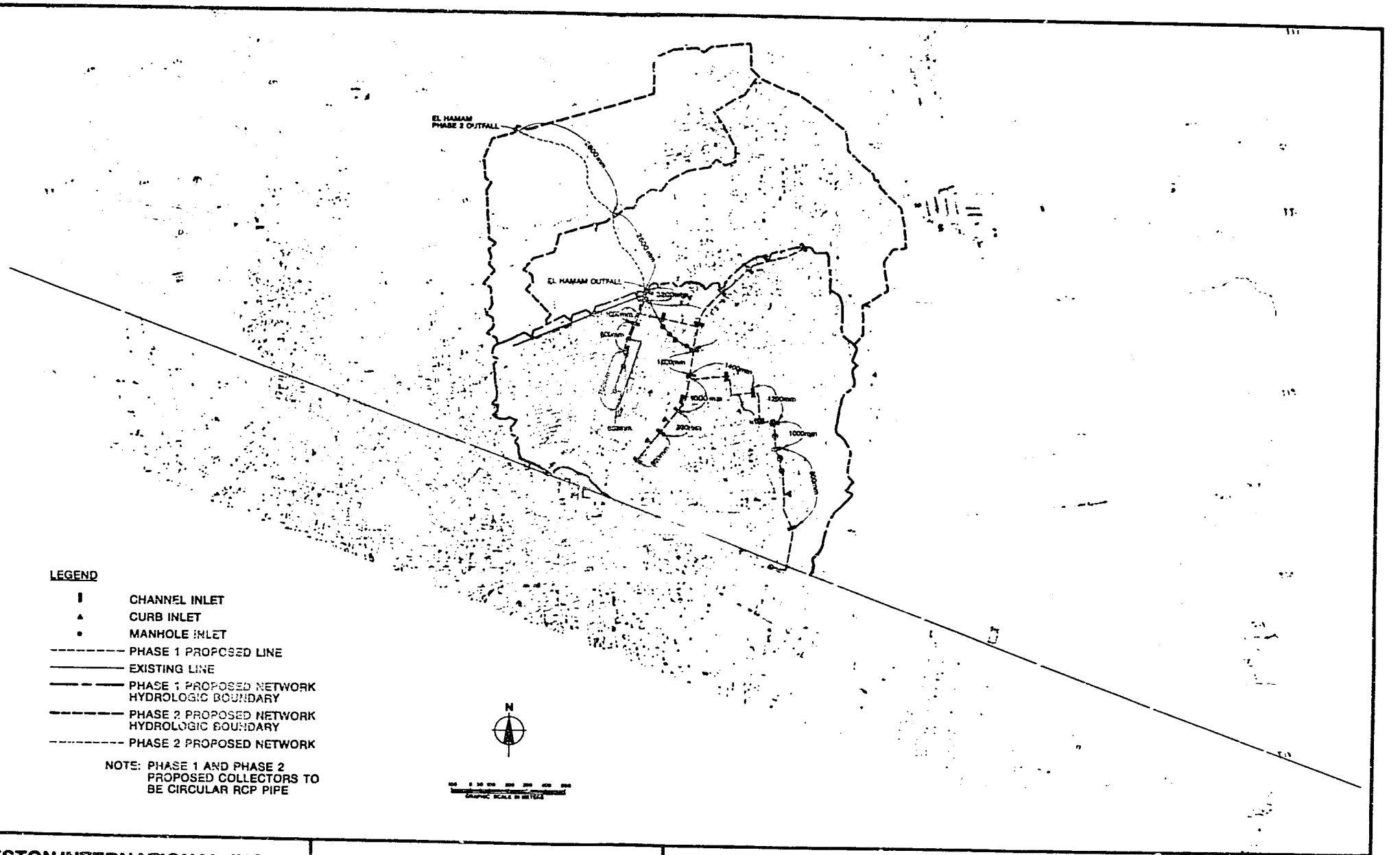


MANHOLE SECTIONS

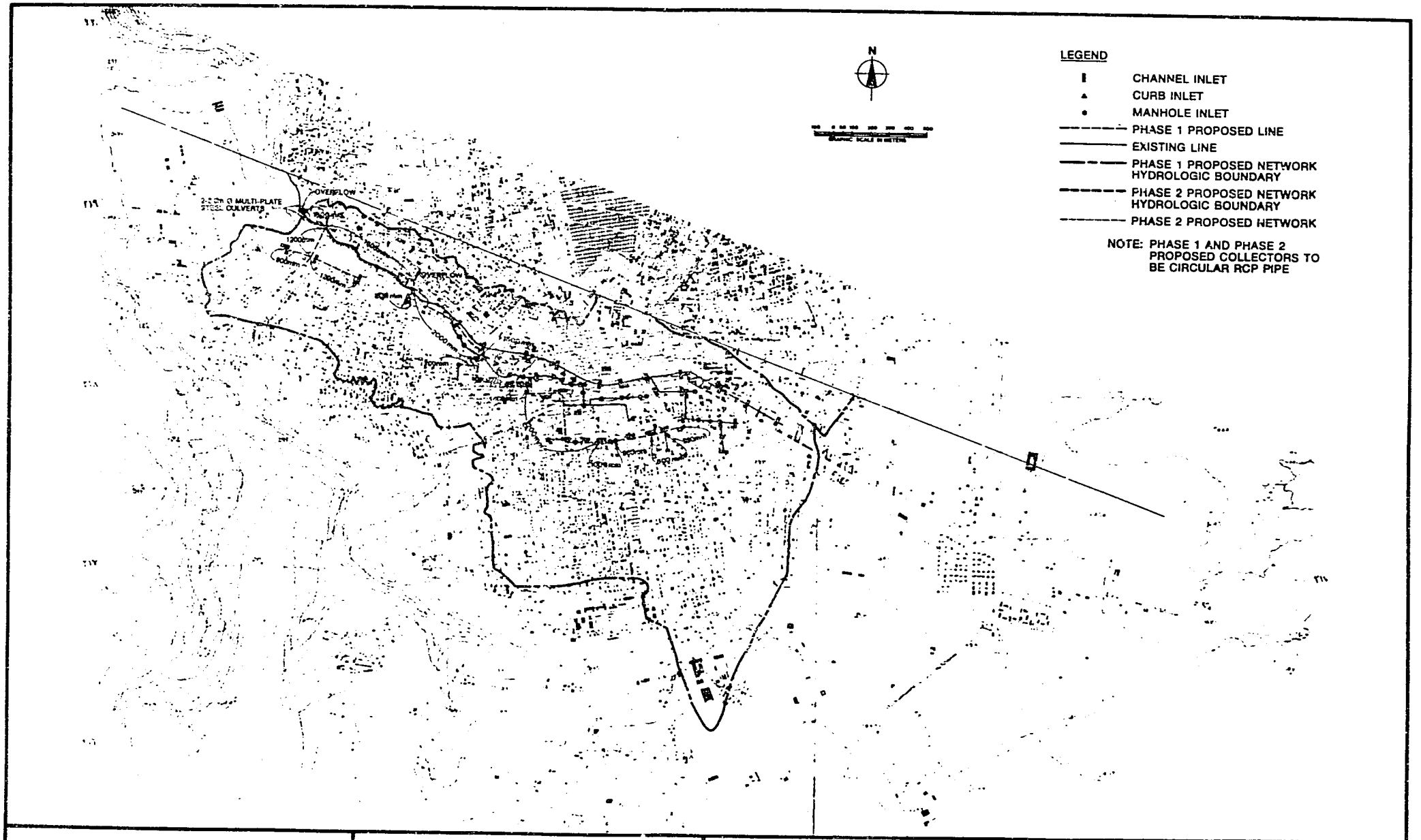


DROP STRUCTURE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., KOMA CONSULTING ENGINEERS FRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	STREET PLAN AND TYPICAL DETAILS	SHEET NO. FIGURE 6-10 DATE: SEPT.1979 BY: CHKD:



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	PROPOSED DRAINAGE IMPROVEMENTS	SHEET NO. FIGURE 6-11a DATE: BY: CHKD:



WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MPM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	PROPOSED DRAINAGE IMPROVEMENTS	SHEET NO. FIGURE 6-11b DATE: BY: CHKD:

Structural repair will be accomplished as needed. The extent of this work will not be known until the cleaning process is under way. Existing network improvements are included as Phase 1 projects and are scheduled for construction in 1980-1981.

6.4.4.2 Immediate (Phase 1) Network Needs.

Improvements to the existing drainage collector system are shown on Figure 6-11. Figure 6-10 displays typical details of proposed structures. Immediate network needs include circular RCP collectors; channel, curb and manhole inlets; a major culvert; drop structures; and miscellaneous outlet/overflow structures. Table 6-3 identifies structures proposed as immediate network needs.

Immediate facility needs are defined by the present extent of growth, as discussed in previous sections of this chapter. Immediate needs are included as Phase 1 projects and are scheduled for construction in 1980-1981.

6.4.4.3 Future Network Needs.

Drainage facilities programmed as future needs are dependent upon anticipated growth and the Town Plan. Future needs are also displayed on Figure 6-11, with typical details shown on Figure 6-10. These facilities include circular RCP collectors; channel curb and manhole inlets; drop structures; and inlet/outlet structures. Table 6-4 identifies structures proposed as future network needs. Future needs are included as Phase 1 projects, and are scheduled for construction in 1990.

6.4.4.4 Right-of-Way Land Requirements.

Right-of-way land is required for portions of the proposed immediate and future networks. Figure 6-11 displays the location and width of permanent right-of-way land required. Table 6-5 summarizes the right-of-way land requirements. The cost of right-of-way land requirements is included in Phase 1.

6.4.4.5 Compatibility with Other Utilities.

New storm collactors are to be constructed along the side of the street that is most convenient to the proposed location of inlets. New water mains will be constructed on the opposite side, and sewer lines will be constructed down the center of the streets. All existing sanitary connections to storm lines will be plugged at the storm conduit and rerouted to the sanitary sewer. Conflicts with existing water mains will be minimized.

Table 6-3

Immediate Network Structures
New Collector System

	Size (mm)	Length (m)
Wadi Tariq Saum Basin		
Pipeline -- Circular RCP	400	135
	600	175
	700	130
	800	140
	900	332
	1,000	621
	1,200	1,305
	1,400	32
	1,600	406
	2,000	545
Total Length		3,821

	Number
Manholes	55
Inlets	
Channel inlet (23-m street)	4
Channel inlet (16-m street)	5
Channel inlet (12-m street)	13
Curb inlet	6
Manhole inlets	2
Special connections	4
Overflow structures	2
Drop structures	22
Culverts (2) - two diameter multiplate steel, 40-m each	2

Wadi El Hamam Basin		
Pipeline -- Circular RCP	500	177
	600	35
	700	356
	800	883
	1,000	1,229
	1,200	448
	1,400	450
	1,600	120
	1,800	589
	2,200	63
Total Length		4,350

Manholes	67
Inlets	
Channel inlet (23-m street)	3
Channel inlet (16-m street)	3
Channel inlet (12-m street)	17
Curb inlet	4
Manhole inlets	4
Special connections	4
Outlet headwall	1
Drop structures	11

Source: Stanley Consultants

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Table 6-4

Future Network Structures
New Collector System

	Size (mm)	Length (m)
Wadi Tariq Saum Basin		
Pipeline -- Circular RCP	1,600	575
	1,800	117
Total Length		692

	Number
Manholes	5
Inlets	
Channel inlet (12-m street)	4
Special connections	2
Outfall structure	1
Drop structures	2

Wadi El Hamam Basin		
Pipeline -- Circular RCP	2,600	380
	2,800	780
Total Length		1,160

	Number
Manholes	5
Inlets	
Channel inlet (23-m street)	2
Channel inlet (16-m street)	1
Channel inlet (12-m street)	1
Curb inlet	7
Special connection	1
Outfall structure	1
Drop structures	8

Source: Stanley Consultants

Table 6-5

Right-of-Way Land Requirements
Immediate and Future Structures

	Collector Name	Length (m)	Width (m)	Area (sq m)
Wadi Tariq Saum Basin				
	N1/N2	50	10	500
	N16	70	10	100
	N17	170	10	1,700
	NF	930	20	18,600
Total area				21,500
Wadi El Hamam Basin				
	CN2/CN3	230	10	2,300
	CN3/Y11	110	15	1,650
	Y1A-Y4 reroute	250	10	2,500
	F	1,150	30	34,500
Total area				40,950
Grand Total				62,450

Source: Stanley Consultants

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6.4.5 Cost Estimate and Implementation Summary

Estimates of capital, operating and maintenance expenditures are discussed in the following subsections.

6.4.5.1 Capital Cost Estimate.

Table 6-6 is a summary of project capital costs estimated for Phase 1 projects and expressed as 1979 Jordanian dinars. Table 6-7 is a summary of the costs for Phase 2 projects, also expressed as 1979 Jordanian dinars. The summary tables separate the project into the following components to which overhead and profit have been added:

1. Pipeline materials installed, inclusive of excavation, bedding, backfill, pavement removal and replacement, and all normal manholes.

2. Inlets including concrete and cast iron materials, excavation, backfill, and pavement removal and replacement.

3. Existing network improvements including new inlets similar to those of the proposed network, cleaning and structural rehabilitation of deteriorated collectors, and plugging existing sanitary connections.

4. Miscellaneous structures including culverts, overflows, outfalls, drop structures, and interconnections between existing and new collectors.

Table 6-6

Phase 1 Capital Cost Estimate
(1979 Jordanian Dinars)

	Local	Foreign	Total
Pipeline	1,459,000	9,000	1,468,000
Inlets	36,000	51,000	87,000
Existing network improvements	159,000	30,000	189,000
Miscellaneous structures	162,000	33,000	195,000
Probable Construction Cost	1,816,000	123,000	1,939,000
Contingency	272,000	18,000	290,000
Engineering and administration	91,000	181,000	272,000
Right-of-way	473,000	---	473,000
Total Project Cost	2,652,000	322,000	2,974,000

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Table 6-7

Phase 2 Capital Cost Estimate
(1979 Jordanian Dinars)

	Local	Foreign	Total
Pipeline	883,000	1,000	884,000
Inlets	11,000	11,000	22,000
Miscellaneous structures	34,000	2,000	36,000
Probable Construction Cost	928,000	14,000	942,000
Contingency	139,000	2,000	141,000
Engineering and administration	47,000	94,000 ?	141,000
Total Project Cost	1,114,000	110,000	1,224,000

Source: Stanley Consultants

The total of these components is a probable construction cost. To arrive at a project capital cost, allowances are added for the following:

1. Contingencies to allow for unforeseen costs.

2. Engineering and administration including technical assessment, construction management and supervision, and administering agency costs, estimated as 15 percent of probable construction cost.

3. Right-of-way and associated land purchase costs.

4. Interest during construction will be assessed in the financial analysis presented in Chapter 9.

6.4.5.2 Operating and Maintenance Costs.

Operating and maintenance costs have been estimated as of January 1979. Expenditures for these categories were developed using typical crews for the various work tasks, and an allowance for equipment and tools. Table 6-8 summarizes these costs for Phase 1 and Phase 2 projects.

6.4.5.3 Project Cost Components.

In estimating project costs, careful attention has been given to construction methods. Estimates account for mobilization, material supply requirements, local work schedules, evaluation of labor production, and similar factors. All associated costs have been considered, including contractor overhead and profit.

Table 6-8

Operation and Maintenance Cost Estimate
Phase 1 and Phase 2 Systems
(1979 Jordanian Dinars)

	Annual Cost
Phase 1 System	
Labor	2,600
Incidental equipment	1,400
Total	4,000
Phase 2 System	
Labor	3,200
Incidental equipment	1,800
Total	5,000

Source: Stanley Consultants

In preparing unit costs, consideration has been given to construction equipment size, type, and number of machines that are expected to be used. Work crews have been projected by number and skills required. The costing of construction operations has been discussed with local contractors. Unit costs for materials have been obtained by reviewing bid information on recent projects in Jordan, by interviewing local contractors and consultants, and by contacting suppliers in the Amman area. Proper attention has been given to shipping costs. Allowance has been made for transportation, accounting for delivery to the Port of Aqaba, and trucking to the project site.

Heavy construction equipment, supervisory personnel, and much of the skilled labor force will be mobilized from countries outside Jordan, and demobilized at project completion. The contractor's overhead, estimated as 20 percent of total direct costs, includes supervision, recruiting of key personnel, office staff, purchasing, warehousing, communications, field office, and maintenance of equipment.

Contractor's profit has been assumed to be 10 percent of the total direct and indirect cost. A contingency is included to provide for unforeseen problems during detailed design, constructability, subsurface conditions, and access.

It is assumed that no import duties will be paid on material used on this project, or on equipment which will be exported at project completion. Duties, on the value when imported, will be charged on equipment which is not removed from Jordan. It is assumed that a contractor will not be required to pay income tax to Jordan.

Using developed cost parameters, estimates have been prepared on a unit cost basis which involve computing material quantities and multiplying by assembled unit costs. Mobilization, overhead, profit, right-of-way, and contingencies as well as administration and engineering have been added, based on these discussions. The costs presented are financial costs, and represent the expenditures required to complete the project as of 1979. Actual costs, which will include an allowance for price escalation to the anticipated time of expenditure, are presented in the appropriate chapter of this report.

6.4.5.4 Construction Methods and Materials.

Preliminary reconnaissance indicates that much of the excavation for stormwater network structures and pipe will be 80 percent rock which will be removed by jackhammer. Excavation within 2 m is mostly soil and ripable rock which can be removed with conventional equipment. Ninety percent of the new collectors are within existing street right-of ways; pavement will also be removed by jackhammer.

It is assumed that the multiplate steel pipe and all miscellaneous cast iron products will be imported to Jordan. For the quantities required, concrete aggregate, sand, and cement appear available within the area.

6.4.5.5 Local and Foreign Costs.

Cost estimates have been prepared showing local and foreign costs. The local component is that portion of the cost attributed to direct expenditures in Jordan. Included are costs of local materials and supplies, and indigenous salaries and wages. It is understood that import duties will not be assessed on materials incorporated into the project.

The foreign component is that portion of project costs which includes items such as foreign mobilization; a foreign company's overhead and profit; materials and supplies of which Jordan is a net importer; and foreign salaries, wages, and incidental expenses.

Some items are split between local and foreign which indicates an indirect foreign expense. The indirect portion is composed of:

1. Expenses to the economy connected with the importation of components and raw materials which will be subject to further processing in Jordan, and then incorporated into the project.

2. Depreciation of the imported machinery and equipment which will be utilized in the construction of the project, but not completely worn out during the course of the project.

6.4.5.6 Implementation.

Consideration given to the time required for construction of the stormwater drainage projects has included problems in rock excavation, labor availability, coincident construction with other utilities, and complications due to everyday traffic. Due to the size of this project, it is not anticipated that staging of construction work will be required. Estimates of construction time for Phase 1 and Phase 2 projects are as follows:

Phase 1	12 months
Phase 2	6 months

Phase 1 design is to be initiated immediately, with construction estimated to begin in 1980-1981. Phase 2 would not begin until 1990.

6.5 RECOMMENDATIONS

Recommendations concerning the stormwater drainage facilities for the City of Irbid include the immediate implementation of the design and construction of Phase 1 facilities to improve the hydraulic characteristics of the existing networks, relieve flooding problem areas, and augment the carrying capacity of existing conduits. Phase 2 recommendations include extension of the two major storm collection networks to just beyond the planning boundary. The second phase extension will be a result of anticipated growth and development of the downstream watershed.

6.5.1 Use of Existing System

The existing network should be upgraded to include additional inlet structures (mostly of the channel collector type) strategically located to increase the efficiency of run-off capture. Figures 6-10 and 6-11 display typical details and recommended locations of new inlet structures on the existing collectors.

In addition to providing better inlet capability, certain existing conduits should be cleaned and structurally rehabilitated to increase their hydraulic capacity. Location of lines requiring this work are shown on Figure 6-11.

All sanitary connections to the existing storm collector network should be plugged and rerouted to the nearest proposed sanitary sewer. The

storm collector network serving the refugee camp will remain in use as a combined sewer system. Dry weather flows will be intercepted by sanitary collectors. Wet weather flows will be regulated, the majority of the flow being discharged to the storm drainage network.

Existing conduits are to be included as an integral part of the proposed collection network. In the Wadi el Hamam basin, the existing line that flows to the north and parallels the refugee camp should be abandoned. This line is structurally incapable of carrying wet weather flows.

The twin box collector outside the planning boundaries in the Wadi Tariq Saum basin will be left as is to carry smaller storm run-off flows. Just outside the planning boundary, an overflow structure will allow relief of this line for the larger storm run-off events. At key places, the Palestine and South Palestine Road collectors should be connected to the new collector so that overflows from existing lines will be carried by the new collector.

6.5.2 Best Apparent Alternative

The major objectives of a new storm run-off collection network are to relieve flooding problem areas, and augment the existing network. The best apparent alternative must handle run-off from the 10-year storm. Evaluation of the existing facilities and system requirements to alleviate flooding led to the proposed network layout displayed on Figure 6-11, with typical details as shown on Figure 6-10.

The extent of immediate needs is dictated by present and anticipated growth patterns in the planning area. A future (Phase 2) extension of the proposed layout is programmed for 1990 when it is anticipated that development of the downstream watersheds will probably occur. Until this time, the discharges from the proposed Phase 1 systems will be to the natural watercourse. The proposed line in the Wadi Tariq Saum basin will connect with the existing twin box collector, but will have a provision for stormwater overflow. The overflow will discharge to the undeveloped wadi area which will flow under Jerusalem Street via a proposed twin multiplate steel culvert. The Phase 2 extension of the Wadi Tariq Saum network will carry the overflow through the culvert in Jerusalem Street.

6.5.3 Right-of-Way Requirements

Right-of-way land needs for the proposed network are shown graphically on Figure 6-11. Purchase of land will be required for both phases of stormwater collector projects. It is recommended that the purchase of all right-of-way land needs be made a part of Phase 1. In this manner, the normal practice of development within the natural drainage course will be stopped.

CHAPTER 7

SOLID WASTE DISPOSAL STUDIES

7.1 EXISTING CONDITIONS

To develop the baseline data necessary for evaluating solid waste management alternatives, the present Irbid solid waste system was reviewed. This review included the following:

1. Existing collection system.
2. Existing collection equipment and methods.
3. Location of all solid waste disposal sites in Irbid.
4. Existing operations and maintenance procedures.

Presently, the Municipality of Irbid regulates the collection, transportation, and disposal of solid waste in the City. All collectors of the solid waste are City employees. Presently, all solid waste collected by the Municipality is transported directly to the disposal site by collection vehicles. Pickup area rather than door-to-door collection is presently utilized. This method is utilized because many alleys and streets are difficult to drive through with large collector trucks. Solid waste collection includes the following categories:

1. Residential/commercial waste.
2. Industrial waste.
3. Major special wastes.
4. Sludge and septage waste.

7.1.1 Residential/Commercial Waste

Residential waste is waste generated in the home. This includes apartments as well as private homes. It is presently known that quantities and characteristics of waste generated will vary from one neighborhood to the next, but overall, the waste characteristics remain within a limited range. Prior to this study, no records of waste characteristics or generation for Irbid existed. Presently, the trash is collected and disposed of in an open dump 14 km southeast of Irbid.

Field observations of Irbid's collection system, methods, and practices were observed during the months of July and August 1979. The Municipality is divided into five major zoning areas (A through E). These planning and building zones theoretically correspond to various income level groups. Zone E represented the City-core (the most dense area of Irbid), and the remaining zones radiate outward to less dense areas. Collection methods employed are similar in almost all zones. Zone E, because of its dense commercial development and congestion, displays a more frequent trash removal rate than other zones. In some areas of the City, vegetable and fruit wastes are deposited into piles at various pick-up

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points along with general rubbish. It appeared that much of this waste was not removed for a long period of time. The commercial areas are relatively clean, except for litter in streets, alleys, and storm drainage channels. Waste in the City is stored at waste pick-up points where are designated locations for waste storage. Collection trucks retrieve the waste from these areas. Many of these areas are not protected from weather or animals. Collection frequencies in the Irbid area range from two- to three-day intervals, and during this period, the refuse is exposed to the elements and animals. The animals destroy the storage containers, plastic or burlap bags, and the food waste is spread over the land. This exposed condition invites flies, mosquitoes, and rodents.

In some collection areas workmen with wheelbarrows were observed shoveling litter and rubbish into piles and transporting this waste to the nearest waste pick-up point. In lower density areas, zones A and B, householders tend to dump their waste in piles located along the road or in vacant lots, where herds of goats and other animals are permitted to eat the trash. In some cases, open burning of waste is practiced.

The Irbid waste collection force consists of approximately 200 men employed by the Municipality. Presently, there are seven collection trucks. The street cleaning operation supplements the solid waste collection in the higher-density areas. The street sweepers are included in the 200-man work force.

7.1.2 Industrial Waste

For the purposes of this study, industrial waste is defined as those wastes generated by noncommercial business establishments. More specifically, those are establishments which manufacture goods. The major constituents of industrial wastes are generally paper, wood, metals, ashes, and other process wastes dependent upon the products manufactured.

Collection of these industrial wastes is not provided by the Municipality. The responsibility for collection and transportation to a final disposal site is the responsibility of the individual industry. In several cases, the waste is disposed of on land in an unsanitary manner. In other cases, waste is transported to the general dump owned by the Municipality.

7.1.3 Major Special Wastes

Major special wastes are identified separately because they represent either large quantities, health hazards, or require special handling and disposal systems. Examples of these wastes are as follows:

1. Construction and demolition waste.

2. Hospital waste.

3. Large bulky waste, such as refrigerators, appliances, and abandoned vehicles.

These items are presently being handled by the following methods:

1. Construction and demolition waste is presently collected and disposed of by the contractor associated with the construction project. The waste is generally disposed of at the municipal dump. In some isolated instances, construction waste is used as roadfill by the Municipality.

2. Hospital waste is presently collected by the municipal collection vehicles in plastic bags and disposed of at the dump. Pathological wastes are combined with other hospital wastes for disposal.

3. Large bulky materials are transported to the disposal site by their respective owners when collection vehicles cannot provide service. Animal carcasses are placed on collection trucks and transported to the dump.

7.1.4 Sludge and Septage Waste

For the purposes of this study, sludge is defined as any solid, semisolid, or liquid generated from a municipal, commercial, or industrial wastewater treatment facility. Presently, no such treatment of wastewater exists in Irbid. Septic tanks and cesspools are utilized for wastewater disposal. Existing collection of semisolid waste is from septic haulage. This operation is provided by individual and commercial concerns.

Presently, the collected septage is disposed into Wadi el Hamam in an uncontrolled manner. At one time, septage waste in Irbid was spread on farm land. During a cholera outbreak in 1977, farmers were required to turn over crops which were grown on land that had received septage waste. Since that time there has been a reluctance on the part of farmers to accept septage waste on their land.

7.2 SOLID WASTE GENERATION

To plan for the present and future management of solid waste in Irbid, it was necessary to determine waste quantities and associated characteristics.

For this study, all waste was categorized according to source as follows:

1. Residential/commercial waste.
2. Industrial waste.
3. Major special wastes.
   a. Hospital waste.
   b. Street waste and sweepings.
   c. Bulky waste.
   d. Sludge and septage waste.

As mentioned previously, Irbid does not currently have detailed waste generation or composition records for any of these categories. Without these data, it was necessary to conduct a field sampling program to survey domestic solid waste. Several meetings were held with key members of the Municipality of Irbid sanitation department. The discussion covered practices presently used in collection and disposal of solid waste. From these officials, the approximate number of waste truckloads delivered daily to the Irbid dump was determined. Knowing the capacity of each truck, an approximate daily waste rate was calculated. The following subsections discuss the various waste generation rates and compositions, as well as methods used to identify them.

7.2.1 Residential/Commercial Waste

Residential and commercial wastes are those wastes generated by the people living in the Municipality of Irbid. These waste categories typically include waste paper, food scraps, plastic containers, glass, and metal cans.

For this study, a sample program was implemented to identify the waste composition. The present waste truck capacities and dumping frequencies were also determined.

Analysis of available collection data and observation of the present collection operation were performed. The present collection system consists of seven trucks. Irbid presently has two new compaction trucks capable of hauling approximately 25 cu m tons each; two smaller compaction trucks each having 20-cu m capacity; two Dodge (noncompaction) vehicles with 25-cu m capacity; and one open dump-truck with a 5-cu m capacity. Typically, each vehicle collects and transports two to three loads to the Irbid dump daily. The estimated average number of loads collected per weekday using all seven serviceable trucks are as follows:

No. of Vehicles	Capacity	Vehicle Type	Loads Per Day	Tons Per Load	Quantity (Tons/ Day)
2	25 cu m	Compaction	2	9.07	36.29
2	20 cu m	Compaction	2	7.26	29.03
2	25 cu m	Noncompaction	2	5.44	21.77
1	5 cu m	Open dump	2	1.81	3.63
					90.72

The total waste collected was divided by the population served to calculate a waste generation factor applicable to Irbid. The 1979 population for the Municipality of Irbid is estimated at approximately 142,000 persons, and waste is collected six days per week at the rates listed.

Thus, the waste generation factor is:

$$\frac{90{,}720 \ \frac{kg}{Day}}{142{,}000 \text{ persons}} \times \frac{6 \text{ collection days}}{7 \text{ days/week}} = 0.55 \text{ kg/capita/day}$$

There may be some questions concerning the use of collection data to provide the basis for waste generation calculation. The observations of the urbanized areas of Irbid, however, indicated that the wastes generated by residential and commercial facilities are collected except for small amounts which are either directly disposed of at the dump by individuals, or those amounts which remain on isolated lots and are eaten by animals. Therefore, use of such collection data for waste generated in Irbid is justified.

Comparison of Irbid's waste generation to generation rates in Europe, the United States, and the Middle East can be made easily. It is a known fact that waste generation in the United States differs a great deal from waste generation in Western Europe. In the United States, a large percentage of paper, metals, and glass, with small percentages of food waste, are present in solid waste. In Europe, less paper and more food waste by weight is present. Similarly, the waste generated in Irbid is composed of less paper, metal, and glass than U.S. waste. Thus, the waste generated in Irbid resembles more closely waste generated in Europe.

The results obtained in our survey compared favorably with the recently determined waste rate for Amman. A study was undertaken by Amman Municipality (Watson Hawksly-ERL Consultants) which revealed approximately 0.54 kg/capita/day.

The relative affluence of a community can be related to solid waste generation. Generally, persons with higher income levels generate larger volumes of solid waste per capita. Three factors contribute to this; they are:

1. More goods will be purchased.

2. More disposable and convenient package goods will be purchased.

3. More nonessential goods will be purchased.

Since the present average income level in Irbid can be considered modest, we expect the solid waste will contain fewer packaging materials than may be expected in more affluent areas. This also means that estimating future solid waste generation rates is extremely difficult. No records have been kept for waste disposal quantities or composition for the past years. In addition, since we are starting from a different base, we expect the solid waste generation rate will increase at a different rate than that projected for the United States or Western Europe.

Solid waste generation rates can be expected to increase for a number of reasons, including:

1. Socioeconomic changes.
2. Improvement in living standards.
3. Increase in spendable income.

As mentioned in Chapter 2, we expect the population of Irbid to increase over the planning period. In addition, we expect the people of Irbid to become more affluent as the City develops as a regional center in an area experiencing increased regional development. For these reasons, we estimate the residential and commercial solid waste generation rates will increase at an annual rate of 1 percent.

7.2.2 Industrial Waste

Estimates of industrial waste were made based on interviews with major industrial plants. The major industry in Irbid is the slaughterhouse. Other industries, including a bottling company, battery company, dairy, and pencil-making factory, are expected to operate within the next year, but are not generating waste at this time.

An industrial waste generation rate was determined for the slaughterhouse waste. This is the only significant industrial waste available at the time of this study. The generation rate was developed by estimating the waste at the slaughterhouse, and dividing by the present population to determine a slaughterhouse waste generation rate of 0.02 kg/capita/day.

For this study, we have assumed a total initial industrial waste generation rate of 0.07 kg/capita/day. This rate was increased 1 percent per year through the study period, and the year 2000 industrial waste generation rate is 0.085 kg/capita/year. The industrial waste generation rate should be monitored and updated periodically.

7.2.3 Major Special Wastes

Certain solid wastes have been designated as major special wastes because they represent large quantities, health hazards, and/or require special handling and disposal systems. The major special wastes are considered to be:

1. Hospital wastes.
2. Street sweeping waste.
3. Bulky waste.
4. Sludge.

Each of these classifications requires an independent waste generation rate. The following subsections evaluate each of the categories and determine a reasonable generation rate.

7.2.3.1 Hospital Waste.

Solid waste generated by hospitals includes a substantial amount of pathological and contaminated waste that must be handled separately because of the presence of disease agents, infected tissue, and other materials.

The most significant amount of waste from a hospital is the "disposable" waste which is finding increased use throughout the world. These disposables prevent cross-infection and reduce labor costs in the hospital, but they increase the solid waste material requiring disposal.

Data on disposable waste from the hospitals in Irbid are not available. Information obtained from hospitals in other areas indicates hospital solid waste generation factors range from 4.5 kg/patient/day to 10.4 kg/patient/day with an average of 7.4 kg/patient/day. A rate of 7.4 kg/patient/day is used to estimate the hospital waste generated rate for this study.

Typically, hospital waste is characterized by having larger amounts of paper, glass, plastic, rubber, and pathological materials, but less kitchen waste than is generally exhibited in Irbid residential waste.

We have assumed the base waste generation rate will remain constant; however, in 1985 the Irbid hospital is expected to expand its facility from 200 to 600 beds.

7.2.3.2 Street Sweeping Waste.

Street refuse includes street sweeping and catch basin dirt, and contents of litter receptacles. Street waste is one of the most visible problems in any waste management system. Based on field observations and previous studies of United States cities it is estimated that the generation rate for Irbid is approximately 13 kg/capita/year.

As Irbid becomes more affluent, street litter may increase. We have assumed an increase of 1 percent per year in the generation rate for street sweeping waste over the planning period.

7.2.3.3 Bulky Waste.

This is one of the most troublesome wastes; it includes items such as refrigerators, sofas, bed springs, and junk cars. Because of their size and weight they require a special collection and handling system, and use large quantities of landfill volume due to their poor compactability. If the collection system is not organized to collect these items, they are usually disposed of by illicit dumping at any convenient location.

Estimating amounts of bulky waste is difficult because it depends on a variety of unrelated factors, and includes many different items. Data available for the United States indicate bulky waste to be approximately 10 to 20 percent of the total solid waste generated. Observations at the Irbid dump, along roadsides, and at other unofficial dump sites, reveal that appliances and abandoned automobiles are significantly fewer than typically found in the United States.

For this study, bulky waste in Irbid was estimated to be 10 percent of the residential/commercial waste, or 0.06 kg/capita/day at present. An annual increase in the generation rate of 1 percent per year is assumed over the planning period.

7.2.3.4 Sludge.

For the purposes of this study, sludge has been defined as any semisolid or liquid generated from a municipal, commercial, or industrial wastewater or water supply treatment plant. Presently, most houses in Irbid are utilizing cesspools or septic systems for sanitary waste disposal.

By the year 1983, a wastewater treatment facility will be operational. It is anticipated that approximately 80 cu m of sludge per day will be generated by 1990. By the year 2000, the daily sludge production rate is expected to increase to 120 cu m/day.

7.2.3.5 Summary of Waste Generation.

Annual solid waste load projections for Irbid over the period 1980 to 2000 are summarized in Table 7-1 at five-year intervals. Figures 7-1 and 7-2 graphically present the percentage total for each of the waste categories described for the years 1980 and 2000.

7.2.4 Waste Composition

Residential/commercial waste is generally composed of paper, food wastes, and many types of packaging, including paper, plastic, glass, and cans. Table 7-2 lists waste composition generally found in the United States.

Table 7-1

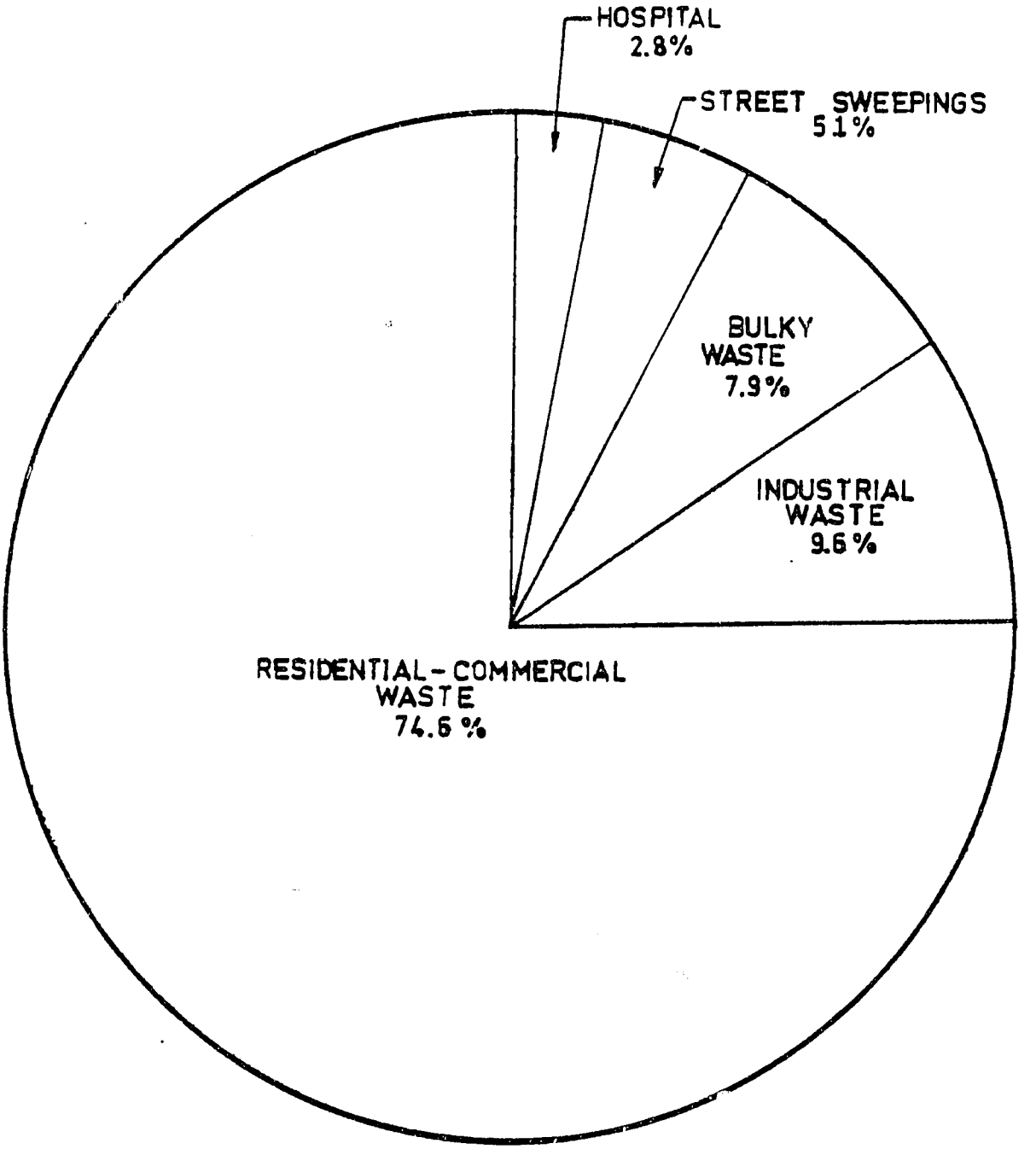
Summary of Projected Wasteloads
(Metric Tons/Year)

Waste Type	1980	1985	1990	1995	2000
Residential/commercial[1]	32,100	42,300	54,000	69,000	88,000
Industrial (including slaughterhouse)[1]	4,100	5,400	6,800	8,800	11,200
Litter and street sweepings[1]	2,200	2,700	3,200	4,600	5,900
Hospital (7.4 kg/patient/day)	1,200	2,700	2,800	3,000	3,000
Bulky waste (0.06 kg/capita/day)	3,350	4,200	5,300	6,400	7,750
Sludge (dry solids)	-	4,600	5,800	7,000	8,500

[1] 1% annual increase of refuse generated.

Note: All quantities are rounded to nearest 100 tons.

Metric ton = 2,205 pounds or 10 cu kg.



WASTE COMPOSITION BY CATEGORY IN IRBID, 1980 (BY WEIGHT)

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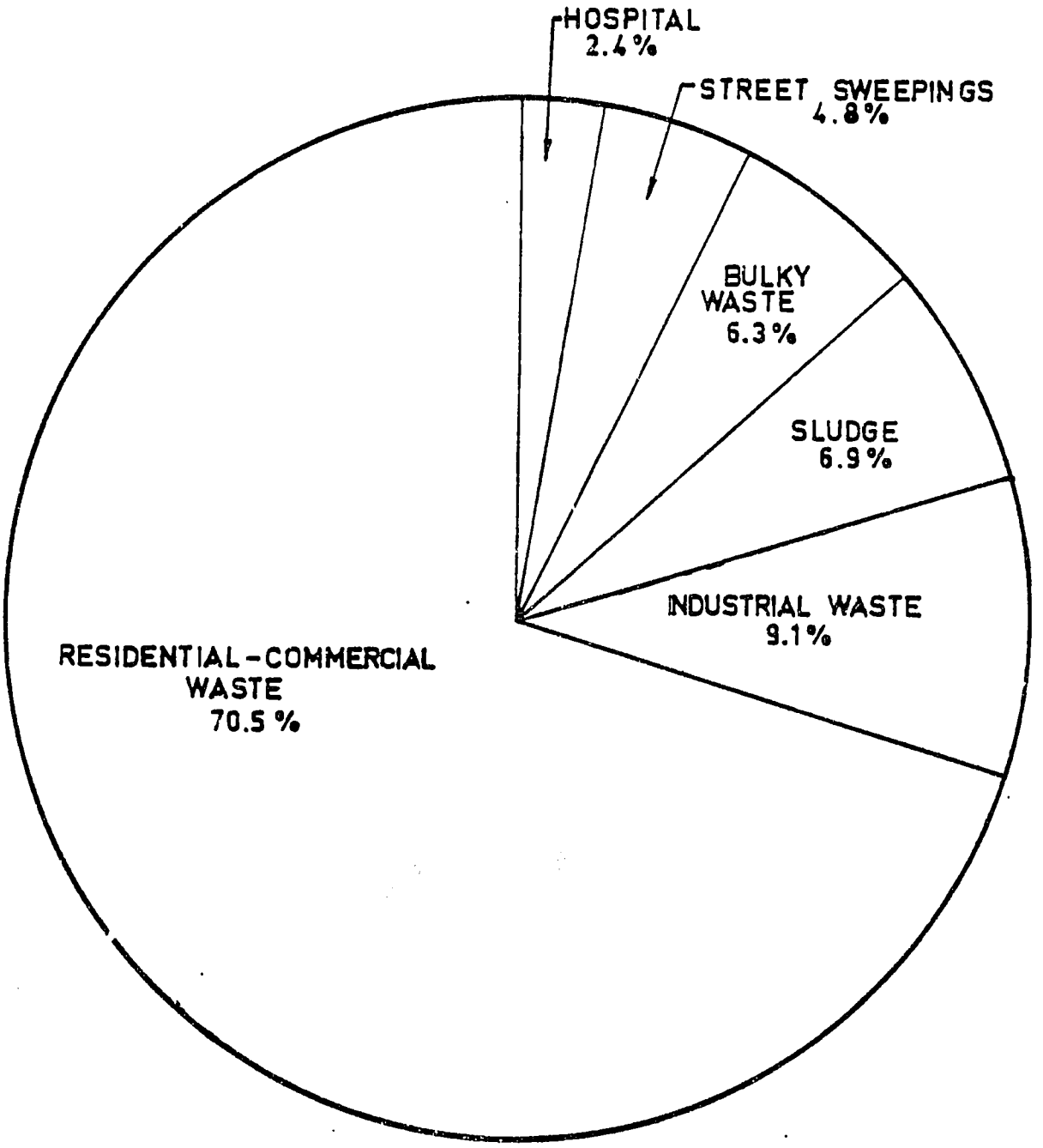
WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 7 –
		DATE: SEPT. 1979 / BY: A.TA / CHECKED P. J. H



WASTE COMPOSITION BY CATEGORY IN IRBID, 2000 (BY WEIGHT)

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT 334	FIGURE 7 - 2 DATE: SEPT. 1979 BY: A. TAYEH CHECKED: P. J. H.

Table 7-2

Residential/Commercial Waste Composition
(Dry Weight)

Constituent	% Weight U.S.A.[1]	% Weight Irbid[2]
Paper	48	34
Glass	6	0.3
Metals	8	0.4
Garbage, yard waste	25	63
Miscellaneous (ash, stone, grit)	8	2
Rage, wood, etc.	5	-[3]
	100	100

[1] Data from nine separate studies, 300 samples, United States Public Health Service, 1968.

[2] Sampling program, Weston International, 1979.

[3] Negligible.

Since the general composition of Irbid waste differs from the United States and European observations, it was decided to conduct a sampling program to determine the composition of solid waste in Irbid.

Fifteen samples, each weighing approximately 10 kg, were removed at random from the general collection system. The samples included trash from each zone. The samples were obtained by driving through the Municipality and removing solid waste, waiting for collection from typical collection points. After the samples were gathered they were weighed. Each sample was sorted into constituents, and each constituent (paper, glass, metal, food waste, etc.) was weighed and the results recorded. Several samples were sent for analysis to the Royal Scientific Society Laboratory in Amman to determine average moisture, ash, and nitrogen content.

The results of the sampling program were compiled and analyzed. The samples were averaged, by weight, for paper, metals, glass, food waste, etc. The results compared favorably with our field observations made during July and August 1979. Table 7-2 lists the average waste composition results of the 15 samples analyzed. Preliminary chemical analyses are presented in Table 7-3. It should be noted that Tables 7-2 and 7-3 are only preliminary, and are to be used only as a guide because they are derived from a limited sampling program. It is generally recognized that a sampling program should continue for an extended period, as long as a year, to establish reliable data. This extended sampling can easily be accomplished once a permanent disposal system is operational.

Table 7-3

Residential/Commercial Waste
Chemical Composition

Wet Basis	U.S.A.			Irbid		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Measure						
% Moisture	20	60	38	35	67	51
% Nitrogen	0.2	3.0	1.0	-[3]	-	-
Btu/lb	3,000	6,000	4,500	-	-	-
Dry Basis						
% Ash	4	9	6.5	19	61	40
% Nitrogen	0.3	5.0	1.0	1.41	6.5	7.9

[1] Data from United States Public Health Service, 1968.

[2] Data from Irbid sampling program, Weston International, 1979. Laboratory analyses by Royal Scientific Society Laboratories.

[3] Not measured.

7.3 FORMULATION OF ALTERNATIVES

In a solid waste system (i.e., collection, storage, and disposal), the disposal element is the most crucial in that its selection will guide the design and management of each of the other elements. Therefore, the formulation and identification of various alternative disposal elements is necessary as a first step in solid waste management.

The following subsections describe the available alternatives for each element of a solid waste management system. The approach used in selecting preliminary alternatives requires a step-by-step procedure which includes:

1. Identifying the field of candidate collection, storage, and disposal systems available.

2. Selecting particular technologies through preliminary screening processes, and defining the "best" waste collection system.

3. Evaluating each approach and the associated technology against a specific list of selection criteria.

Figure 7-3 and the following discussion delineate the available alternatives for Irbid.

7.3.1 Disposal Alternatives

A most significant fact that develops when identifying solid waste disposal alternatives is that ultimately land disposal will be required regardless of the intermediate steps which may be used to reduce the waste volume prior to its eventual disposal. The objective of the disposal system selection process is to select a disposal strategy which cost-effectively minimizes land requirements and provides long-term disposal capacity at minimum cost.

Disposal capacity requirements can be minimized through a number of general approaches, as follows:

1. Reduce waste generation.
2. Recover energy/material resources.
3. Maximize utilization of land resources.

7.3.1.1 Reduce Waste Generation.

The ability to reduce waste generation rates is beyond the influence of the local community since the rate of waste generation is influenced by packaging practices designed to service national distributor markets. In fact, we expect waste generation rates in Irbid to increase as the community increases in affluence.

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7.3.1.2 Recover Energy/Material Resources.

The volume of solid waste to be disposed of can be reduced by removing certain reusable components from the waste stream, and disposing of only the residues and nonrecyclables in a land disposal site. Recovery of energy and material resources can be accomplished through:

1. Source materials recovery.
2. Post-consumer materials recovery.
3. Energy recovery.

Source separation of materials requires separation, at the home, of key components of municipal solid waste. Collection is accomplished using compartmented collection vehicles or separate vehicles for each component.

Source separation is currently emerging as a reasonable approach to waste reduction. In situations where high population density, available markets, and controlled refuse collection exist, separate collection of recyclable components at the curb may be feasible. Source separation, however, is in the developmental stage, and little significant information is available to support source separation as the key long-term disposal strategy for Irbid.

Post-consumer materials recovery at a processing center can also be considered. Shredding of solid waste, followed by ferrous (magnetic) materials recovery, is technologically feasible; however, it cannot be justified economically unless considered an adjunct to a more comprehensive system such as energy recovery or shredfilling which is described later.

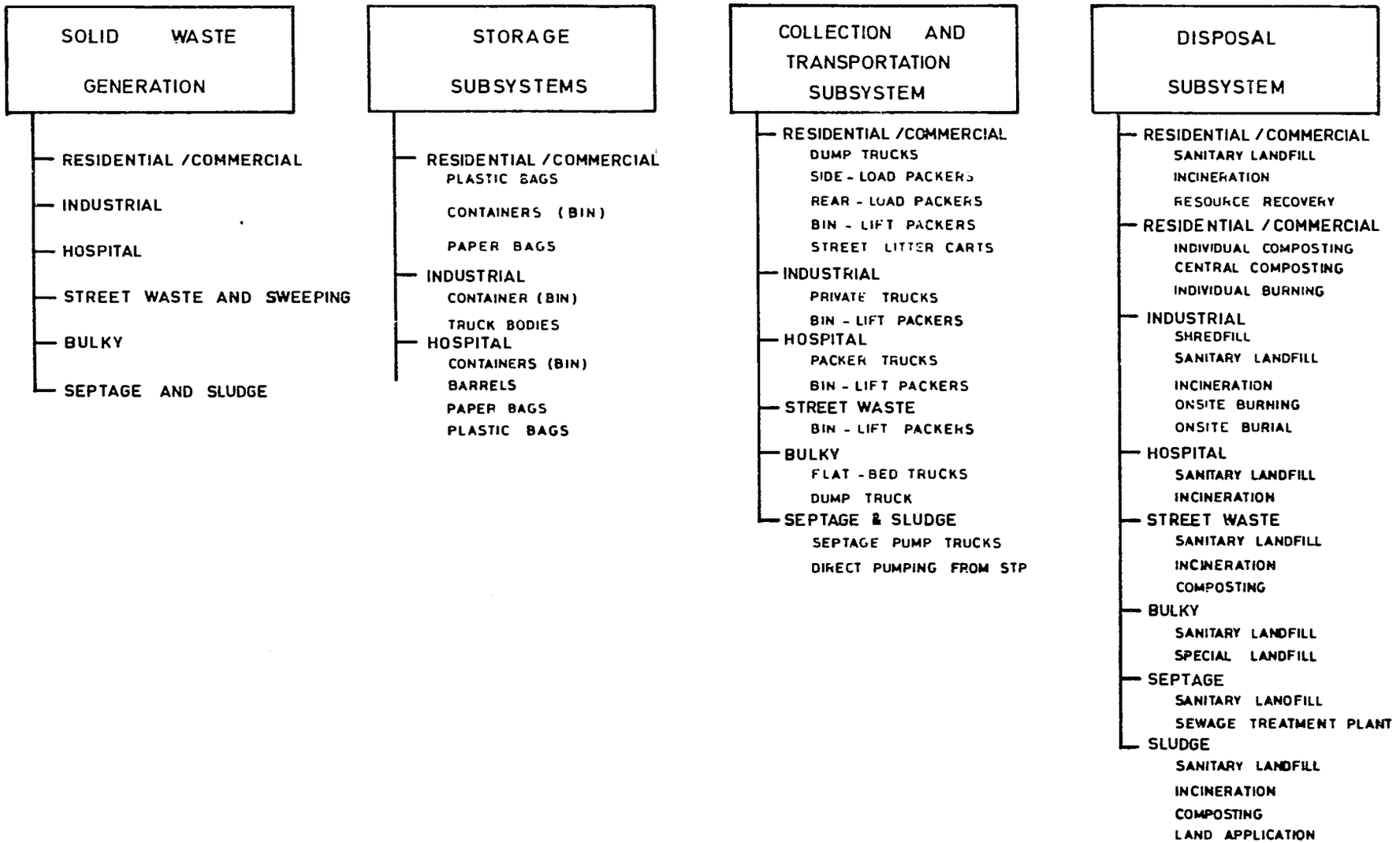
The recovery of glass or aluminum is currently being tested at several facilities in the United States including: Baltimore, Maryland; Franklin, Ohio; and New Orleans, Louisiana. The technology is experimental, and is subject to further development and documentation.

The processes which have been developed, theorized, or otherwise proposed to recover the energy value of refuse can be divided into:

1. Mechanical processes -- Including combinations of several stages of shredding, cleaning, refining, and storing; these are designed to produce a homogeneous marketable fuel.

2. Thermal processes -- Including combustion, pyrolysis, or combinations of the two; these are designed to produce steam or gaseous and liquid fuels.

3. Biological processes -- Including the use of anaerobic microorganisms to digest organic materials and produce methane gas.



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	GRAPHIC LISTING OF SOLID WASTE MANAGEMENT ALTERNATIVE	FIGURE 7-3 DATE SEPT., 1979 BY A. TAYEH CHECKED P. J. H.

This type of classification of processes poses many problems in that each of these processes may require any of the others as a preliminary or final step.

A more convenient method classifies the assortment of technology based upon its principal end-products, i.e., the energy which constitutes the principal energy-based source of revenue.

Table 7-4 lists 15 energy recovery technologies which represent a wide range of reasonable systems.

1. Steam Generation.

The generation of steam through nonpyrolytic systems is the most common of all waste-to-energy technologies. The practice of heat recovery from refuse is widespread throughout Europe with over 50 plants reportedly in operation (Table 7-5). North American practice is somewhat more limited, with nine plants currently reported in operation (Table 7-6). Each of these plants utilizes the mass burning or semisuspension technique of refuse firing.

Heat recovery incineration using modular techniques is generally adaptable to smaller communities generating less than 400 tons/day. Scores of units are reportedly in operation in industrial locations.

Steam generation using pyrolytic techniques is not developed on a commercial basis at this time. There are no successful full-scale systems in operation in North America.

2. Electric Power Generation.

The production of electric power for external use, i.e., sale to an electrical utility grid or specific client, requires the initial step of steam generation in large quantities at relatively high temperatures and pressures in order to achieve efficient production of electrical power. High efficiency is not achieved using municipal refuse because of resulting corrosion problems. Additionally, Irbid's solid waste load is too low to achieve any reasonable economies of scale for electric power production.

Electric power production for internal use in a plant generating steam for export, however, can be considered.

3. Dry Fuel Production.

The production of a solid fuel from refuse can be accomplished through several techniques, using proprietary and nonproprietary designs. A number of systems have been demonstrated to a reasonable degree, and are in some stage of implementation.

The concept of mechanically-processed dry fuel production was not considered suitable for further evaluation by Irbid as part of the overall solid waste disposal plan due to the lack of large energy users.

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Table 7-4

Energy Recovery Technologies
Classified by Type of Energy Product

Steam Generation

1. Heat recovery incineration (mass burning).
2. Heat recovery incineration (semisuspension).
3. Heat recovery incineration (modular).
4. Pyrolysis incineration (Monsanto-Landgard).
5. Pyrolysis incineration (Andco-Torrax).

Electric Power Generation

1. Steam generation; steam turbine.
2. Gas turbine.

Dry Fuel Production

1. Refuse derived fuel -- RDF (cofiring).
2. Refuse derived fuel -- 100% RDF.
3. Chemically-processed fuel (Combustion Equipment Associates).
4. Wet pulped fuel (Black-Clawson).

Gaseous Fuel Production

1. Pyrolysis incineration (Union Carbide-Purox).
2. Methane from landfills.
3. Anaerobic digestion.

Liquid Fuel Production

1. Pyrolysis (Occidental Petroleum).

Table 7-5

Typical European Steam-Producing Incineration Plants

Country	No. of Plants	Total Capacity (tpd)[1]
Germany	20	8,820
Switzerland	10	2,510
Netherlands	2	1,000
Austria	1	400
Sweden	4	990
France	7	5,110
England	3	1,000
Soviet Union	1	220
Italy	2	490
Finland	2	220
Norway	1	170

Table 7-6

North American Mass-Burning Plants (Refuse to Energy)

Location	Start-Up Date	Capacity (tpd)[1] No. of Furnaces x Unit Capacity
Braintree, Massachusetts	1971	2 x 120 = 240
Chicago, Illinois	1972	4 x 400 = 1,600
Harrisburg, Pennsylvania	1972	2 x 360 = 720
Montreal, Quebec	1971	4 x 300 = 1,200
Quebec City, Quebec	1974	4 x 250 = 1,000
Nashville, Tennessee	1974	2 x 360 = 720
Norfolk, Virginia	1967	2 x 180 = 360
Saugus, Massachusetts	1975	2 x 600 = 1,200
Portsmouth, Virginia	1976	2 x 80 = 160

[1] Short tons (907 kg/ton)

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4. Gaseous Fuel Production.

The production of gaseous fuel using the oxygen-enriched pyrolytic technique has not seen application beyond the demonstration unit in operation in South Charleston, West Virginia. Because of the lack of conclusive data on performance and nominal operating experience of the unit, and due to the relatively low solid waste tonnage generated by Irbid, the pyrolysis process should not be considered further by Irbid.

The recovery of methane from landfills is currently in developmental stages, with two projects under review in the State of California. This concept is not sufficiently developed, especially in an arid climate, for serious short-term consideration by Irbid.

The anaerobic digestion technique is also in early developmental stages under United States Department of Energy sponsorship in Pompano Beach, Florida, and should not be considered further by Irbid at this time.

5. Liquid Fuel Production.

A 200-tons/day unit is currently in preliminary operation in San Diego County, California. No significant data or experience are available to warrant further consideration by Irbid.

6. Codisposal.

The state-of-the-art of codisposal, a matching of energy recovery from solid waste disposal to the energy requirements of a large user, is inadequate at this time; however, it may be a viable option for energy recovery in the future if Irbid's development attracts a large energy user.

7.3.1.3 Optimize Utilization of Land Resources.

The final general approach to maximizing available land resources is to ensure optimum utilization of available disposal sites. This can be accomplished by:

1. Reducing volume requirements utilizing preprocessing techniques such as shredding or composting.

2. Maximizing site resources through good landfill operating practices and well-designed utilization of existing contours and fill materials.

1. Shredding.

Shredding reduces the volume of solid waste and transforms the waste into a relatively homogeneous material. Shredded waste does not attract vectors, support combustion, or cause objectionable odors. If properly operated, shredding limits littering which can be associated with land

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disposal. A benefit of shredding is the reduction in the consumption of land, and in the amount of the required cover material. Availability of cover material is a concern in Irbid, and land use optimization could be accomplished by shredding. Once shredded and compacted, the material has fewer voids than unprocessed waste. Shredding requires additional equipment and operational costs compared to direct landfill of solid waste. Shredding provides an important first step in other recovery systems. Figure 7-4 illustrates schematically a typical shredfill operation.

2. Composting.

Composting consists of the biochemical degradation of organic material, and can be utilized as a sanitary process for treating municipal waste. The end product is a humus-like material, useful as a soil conditioner.

Composting has developed into a multitude of processes. Approximately 30 processes have been developed throughout the world. All processes contain the following steps:

a. Preparation -- Sorting of bulky waste.

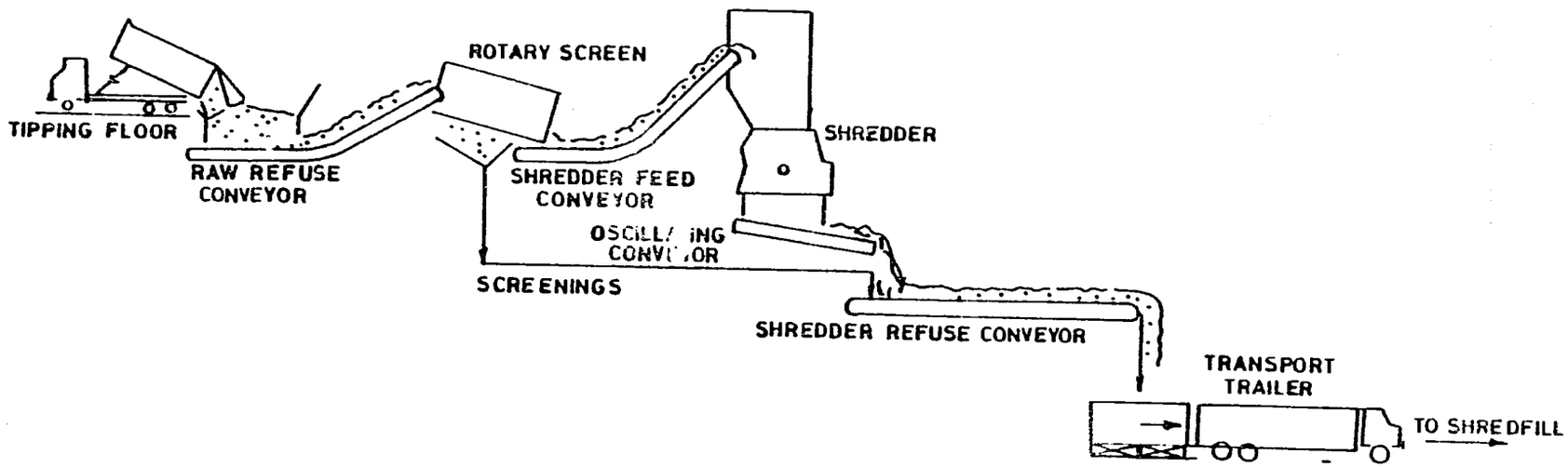
b. Composting -- Creation of an environment in which micro-organisms will decompose organics.

c. Curing -- Period where additional action takes place on cellulose and lignin.

d. Finishing -- Screening of plastics, and nonprocessed objects.

In Europe and the United States, these products are used primarily for luxury agricultural markets.

At one time Tel Aviv had the world's largest windrow plant. Both Haifa and Jerusalem at one time operated composting facilities. A recent review of these composting facilities revealed that the windrow plant at Tel Aviv has discontinued operation and is now landfilling refuse. Similarly, the compost operation in Jerusalem was discontinued, and now functions as a transfer station. The Haifa plant is reported operational. The various composting plants presently operating (or which once operated) near Jordan are as follows:



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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE	SHREDFILL OPERATION - SCHEMATIC DIAGRAM	FIGURE 7-4 DATE BY: A. TAYEH

Middle Eastern Municipal Refuse Composting Plants

Location of Plant	Type	Population Area	Year	Remarks
Tehran, Iran	Windrow	2,500,000	1970	
Tel Aviv	Windrow	100,000	1963	Not operational
Haifa	High rate -- mechanical turning	170,000	1964	
Jerusalem	High rate	120,000	1969	Not operational

Compost cannot be considered a complete fertilizer with respect to supplying required plant nutrients. A typical compost contains approximately 1 percent nitrogen, 1/4 percent phosphorus, and 1/4 percent potassium.

The major benefits of adding compost to soil are:

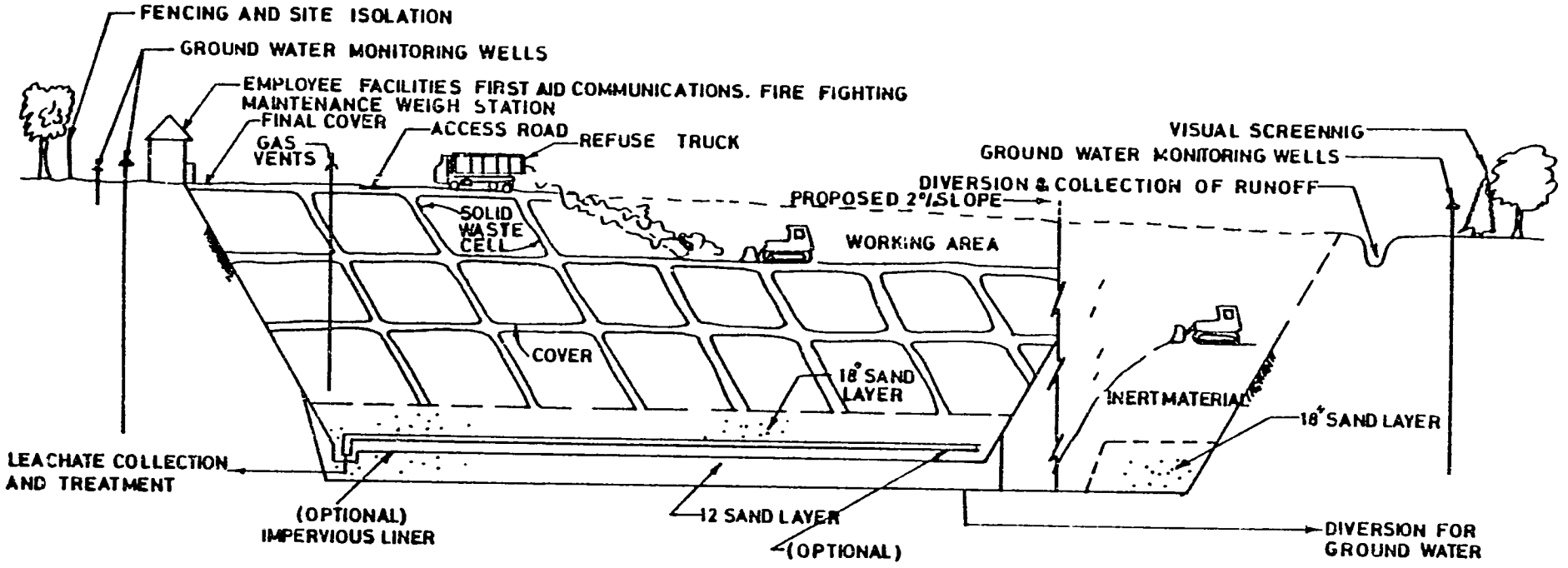
a. Improved workability.
b. Increased water-holding capacity.
c. Better erosion resistance, and reduction in water runoff.

Compost can be mixed with local soil to manufacture landfill cover material. The increased water-holding capacity and resistance to erosion are distinct benefits.

3. Landfilling.

Sanitary landfilling is presently the most economically-accepted disposal method in general use. It is extremely important that a landfill be properly designed and properly operated.

The disposal of refuse in a sanitary landfill is accomplished by burying solid waste at optimum compaction in sealed earth cells in a manner that produces a minimum impact on the environment. This method of disposal consists essentially of continuous spreading and compacting of raw refuse, and covering it with a compacted earth seal after each day's operation. The daily cover provides protection against the spread of underground fires, eliminates fly and mosquito breeding, and seals off organic waste which can be a food source for rats and other vermin. An adequate cover will also provide protection against burrowing rats. Figure 7-5 illustrates the typical cross-section of a well-operated landfill.



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE	LANDFILL OPERATION CROSS SECTIONAL PLAN	FIGURE 7-5 DATE BY: A.TAYEH

7.3.2 Collection and Storage Alternatives

After reviewing the present collection and storage system, it becomes apparent that modification to the system is required. Collection and storage of solid waste are highly important in achieving health standards and control of vectors.

As waste is generated, it must be temporarily stored, both for the residents' convenience and to await collection. Collection frequency can range from daily pick-up to weekly pick-up. The level of service required generally determines the frequency of collection. As the level of service increases, so will the frequency of collection and the respective costs.

In order to properly match the level of service with the objectives and planning criteria, it is necessary to carefully review available alternatives. The list of possible alternatives can be narrowed to a field of candidates best suited for Irbid. The following is a list of prescreened collection/storage alternatives available and applicable for this project.

1. Storage System Alternatives

   a. Manufactured portable containers.
   b. Constructed in place containers (metal and concrete).
   c. Open storage areas.

2. Collection Alternatives

   a. Private vehicles.
   b. Public collection system with trucks.
   c. Pneumatic conveyors.

7.3.2.1 Storage Systems.

It is recommended that all waste generated by residential and commercial establishments be properly stored in suitable containers to avoid adverse impacts on both health and collection system efficiency. Storage regulations should be enforced to ensure that storage practices meet the following objectives:

1. Sanitary methods.
2. Adequacy in number of containers.
3. Collection accessibility.
4. Removal convenience.

The type of storage container used depends partially on other features of the collection system. For example, where vehicles have a mechanical lift capability, containers can be heavier and larger; curbside collection may require plastic bags or small individual rigid containers. Improper storage results in litter due to blowing wind or animal attack.

Litter, in turn, promotes proliferation of flies and other vermin, and results in general unsightliness.

Since the various zones in Irbid differ physically as related to streets, it is necessary to arrange a collection system based on these various physical contraints. Many streets and alleys are not capable of handling large packer trucks or small motored vehicles.

Among storage alternatives, only major differences are apparent. When reviewing the storage containers as listed in Table 7-7, the ranking differs slightly. Very little difference exists among the functional aspects. Some storage units are penalized, however, because of greater capital costs.

Table 7-7 lists the screening method used in selecting the appropriate storage alternatives for Irbid. Many of the components used in a storage system consist of a wide variety of baskets, carts, metal and plastic containers, bags, and large metal containers.

Each component of the storage system has a particular advantage, coupled with a disadvantage. The following discussion describes the functional advantages and disadvantages for each storage method.

1. Paper or Plastic Bags.

The paper or plastic bag storage method is considered clean as well as labor saving, in that the bags are light in weight, expendable, and reduce the amount of unnecessary walking required in returning the container to the household.

There are certain disadvantages and problems associated with paper or plastic bags use, however. These storage bags require a continuous outlay of money for their purchase. The approximate cost may vary, but is generally 1 JD per 50 bags. In many cases, the long-term costs will exceed the cost for permanent containers. Plastic or paper bags tend to be fragile. Since most households will have the rubbish outdoors awaiting pick-up, the receptacles become targets for animals. They tend to be easily torn by overfilling, animals, and playing children. In observed instances, once broken the bags are generally left unattended. This results in uncontrolled scattering of the contents by blowing wind, rodents, and grazing animals.

2. Metal or Plastic Cans.

Metal cans are available in various sizes. The most common size is 120 liters, with a securing cover to prevent unwanted visits by animals. The problem associated with this type of container is that they are damaged by rough handling. They also tend to be heavier than bags, and once emptied must be returned to the respective household. Empty containers can be scattered and/or damaged by blowing winds. In some cases, the airborne cans are dangerous objects which sometime collide with vehicles, homes, and passing pedestrians.

Table 7-7

Rating of Alternative Storage and Collection Systems

Proposed Concept	Relative Cost (30)[1]	Health and Environmental Benefits (25)[1]	Efficiency (20)[1]	Technical Reliability (20)[1]	Appropriate Technology (15)[1]	Flexibility (10)[1]	Implementation Time (10)[1]	Rating Total
Storage Systems								
Container bin-system	1 (30)	3 (75)	3 (60)	3 (60)	2 (30)	3 (30)	1 (10)	295
Paper bags	2 (60)	1 (25)	2 (20)	2 (40)	2 (30)	3 (30)	3 (30)	237
Plastic bags	2 (60)	2 (50)	2 (20)	2 (40)	2 (30)	3 (30)	3 (30)	260
Metal cans	1 (30)	2 (50)	1 (20)	2 (40)	1 (15)	2 (20)	2 (20)	195
Open lots	3 (90)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	3 (30)	150
Collection Systems								
Open dump trucks	2 (60)	0 (0)	1 (20)	2 (40)	0 (0)	2 (20)	3 (30)	170
Loaders/packers	1 (30)	3 (75)	2 (40)	2 (40)	2 (30)	2 (20)	3 (30)	265
Bin-lift packers	2 (60)	3 (75)	3 (60)	2 (40)	3 (45)	2 (20)	2 (20)	320
Street litter carts	3 (90)	1 (25)	0 (0)	2 (40)	0 (0)	0 (0)	3 (30)	185
Noncompactors	2 (60)	2 (50)	1 (20)	2 (40)	2 (30)	2 (20)	3 (30)	250
Conveyor systems	0 (30)	1 (25)	3 (60)	0 (0)	0 (0)	0 (0)	1 (10)	125
Pneumatic systems	0 (30)	1 (25)	3 (60)	1 (20)	0 (0)	0 (0)	1 (10)	145

[1]Weighted factors rating points: 3 - Best, 2 - Good, 1 - Fair, 0 - Poor

Because they represent a significant investment and require proper return by the collectors, metal or plastic cans reduce the overall efficiency of the collection system.

3. Metal Bins.

Metal bins are primarily used in areas which have unusually high solid waste generation rates, or in neighborhoods having poor road access to individual residences or shops. Generally, users of these bins place their waste in smaller temporary containers (i.e., bags, disposable boxes, or sacks) prior to placement in the bins. The bins are normally located in back alleys or corner lots so that a bin-loader may have easy access.

This type of storage system is not generally cost-effective in areas that are accessible by normal rear loader compactor. The bins are most effective in areas which are not accessible to large collection units for curbside or door-to-door collection. Bins discourage attacks by animals, rodents, and unwanted pests.

Under normal conditons, metal bins can be easily collected by the mechanical lift unit. No direct contact or manual lifting by individual collectors is required. It is recommended that metal storage bins be provided in areas where door-to-door collection is difficult, and in low density areas where storage for several days may be advantageous.

4. Constructed Storage Areas.

Open constructed storage areas can be used for temporary storage where collection service is limited. This type of storage is not recommended for the following reasons:

a. Will not prevent attack on refuse by animals.

b. Would require physical construction, thereby prolonging implementation time.

c. Are inflexible.

d. Will require repair and maintenance.

5. Summary of Storage Systems.

As described previously, there are variations in storage systems. The type of storage container used depends partially on other features of the collection system, and physical constraints.

It is recommended that a combination system involving plastic bags and metal storage bins of 6-cu m capacity be utilized. It is believed that more useful containers can conserve collectors' energy, increase the speed of collection, and reduce the unsightly problem of blown and half-eaten solid waste along Irbid streets. Table 7-7 lists the various storage containers, and applies a weighted factor with respect to the screening criteria.

7.3.2.2 Collection System Alternatives.

Collection methods are influenced by the final method of disposal and vice versa. Both operations must be coordinated; e.g., some methods of disposal require separate collection for various refuse components. The cost of this separation becomes an important factor in selecting a disposal method. Furthermore, the inconvenience created by separate collection methods must be considered.

Separate collection at the household level is usually objectionable because of inconvenience. Sometimes separate collections are necessary for operating, health, and disposal purposes. For example, collection of pathogenic waste may require separate collection or storage.

Separate storage of various kinds of refuse at the source has obvious advantages. Nonetheless, separate collection increases collection costs over the cost for combined collection if the collection frequency is the same. Table 7-7 gives common practices for separation of refuse for the various disposal alternatives.

The degree to which refuse components are separated depends largely upon costs. In any method of disposal or collection, there is some degree of latitude in the amount of separation, and cost may become the deciding factor. In any disposal method, even sanitary landfill, some degree of separation must precede disposal. The separation may be mechanical or manual, and it may be complete or incomplete. For example, large bulky items which are not compactable must be separated in a sanitary landfill.

For Irbid, the collection alternatives are limited more by physical constraints than by the economics of disposal. Many areas in Irbid have limited street widths or topography. Narrow and steep alleys are not accessible to large collection trucks. Door-to-door collection in many of these areas is almost impossible because of these physical restrictions. Collection is often done by collectors walking up streets and carrying the trash to nearby lots accessible to packer trucks. In many cases, the waste will remain on these lots for several days. This may cause direct health problems in the local community.

Table 7-7 identifies several available modes of collection. Some of the alternatives use advanced technology while others rely on manual labor. Higher technology usually requires greater initial capital expenditures. Similarly, lower technology methods require less capital, but are more labor-intensive. The preliminary screening method used in Table 7-7 considers the cost, health, environmental, efficiency, and appropriate technology relationship for each alternative.

Packer trucks generally range from 11 to 23 cu m in capacity. In most cases, the manufacturers rate the compaction of the vehicles to be 2:1 or 356 kg/cu m. Many manufacturers claim higher densities can be achieved; however, in actual practice,hydraulic system maintenance can be minimized by using lower compaction pressures.

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Bin-type loaders are more sophisticated mechanically than the common packer truck. The bin loader lifts a container automatically and dumps the contents into the truck body. Once in the truck, the waste is automatically compacted in a manner similar to the packer vehicles. The advantages of such equipment are:

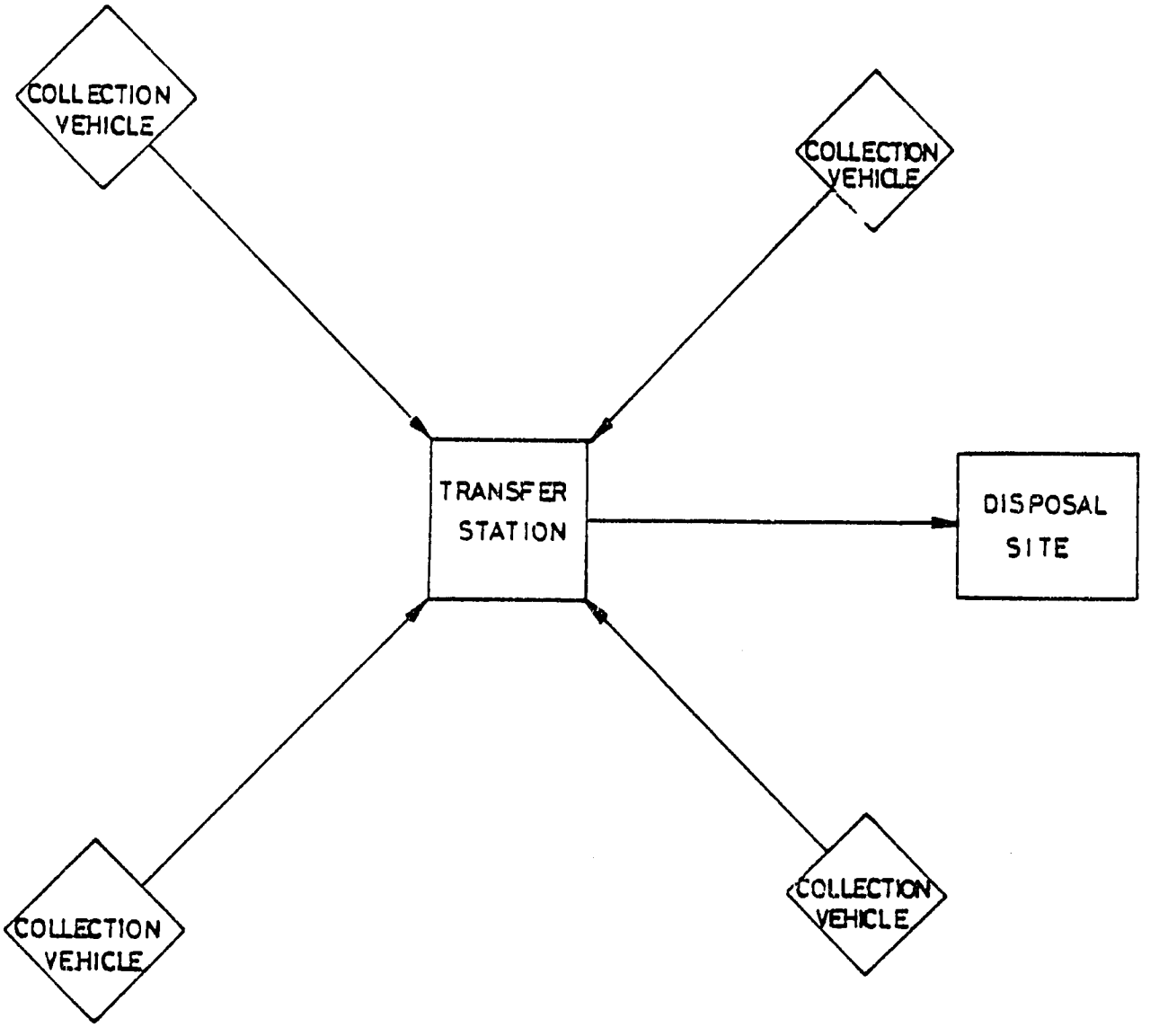
1. Fewer collectors are required per truck.
2. Greater efficiency.
3. No direct handling of solid waste by collectors.
4. Ability to load larger vehicles.

Open dump trucks have been used both in Irbid and in other communities throughout the world. The advantage offered by such a collection vehicle is the ability to collect and transport large bulky items such as construction debris, appliances, and other items difficult to compact in a standard collection vehicle. The disadvantages associated with these units for everyday collection is the lack of self compaction. The waste transported in the truck has the same density as general refuse. This requires more trips to the final disposal site. Dump trucks are a good complement to a collection system, but should not be used as the main collection vehicles.

7.3.3 Transportation System Alternatives

When the distances between the collection points and the final disposal site are great, alternative transportation systems are considered. These alternatives include evaluation of transfer stations. Transfer stations are equipment-intensive. As indicated in Figure 7-6 they provide an intermediate disposal point for collection vehicles. The transfer station further compacts solid waste from collection vehicles and loads the waste in larger vehicles (50-cu m capacity) for delivery to the final disposal site.

There are two basic types of transfer systems. The first is the direct-dump system where a collection vehicle dumps by gravity into an open-top trailer. In this case, the trailer is located under a hopper. There are several variations to this system, but the basic ideas are similar. The second type of system is one which uses a stationary compactor and/or pushpit (Figures 7-7 and 7-8). This system is most advantageous in high-volume transfer stations. It requires expensive mechanical and electrical equipment and controls. The system utilizes hydraulic pressure to obtain horizontal compaction of waste within the transfer trailers. A hydraulic-ram bulkhead travels into the body of the trailer and rams the waste against the trailer. The entire compaction operation is contained within the trailer body. Maximum payloads can be easily obtained to ensure maximum efficiency.



SIMPLIFIED BLOCK DIAGRAM
TRANSFER SYSTEM

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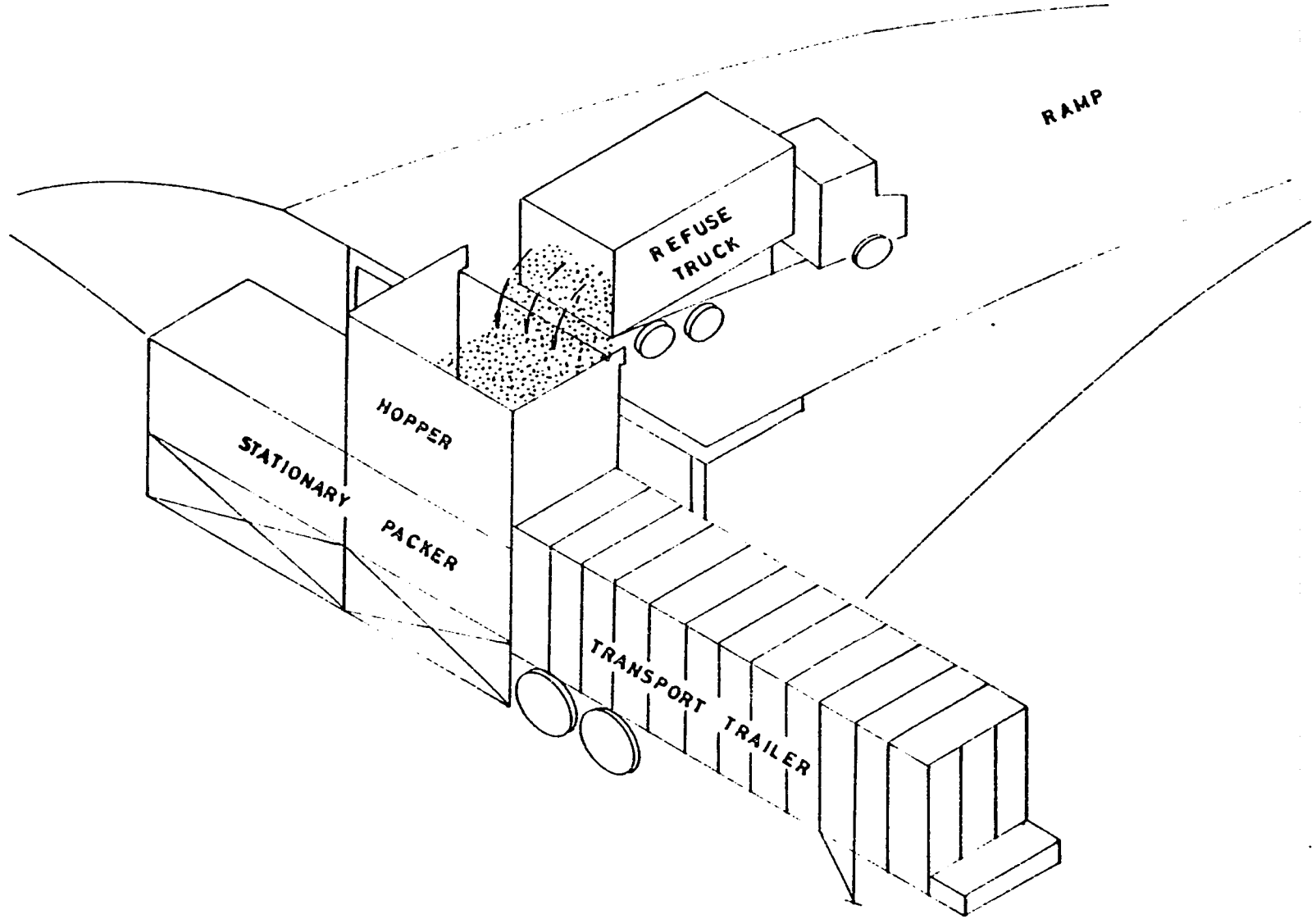
WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 7-6 DATE: SEPT. 1979 BY: A. TAYEH CHECKED: P. J. H.



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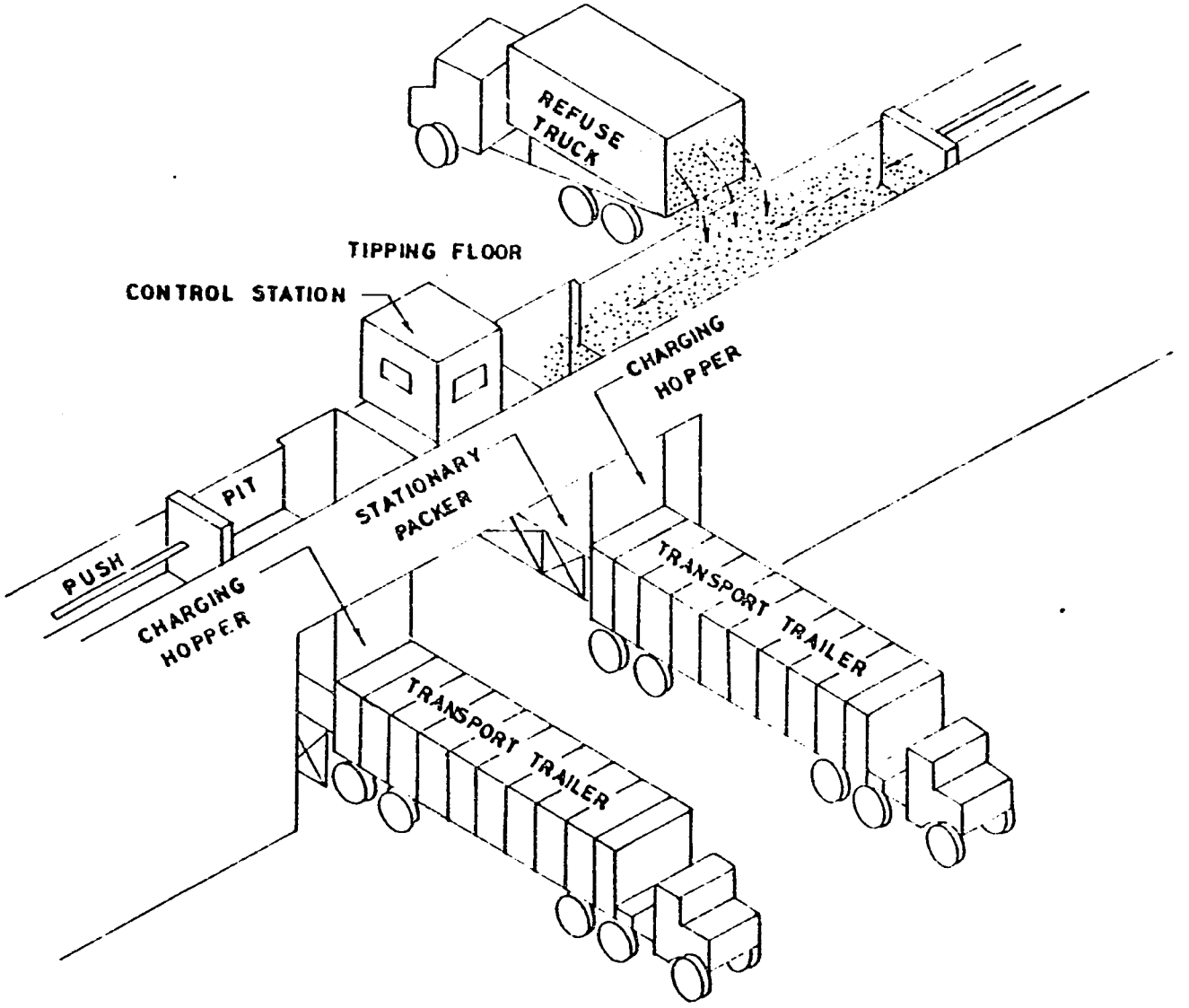
WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	50 TPD REFUSE TRANSFER STATION	FIGURE 7-7 DATE BY A.TAYEH E.R.



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co., Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	75 TPD TO 300 TPD TRANSFER STATION	FIGURE 7-8 DATE: SEPT. 1979 BY F. R. A. TAYEH CHECKED R. L. M.

Advantages of the stationary compactor system are as follows:

1. Maximum payload can be easily obtained.

2. Unloading of the trailer is fast and efficient.

3. No canvas or metal tops are required because the trailer is completely enclosed.

4. The compactor can handle nearly all bulky material which is placed in the hopper.

5. Waste receives minimum exposure because it is rapidly pushed into the sealed baler.

Disadvantages of the stationary compactor system are as follows:

1. Should the compactor fail, there is no other way to load the trailer.

2. The initial cost of the trailer is higher than open-tops.

7.3.4 Preliminary Screening of Alternatives

The objective of this screening process is to determine the combination of alternatives and technology which will provide the required level of service in Irbid at a minimal total cost and meet the planning criteria set forth in Chapter 3. To logically accomplish this task, it is necessary to carefully analyze all the available alternatives, perform comparative screening, and narrow the field of alternatives to those best suited to the conditions of Irbid. This screening is summarized in Table 7-8.

Table 7-8

Screening of Alternatives -- Summary and Evaluation

System	Disease Vectors	Air Pollution	Water Pollution	Land Use	Location	Appropriate Technology	Performance	Reliability	Flexibility	Capital Cost	Operational Cost	Management Cost	Efficiency	Revenue	Public Acceptability	Operational Skill Required	Management Skill Required	Training	Administration	Regulation	Score	Preference Ranking
Storage System																						
Bin-containers	3	3	3	3	3	2	3	3	3	1	2	2	3	-	3	2	2	2	1	1	45	2
Open areas	1	1	1	1	1	2	1	3	3	3	3	2	1	-	0	3	1	2	1	1	31	3
Plastic bags	3	3	2	2	3	1	3	3	3	2	2	2	3	-	2	3	2	2	1	1	44	1
Collection/Transport System																						
Pneumatic conveyors	3	2	2	1	1	0	1	1	1	1	1	1	3	-	1	1	1	1	2	2	26	5
Conveyor system	3	2	2	1	1	0	1	1	1	1	1	1	3	-	1	1	1	1	2	2	26	5
Packer trucks	2	2	3	3	3	3	3	3	2	3	2	2	2	-	3	3	2	2	2	2	47	2
Front-end loaders	3	2	3	3	3	3	3	3	3	2	2	2	3	-	3	3	2	2	2	2	49	1
Dump trucks	2	2	3	3	3	2	1	1	1	3	2	2	1	-	2	3	2	2	2	2	39	3
Small trucks	2	2	2	3	3	1	1	1	2	2	2	2	1	-	2	3	2	2	2	2	37	4
Disposal Systems																						
Energy recovery											Inapplicable											
Incineration	3	3	3	1	1	0	1	1	1	1	1	1	1	-	1	1	1	1	2	2	27	4
Open dump	1	1	1	1	1	1	1	-	-	2	2	2	1	-	1	1	2	2	2	2	24	5
Shredfill	3	2	3	2	1	2	2	3	2	2	1	2	3	-	1	1	1	3	2	2	39	3
Landfill	3	3	3	3	2	3	3	3	2	3	3	2	3	-	3	3	3	3	2	2	52	1
Composting	3	3	3	3	2	2	2	3	2	2	2	2	3	1	2	2	2	3	2	2	46	2

Rating system:
3 - Preferred
2 - Acceptable
1 - Unacceptable
0 - Inapplicable

7.4 EVALUATION OF ALTERNATIVES

7.4.1 Evaluation of Disposal Systems

Five alternative solid waste disposal systems were identified for consideration based upon the preliminary screening of alternatives. These alternatives are as follows:

1. No action.
2. Incineration.
3. Energy recovery.
4. Sanitary landfill.
5. Composting.

As stated previously, no matter what disposal method is finally selected, a portion of the solid waste will require final disposal on land. The disposal alternatives identified are discussed in the following subsections.

7.4.1.1 No Action.

This alternative implies continuing the open and uncontrolled dumping of solid waste at the present disposal site. This alternative is not responsive to the criteria set out in Chapter 3. It is apparent that the present solid waste disposal methods could promote environmental and public health problems.

Although the existing site is isolated from existing development, it is adjacent to the proposed permanent Yarmouk University campus. This site should not only be abandoned as an uncontrolled dump site, but action should be taken to correct the existing potential public health problems at the site.

7.4.1.2 Incineration.

Incineration is a solid waste disposal process in which wastes are converted, through controlled combustion, to a residue. Incineration is not a complete disposal method. Both residues and the gas stream produced by incineration must be properly handled. In addition to gases, a significant amount of particulate matter and effluent process water is produced. These waste products require proper disposal.

Incineration is advantageous as a waste disposal alternative operation if land is not available within economic haul distances from the refuse sources. In the case of Irbid, incineration has several advantages and disadvantages, some of which are summarized as follows:

Advantages	Disadvantages
Solid waste is reduced (volume reduction = 80%)	High capital costs
Operation can be centrally located	High operation costs
Minimum land requirements	Consumption of water (1,100-3,800 liters/ton). Wastewater must be processed.
Residue is free of degradable material	Particulate matter must be collected and disposed of

The major disadvantages to incineration for Irbid is the large capital investment, as well as the high level of operator skills required for reliable operation. This option did not receive further consideration for these reasons.

7.4.1.3 Energy Recovery.

Although energy recovery at first appears attractive, it is not viable unless the waste stream and an energy user are matched. Presently, Irbid neither produces a significant amount of waste, nor has an industrial user been able to accept energy produced from such an operation. The Municipality would be required to support the high operational costs as well as pay all capital costs associated with a recovery facility. Table 7-9 lists the costs associated with a typical 200 tons per day mass-burning energy recovery facility. In the United States and Europe, this type of facility has been demonstrated to be the least-cost energy recovery facility. The costs presented in this report are for comparison purposes. Because of the high capital costs, insufficient energy market, and scarcity of water supply, we have concluded that this is not a feasible solid waste disposal alternative for Irbid.

7.4.1.4 Landfill.

Landfill is the simplest solid waste disposal alternative available. A sanitary landfill system requires proper engineering and careful selection of a final disposal site. The overall operation is operated according to a definite plan which provides proper sequencing of landfill borrowing operations, surface and diversionary drainage, and interim, as well as final grades. There are numerous arguments for and against sanitary landfills. Listed here are some of the advantages and disadvantages associated with this alternative.

Table 7-9

Mass-Burning Energy Recovery Costs

Capital Cost	Cost (JD)
Steam plant construction and site development	2,330,000
Land costs	300,000
	2,630,000
Annual Cost	
Amortization of facility (10% - 20 years)	308,900
Disposal costs for residue	9,300
Steam Plant Operation	
Manpower (17)	49,000
Maintenance	29,600
Power	71,800
Water and sewer	12,000
Miscellaneous	15,000
Total Annual Costs	495,600

Note: If steam can be sold, an annual revenue of 90,000 JD is estimated.

Advantages	Disadvantages
Ease of operation requires less training	Public acceptance
Low operating costs	Siting constraints
Low capital costs	Dust from continuous movement of earth
Operation flexibility	Limited resources recovery potential
System operation is not affected by waste stream variations	Requires cover material
	High land use

Two basic methods of landfilling are available:

1. Trench method.
2. Area method.

In general, the trench method is used when groundwater is low or excavatable soil is more than 1.5 m deep. The trench method is best suited for flat or gently-rolling hills. The area method can be used on most types of topography, and is often used when a high water table is present or excavation is neither practical nor cost-effective.

The element common to both methods is the earth cell. Solid waste is compacted in layers, and then covered with a continuous layer of soil. Excess cover material is generally stockpiled for later use.

As noted in Tables 7-10 and 7-11, approximately 22 hectares are required to dispose of Irbid's solid waste through the year 2000 if compaction practices are used. If in-place compaction is not used, approximately 40 hectares will be required to handle the same waste volume. These estimates are based on developing the landfill to a height of 15 m in lifts of 3 m each. The estimated total landfill volume will be 2,750,000 cu m. This includes 397,000 cu m of cover material. The uncompacted landfill volume would be 5,463,000 cu m, and would require 789,000 cu m of cover material.

In selecting the landfill operating method, compaction versus noncompaction, the reduced land costs and cover material costs for the compaction alternative must be compared to the cost of purchasing, operating, maintaining, and replacing the compaction unit. Table 7-12 presents this cost comparison. From this table it is apparent that the compaction alternative requires the least total annual cost.

Table 7-10

Landfill Volume Requirements with Compaction

Year	Yearly[1] Volume (cu m)	Cumulative Landfill Volume (cu m)	Cover Volume Of Each Year (cu m)
1980	78,100	78,000	11,300
1981	81,000	159,100	11,700
1982	90,100	249,200	13,100
1983	93,900	343,100	13,600
1984	97,700	440,800	14,200
1985	104,300	545,100	15,100
1986	107,900	653,000	15,600
1987	112,800	765,800	16,400
1988	117,900	883,700	17,100
1989	123,300	1,007,000	17,900
1990	129,200	1,136,200	18,700
1991	134,200	1,270,400	19,500
1992	139,100	1,409,500	20,200
1993	144,700	1,554,200	21,000
1994	150,000	1,704,200	21,700
1995	156,300	1,860,500	22,700
1996	162,300	2,022,800	23,500
1997	168,900	2,191,700	24,500
1998	175,600	2,367,300	25,500
1999	182,700	2,550,000	26,500
2000	190,500	2,740,500[2]	27,600
		Total =	397,400

[1] Includes required cover material.

[2] Required area = 22 hectares.

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Table 7-11

Landfill Volume Requirements Without Compaction

Year	Yearly[1] Volume (cu m)	Cumulative Landfill Volume (cu m)	Cover Volume[2] Of Each Year (cu m)
1980	155,700	155,700	22,600
1981	161,500	317,200	23,400
1982	179,700	496,900	26,100
1983	187,300	684,200	27,200
1984	194,800	879,000	28,200
1985	207,900	1,086,900	30,100
1986	215,130	1,302,000	31,200
1987	224,800	1,526,800	32,600
1988	235,100	1,761,900	34,100
1989	245,700	2,007,600	35,600
1990	257,500	2,265,100	37,300
1991	267,500	2,532,600	38,800
1992	277,200	2,809,800	40,200
1993	288,500	3,098,300	41,800
1994	299,000	3,397,300	43,400
1995	311,500	3,708,800	45,200
1996	323,600	4,032,400	46,900
1997	336,600	4,369,000	48,800
1998	350,000	4,719,000	50,700
1999	364,200	5,083,200	52,800
2000	379,700	5,462,900	55,600
		Total =	789,100

[1] Includes required cover material.

[2] Required area ≈ 40 hectares.

Table 7-12

Landfill Costs

Item	Cost With Compaction (JD)	Cost Without Compaction (JD)
Capital Costs		
Sanitary landfill construction and site preparation	220,000	250,000
Land cost (1.5 JD/sq m)	330,000	600,000
Total capital cost of landfill	550,000	850,000
Equipment costs (7-year replacement period)	95,200	50,000
Total initial capital cost	645,200	1,750,000
Annual Costs		
Amortization of capital cost (20-year period, 10 percent interest)	64,000	174,000
Equipment operation and maintenance	9,400	5,000
Facility manpower	8,600	6,200
Cover material	10,000	19,800
Total annual costs	92,000	205,000

7.4.1.5 Composting.

Composting experience shows that a successful system must be selected to compliment its geographical area.

A block diagram typical of a composting system is presented in Figure 7-9. Properly practiced, composting can be a viable way to recycle organic solid waste without significantly polluting land resources. Composting is feasible but costs more than sanitary landfilling. The process is more equipment- and manpower-intensive, and requires greater operator technical expertise than landfill operation.

The problems that have prevented composting from becoming an accepted method of treating solid waste and wastewater sludge relate primarily to overstatement of the value of finished compost. Compost cannot be priced high enough to recover all of the costs required to operate the system.

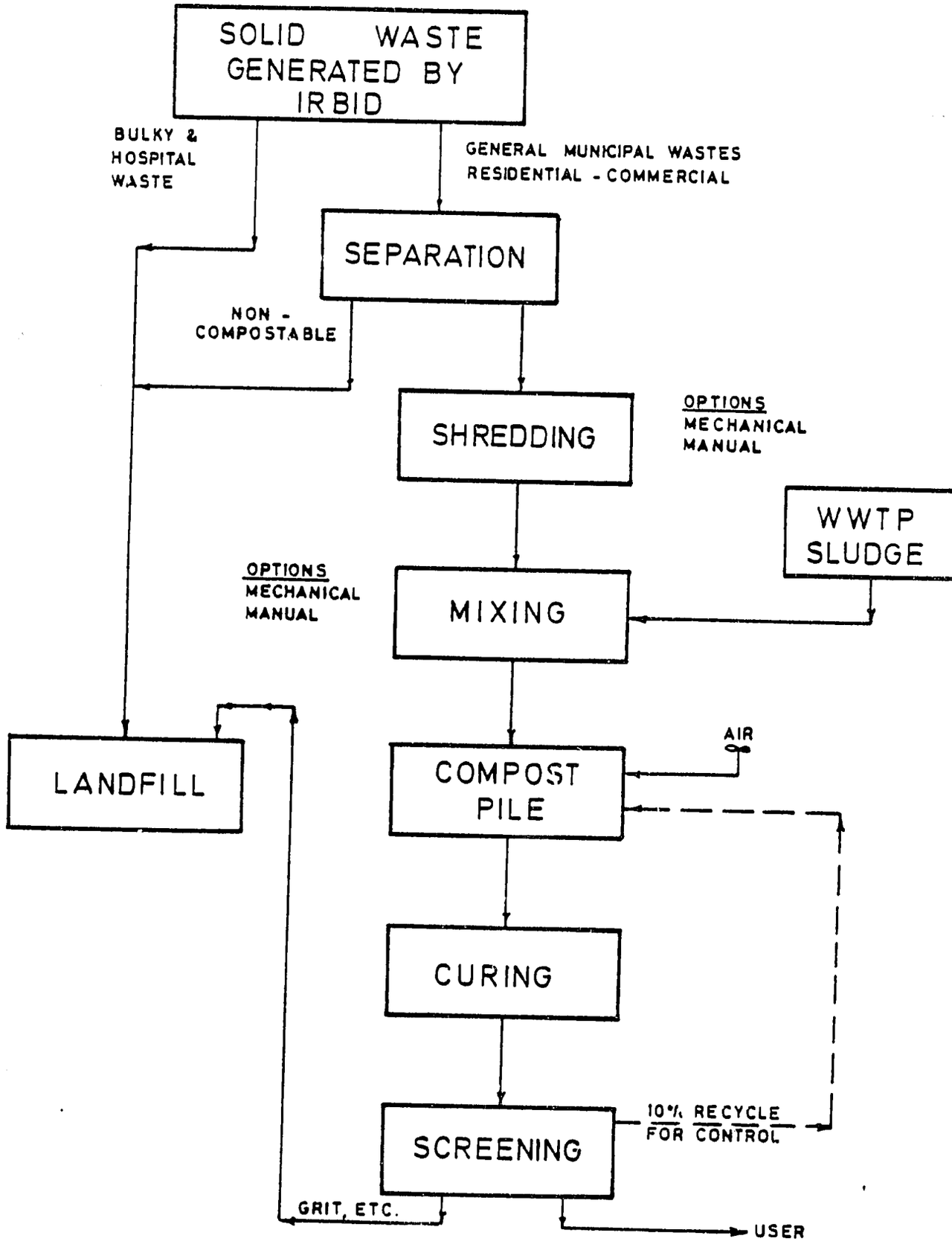
Weston attempted to seek capital and operational costs of various composting facilities in the Middle East. Unfortunately, little data are available. Many of the facilities mentioned in technical literature are no longer operational.

Considering these facts, it was decided to present costs derived from existing windrow and enclosed high-rate composting facilities in the United States in this evaluation. The costs have been monitored and documented by the USEPA. Table 7-13 delineates costs associated with a windrow system being operated in Johnson City, Tennessee. The costs are presented in Jordanian dinars. When comparing the facility costs of the various size units, it can be seen that a definite savings is achieved by economies of scale.

The cost of composting refuse may be reduced by sale of the final product. The sale price for compost depends on the benefits obtained by the user, and the amount the customer is willing to pay.

Since the compost volume is approximately 50 percent of incoming waste volume, and possible sale price of compost could be 1 to 2 JD/ton, the revenue from the sale of compost would be approximately 1/2 to 1 JD/ton of incoming raw refuse. Of course, a demand for compost is required before it can be sold.

Many enclosed digestion composting plants have been operated in the United States. Enclosed digestion plants are similar to windrow plants. Both systems require storage of compost for curing and stockpiling. Capital costs for an enclosed digester plant is approximately 60 percent higher than for a windrow plant because of equipment costs and construction complexity.



SIMPLIFIED BLOCK DIAGRAM - COMPOSTING SYSTEM

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 7 - DATE: SEPT. 1979 BY: A. TAY CHECKED:

Table 7-13

Estimated Capital Costs for Windrow Composting Facility

Item of Cost	47 Tons/Day (Plant-1 Shift) JD	45 Tons/Day (1 Shift) JD	90 Tons/Day (45 Tons/Day 2 Shifts) JD	90 Tons/Day (1 Shift) JD	180 Tons/Day (90 Tons/Day, 2 Shifts) JD
Building	111,600	63,600	70,000	70,000	76,100
Equipment	140,400	146,300	146,300	184,000	184,000
Site Development	38,400	38,400	38,400	46,100	46,100
Land Costs	2,300	2,500	3,800	3,800	6,400
Total Capital Costs (1971)	292,700	250,800	258,500	303,900	312,600
Operations and Maintenance	40,000	53,800	82,710	78,100	137,100
Amortization (10% - 20 years)	34,400	29,500	30,400	35,700	36,700
Total Annual Cost	74,400	83,300	113,110	113,800	173,800

Table 7-14 presents estimated costs for a typical windrow composting facility in Irbid. The estimated capital costs include site development, equipment costs, and site preparation for a landfill to accept uncompostable waste. These costs compare favorably to plants presently operating in the United States. Costs in the United States for a windrow plant range from 1 JD to 7 JD/ton.

At this time, composting cannot economically compete with sanitary landfilling when net costs are compared. Composting offers a number of noncost advantages however. Some of the benefits derived by composting are:

1. Reduction in disposable volume.

2. Final product is more attractive in appearance than refuse.

3. Generates less odor than landfilling.

4. Requires less cover than a landfill.

5. Pathogenic bacteria are destroyed because of elevated temperatures.

6. Provides a usable end product.

7.4.1.6 Selected Disposal Alternatives.

The costs for the solid waste disposal alternatives considered for Irbid are presented in Table 7-15. The sanitary landfill alternative is most economical. Consequently we recommend that a sanitary landfill be constructed to dispose of Irbid's solid waste during the study period. In addition, we recommend that a pilot composting facility be developed to determine the viability and true economics of a composting operation in the Irbid area.

Composting is a viable solid waste disposal alternative for Irbid second only to landfill disposal at this time. Composting provides additional benefits in that it allows for the reuse or recycling of solid waste, reduces the amount of land required for the ultimate disposal of solid waste, and produces a useful soil conditioner. It is possible that a future market could be developed for the sale of compost in the Irbid area.

Accordingly, we feel that a pilot composting facility should be set up in addition to the ongoing landfill operation. This is recommended because it will allow Irbid to assess the long-term viability of composting without large capital investments. Since landfilling is a flexible alternative, it can be modified or phased accordingly if composting does indeed prove successful.

Table 7-14

Estimated Costs of Composting Facility for Irbid
(150 Tons/Day)

	JD
Capital Cost	
Site construction and equipment	2,380,000
Annual Costs	
Amortization at 10%	279,600
Labor (9 men)	14,600
Power	36,600
Maintenance	54,900
Overhead	11,000
Total annual costs	396,700

Cost per ton	7.25 JD
Estimated sale	1.00 JD
Net cost per ton	6.25 JD

Table 7-15

Solid Waste Disposal Alternatives -- Costs

Proposed Concept	Total Annual Costs	Estimated Cost Per Ton	Revenues Per Ton (Incoming Waste)	Net Cost Per Ton
No Action		Not recommended		
Incineration		Not recommended		
Energy recovery	495,600	9.70	1.76[1]	7.94
Landfilling	92,000	1.80	N/A	1.80
Composting	396,700	7.70	1.0[2]	6.70

[1] Assuming a market exists for steam, producing an essential annual revenue of 90,000 JD.

[2] Assuming an estimated compost sale of 51,000 JD/year.

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The pilot composting facility can be developed on the unused area of the proposed landfill. This will avoid additional and unnecessary capital expenditures for land. If compost cannot be sold, it can be mixed with the daily cover material to increase the moisture retention capacity of the soil, as well as improve and enhance vegetation growth. As mentioned, vegetation is important in a landfill operation as an aid in preventing erosion.

If composting proves effective, it can be developed according to the demand. A pilot plant will allow all concerned to gain experience in refuse composting. Approximately 40,000 JD is the estimated cost of such a plant. The cost considers using some mechanical equipment in a dual role. For example, a rubber tire or track loader may be utilized at both the landfill operation as well as the pilot composting facility. It is suggested that the pilot facility be set up to handle 10 tons of refuse in a nonmechanical-type system. This system will require hand picking, and mixing with a loader. It is suggested that 10 blowers, each approximately 1/2 hp, be supplied to draw air for the digestion cycle.

The pilot plant will demonstrate and answer five specific questions:

1. Can optimum moisture be maintained in an arid climate?

2. How efficient is a typical composting plant in Jordan?

3. What are the attitudes of the residents toward using compost?

4. What are the values of composting to agriculture in the Irbid area?

5. What are the market demands for compost?

Once the results and operational costs have been reviewed, a final judgement on the use of a compost process in Irbid can be made. Until that time, it is recommended that composting not be considered as a final disposal system.

7.4.2 Evaluation of Storage and Collection Alternatives

The preliminary screening indicates only minor differences between the storage and collection alternatives, except for those alternatives using open storage. Open storage should be avoided for public health reasons.

Table 7-16 shows a recommended storage and collection scheme developed using a combination of metal bins with mechanical pick-up and curbside collection with storage in plastic bags and metal cans. Metal bins are proposed in areas that are not amenable to curbside collection. Metal cans should be used by commercial establishments, and should be provided by the establishments at their own cost. Paper bags should not be allowed for curbside collection as these bags tend to absorb moisture and break.

It is recommended that compaction trucks be utilized for general collection, and a dump truck for large bulky items. Noncompaction vehicles (two are presently used) should be phased out and replaced by front-end bin loaders which can accommodate the various metal bins. This mechanical method of lifting metal bins will reduce contact by collection personnel with the garbage. It also allows pick-up flexibility. As growth patterns change, collection points can be rearranged to suit the required needs. A front-end bin loading collection truck can lift an 8-cu m container (approximately 1,100 kgs when full) in about 15 seconds. If done by a collector, this would require lifting about 36 sacks, taking 30 seconds per sack, or a total of 15 minutes.

Collection and transport of industrial waste from large industries should be the responsibility of the individual plants. This is justified by the special requirements often necessary to handle industrial solid waste. It would not be economical for the Municipality of Irbid to provide special service unless there are other uses for the same equipment productively employed.

Hospital waste collection should be treated separately because it contains pathological matter. The overriding criteria for hospital waste are avoidance of disease vectors, and avoidance of contamination of collectors, collection containers, and truck bodies. It is recommended that the hospitals process pathological waste by incineration prior to collection. Kitchen waste from hospitals can be stored and collected in metal bins with the general collection.

Few alternatives exist for bulky waste collection. A dump truck generally is best suited for this task because of the variety of items it can hold and transport.

Table 7-17 provides a list of the manpower required to effectively collect the street waste in Irbid.

Table 7-16

Collection of Irbid's Residential/Commercial Waste

Subarea	Estimated Population (x 10^3)	Frequency of Collection	Type Collection	Estimated Daily Waste (kg)	Waste Collected Per Collection Day (kg)	No. of Truck-loads Per Day	Collection[1] Day of Week	No. of Containers Required
A-1	3.7	Twice/week	Curbside	2,035	7,100	1-25 cu yd	1,4	
A-2	2.6	Twice/week	Curbside	1,430	5,000	1-25 cu yd	1,4	
A-25	0.6	Twice/week	Curbside	300	1,000	1-25 cu yd	1,4	
Army Camp	1.5	Twice/week	Container	825	2,900	1-FEL[2]	3,6	
	Total Waste			4,590	16,000			
B-1	14.8	3 times/week	Containers and Curbside	8,100	18,900	1-FEL 1-25 cu yd	2,4,6	
B-2	6.5	3 times/week	Curbside	3,600	8,200	1-30 cu yd	1,3,5	
B-3	6.5	3 times/week	Curbside	3,600	8,200	1-30 cu yd	2,4,6	
B-4	7.3	3 times/week	Curbside	4,000	9,333	1-30 cu yd	2,4,6	
	Total Waste			19,300	56,133			
C-1	10.0	3 times/week	Containers	5,600	13,100	2-25 cu yd	1,3,5	18
C-2	1.1	Twice/week	Curbside	600	1,400	1-25 cu yd	1,4	
C-3	15.7	3 times/week	Containers	8,600	20,100	3-FEL	2,4,6	28
C-4	12.3	3 times/week	Containers	6,800	15,900	2-FEL	1,3,5	22
C-5	6.5	3 times/week	Curbside	3,600	8,400	1-25 cu yd	1,3,5	
D	14.3	3 times/week	Containers and Curbside	7,900	18,400	1-FEL 1-25 cu yd	1,3,5	13
E	28.6	3 times/week	Curbside	15,700	27,600	5-25 cu yd	2,4,6	
Refugee Camp	16.0	3 times/week	Container	8,800	10,533	3-FEL	3-FEL	28
						Total Containers	=	92

[1] Days = 1,2, --- 6 (6 days of waste collection).

[2] FEL = Front-end loader.

Table 7-17

Street Sweeping Areas and Manpower

Subarea	Area (sq km)	Non-street Area (sq km)	Street Area (sq km)	Percent Effective (%)	Effective Street Area (sq km)	Street Length (km)[1]	Manpower Required
A-1	4.1	3.1	1.0	10	0.1	6	3
A-2	1.3	0.9	0.3	70	0.21	14.4	7
Yarmouk Uni.	0.4	0.3	0.1	0	0	0	0
B-4	3.1	2.3	0.8	90	0.72	49	25
C-1	1.7	1.3	0.4	50	0.20	13.7	7
C-2	1.7	1.3	0.4	0	0	0	0
C-3	1.6	1.2	0.4	60	0.24	16.4	8
C-4	1.9	1.5	0.4	70	0.28	19.2	10
C-5	0.4	0.3	0.1	80	0.08	20.5	10
D	0.5	0.4	0.1	100	0.3	20.5[3]	20
E	0.8	0.6	0.2	100	0.2	14[3]	14
Refugee Camp	0.2	0.15	0.05	100	0.05	3.4	2
						Total =	103 men

[1] Assuming average width is 14.6 m: 1.0 m x 14.6 m = 14.6 sq m = 0.0146 sq km/m.

[2] 0.24 km both sides per hour times 8 hours = 2.0 km/day.

[3] Productivity in D and E areas is 1.0 km/day.

7.5 RECOMMENDED SOLID WASTE DISPOSAL PLAN

The following subsection describes the recommended plan and represents an optimum comprehensive solution to the existing solid waste disposal problem in Irbid. This recommendation ensures adequate management of the solid waste disposal system.

It is our recommendation that all functions related to solid waste be consolidated under one office. Figure 7-10 graphically represents the management and basic structure for solid waste management. The solid waste department should be assigned sufficient regulatory power to enable it to function properly and support the system in a manner beneficial to the community.

The collection and storage system should be as outlined in subsection 7.4.2.

The collection schedules and street sweeping manpower requirements presented in subsection 7.4.2 are estimated requirements to serve 1980 development. These requirements should be reviewed periodically and revised as the City develops over the planning period.

7.5.1 Sanitary Landfill

The recommended method for ultimate disposal of solid waste in Irbid is at a central state-of-the-art sanitary landfill, properly designed and operated. The sanitary landfill will be approximately 22 hectares in area, and designed using the best available technology, complete with all required environmental controls. Significant environmental controls include gas monitoring and venting, and leachate collection, as well as erosion and sedimentation control.

7.5.1.1 Construction.

Gas venting and monitoring will be accomplished by the installation of a gas collection system with point venting at specified locations. On a weekly basis, landfill personnel should measure the explosive level (if any) of gases present at each vent point. On a bi-annual basis, grab samples should be obtained and analyzed to properly identify the constituents vented.

Erosion and sedimentation controls will be designed into the landfill operation. Proper grading, seeding, and maintenance of the landfill cover are of vital importance to erosion control, and minimize the quantity of precipitation which could infiltrate into the landfill.

Diversion ditches will be engineered to intercept and transport the surface run-off to a retention pond. The objective of proper surface grading, ditching, and seeding is to prevent precipitation from ponding on the surface of the landfill, yet have slopes gentle enough and protected enough to prevent erosion. The retention pond serves a dual

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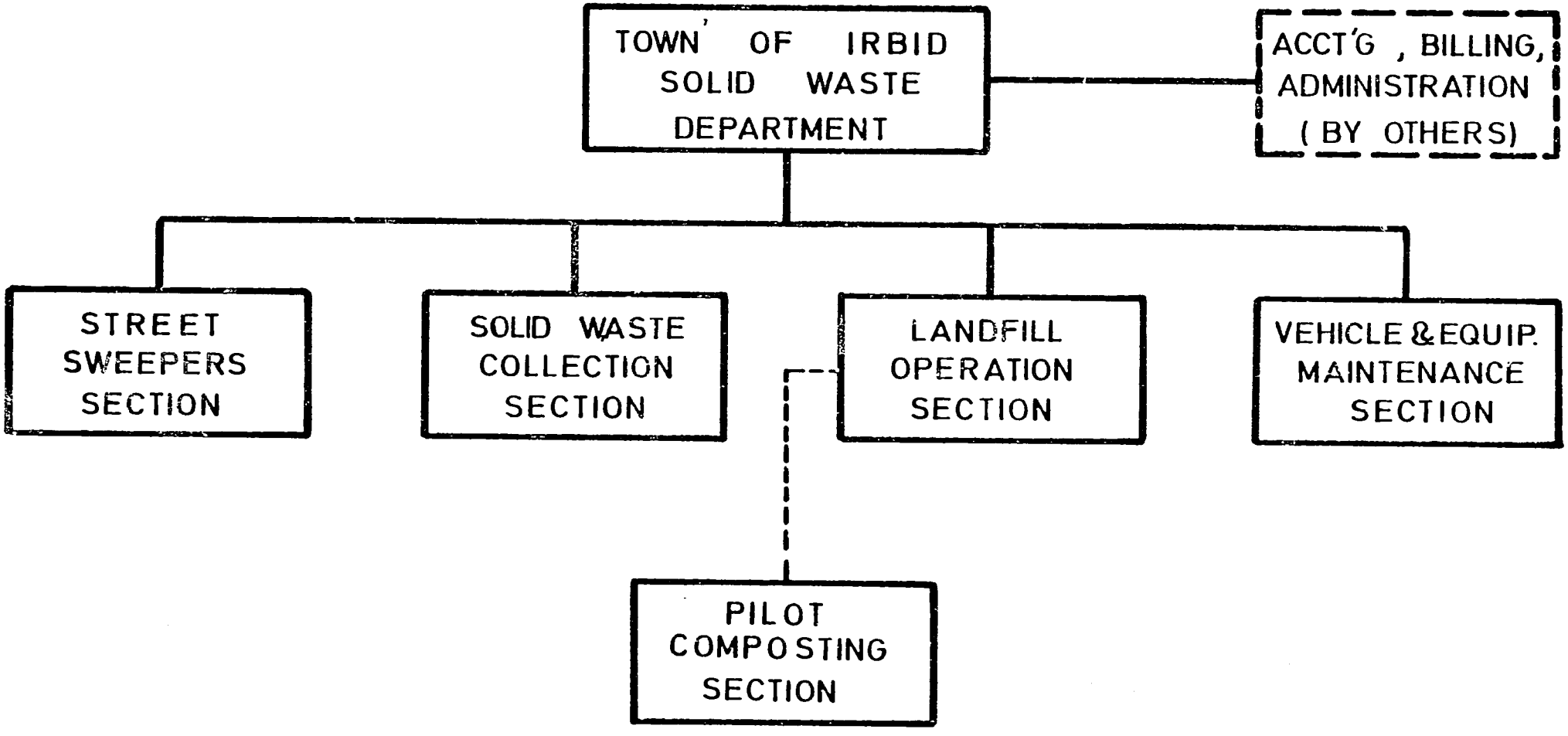

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE	ORGANIZATIONAL CHART FOR SOLID WASTE DEPARTMENT	FIGURE 7-10 DATE BY A.TAYEH

purpose: provides a collection point for run-off, and allows sedimentation of suspended materials to occur before discharge to natural drainage systems.

7.5.1.2 Education of Personnel.

A sanitary landfill is a processing facility which is engineered and designed to protect the public from pollution of air, land, and water caused by the disposal of solid wastes. It is a controlled process with significant monetary investment set forth by the Municipality to provide an environmentally-acceptable solution to the final disposal of solid waste. To operate as such, education of landfill operators as to the environmental impacts of an improperly-operated landfill is necessary. Continuous education to maintain a level of acceptable technology is required. Additionally, continuous monitoring of operations requires trained personnel.

7.5.1.3 Site Selection.

The major emphasis in site selection is placed on environmental adequacy and protection of public health. In general, the facility siting is guided by two limitations:

1. Geographical and geological constraints.
2. Economic realities of Irbid.

The actual site will be located somewhere outside the City of Irbid. The facility site selection will be limited by the following site criteria:

1. General Site Selection -- Through interpretive analysis and overview, specific areas can be quickly classified as not suitable for a solid waste facility by being located in either wadis or flood plains. Conversely, those areas with favorable conditions will be noted so that further, more detailed analyses and evaluations may take place. These detailed analyses will lead to the site selection process.

2. Final Site Selection Process -- The physical, land use, and engineering conditions as they relate to land, water, and air will be confirmed by the following for each primary candidate:

   a. Subsurface soil investigation.
   b. Hydrologic investigation.
   c. Geologic investigation.

Subsurface soil investigations reveal the underlying soil conditions at the sites as they relate to a secondary barrier or back-up liner. Also, these will determine if suitable cover material is available which can be excavated and stored.

Hydrology investigations explore the relationship of the sites to water-bodies and to watercourses. They determine the suitability of the sites with respect to groundwater. Favorable conditions would limit the potential for leachate to enter any water-oriented resource.

Geology within the region is investigated to determine the physical changes in geology (such as unconsolidated deposits, bedrock), as well as to investigate availability of cover material.

Several sites were superficially investigated for adequacy as a sanitary landfill. A brief description of each site follows and is shown in Figure 7-11.

1. Site 1.

Site 1 is an abandoned quarry approximately 3.5 km northeast of Irbid. The site consists mostly of exposed sedimentary rock and was considered unsuitable.

2. Site 2.

This site is located approximately 8 km southeast of Irbid, adjacent to the main highway between Irbid and Mafraq. The site is located in a low-lying area adjacent to the Wadi Zuur. The surrounding area is primarily farming land with isolated residential developments along the highway.

The site is not suitable for landfilling because of its location with respect to the centroid of population. If landfilling would be developed on this site, all trucks would be traveling long distances to dispose of their loads, and the landfill operation would take prime farmland and use it as a solid waste disposal site.

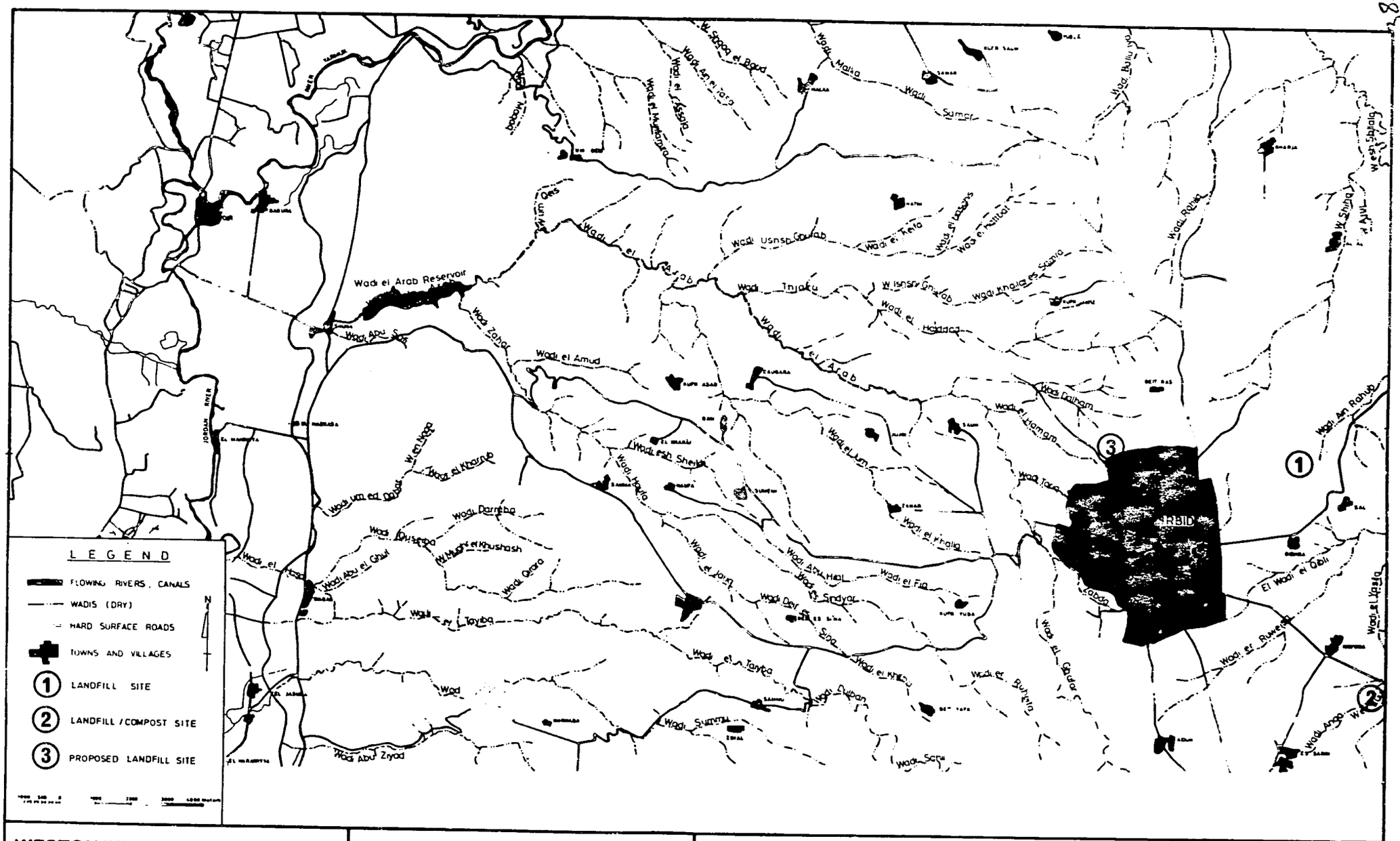
3. Site 3.

Site 3 is located to the northwest of Irbid, just outside the present City limits. The site is situated opposite the proposed wastewater treatment facility. The site topography is gentle rolling hills with flat areas adjacent to the access road.

This site was considered for the following reasons:

1. Short haul for disposal of Irbid's solid waste.

2. Wastewater treatment plant sludge can be easily and economically transported to the site.



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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

ALTERNATIVE LANDFILL SITES

FIGURE 7-11

DATE: SEPT 1979

BY: A TAYEH

CHKD: HALVENSLEBEN

3. All drainage and leachage collection from the landfill can be rerouted from the site to the treatment plant for processing, if necessary.

4. If vegetation requires irrigation, wastewater treatment plant effluent can be pumped to the site.

In addition, field inspection indicates sufficient cover material is available at this site. The present site is now used as a dumping ground for trash, bulky items, and excavation waste from Irbid. Considering these factors, this proposed site appears most suitable. The suitability will be confirmed after geological investigations are completed during the design phase of the project.

The National Water Plan of Jordan identifies the Amman-Wadi Sir aquifer system, which consists of carbonate rocks (limestone, chert-limestone, and sandy limestone) of the Upper Cretaceous Age as the most important aquifer system in Jordan. Outcrops and potential recharge areas for this system occur to the south of Irbid. To the north of Irbid the aquifer system is confined by marl layers. Depth to groundwater in the area to the north and east of Irbid exceeds 250 m. Groundwater at this depth is generally considered economically nonexploitable. These conditions are considered suitable for a sanitary landfill development. Site 3 is located to the northwest of Irbid. Previous field investigations by Hydroconsult Bratislava for the Irbid sewerage and drainage scheme identified the presence of the confining marl layers in this area. Landfill development on this site will therefore have minimal effect on groundwater recharge.

7.5.1.4 Design of Disposal System

The disposal system is composed of a state-of-the-art sanitary landfill. The design of this disposal system is a process requiring the following components:

1. Identification of the elements to be contained in the design.

2. Basis for design.

3. Description of the facilities.

4. Cost-related elements.

Once the site is selected, most of the data required for design will be available; however, additional soil, hydrologic, and geologic investigations will have to be conducted to provide supplemental information.

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The sanitary landfill will be designed based on site configurations, hydrogeological characteristics, and volume requirements. The design will meet all the criteria established in Chapter 3.

The design for the sanitary landfill should contain the following elements:

1. All the necessary drawings and text outlining operation procedures to adequately describe the facility and its operating procedures.

2. Proper placement, compaction, and covering of waste procedures.

3. Gas venting and monitoring system.

4. Weighing and recordkeeping facilities and procedures.

5. Buildings for equipment maintenance and employee comfort.

6. Fire protection system.

7. Traffic control.

8. Insect and vector control.

9. Litter control.

10. Dust control.

11. Proper site grading.

12. Surface-water interception and diversion.

13. Sedimentation and erosion control.

14. Revegetation procedures.

15. Equipment list.

16. Bid documents.

17. Long-range budget.

It is recommended that the final landfill design package contain the following drawings:

1. Location map.

2. Existing topographic map with locations of borings and test pits.

3. Structural contours of various geologic formations.

4. Excavation plan complete with bottom contours at 0.5-m intervals.

5. Location plan of leachate collection system.

6. Profile of leachate collection system.

7. Location plan of subsurface drainage system.

8. Profile of subsurface drainage system.

9. Completed site plan, with contours at 2-m intervals.

10. Geologic cross-section through site using test pits and borings.

11. Operation and general notes.

12. Volume cross-sections.

13. Operational plan site preparation (indicating sequence and dates for preparation and filling).

14. Details:

    a. Placement of PVC pipe.
    b. Gravel placement.
    c. Lateral drainage.
    d. Anchorage of liner.
    e. Buffer zone cross-section.
    f. Fence and post detail.
    g. Groundwater monitoring wells.
    h. Landfill access road cross-section.
    i. Gas monitoring wells.
    j. Gas collection and vent system.
    k. Landscaping.
    l. Structural.

It is recommended that the pilot composting facility contain the following drawings:

1. Location map.

2. Existing topographic map with locations of borings and test pits, with contours at 5-ft intervals.

3. Site plan.

   a. Grading of approach ramps.
   b. Location of compactor.
   c. Traffic pattern.
   d. Utilities.

4. Structural plan.

   a. Detail of pads and foundations.
   b. Detail of equipment.
   c. Utility details.

5. Operation and maintenance manual.

7.5.1.5 Basis for Design.

In order to design a disposal facility, certain basic assumptions must be made. For the sanitary landfill, these are:

1. The sanitary landfill must provide sufficient volume to remain useful as a disposal facility through the year 2000.

2. Quantities of wastes generated are those presented in Chapter 7, unless modified by a proposed weighing program.

3. Refuse compaction achieved is 700 kg/cu m.

4. Daily cover material will use 15 percent of the available volume.

5. Only 90 percent of the surface area is available; the remainder is used for buildings, buffer zones, roads, etc.

6. Landfill will be composed of three lifts:

   a. First lift from 1 m below ground level to ground level.

   b. Second lift from ground level to 3 m above ground level.

c. Third lift from 3 m above ground level to 6 m above level.

7. Construction and operation of the landfill will be staged, and will proceed according to an integrated time schedule.

8. All side slopes are 3:1 (3 horizontal to 1 vertical).

9. All surface slopes are 2 percent.

10. Leachate and gas controls are provided.

11. A special section, unlined, is reserved for the disposal of inert and bulky wastes.

7.5.2 Equipment Requirements

In any sanitary landfill operation, no decision is more critical than equipment selection. No matter how well the operation is planned, refuse disposal systems cannot succeed if inadequate or unsuitable equipment is used. There are three primary considerations when selecting equipment: size, type, and attachments. The types of equipment available for a 60 to 500 ton/day landfill operation are as follows:

Tons/Day	Track Type	Track-Type Loaders	Wheel-Type Loader	Landfill Compactor
60-200	Small	Small	Small	Small
175-272	Medium	Medium	Small	Small
250-500	Large	Large	Small	Small

Track-type tractors are best suited for an area fill operation because of their ability to bulldoze cover material up to 100 m. They are also excellent for site preparation.

Track-type loaders are often used for trench fills due to their excavation capabilities. They also provide good ability to spread cover material, but must be fitted with a special landfill bucket.

Wheel-type loaders are rubber-tired machines noted for their mobility. They are especially useful in providing cover material from distances of 200 m or more. The wheel-type loader is not an efficient excavating machine, but this undesirable feature is offset by its mobility.

Specialized landfill compactors have been designed to compact refuse, thus increasing refuse density and providing more efficient use of disposal space. Their chopper blades impact greater crushing and compaction

effort than equal weight track-type tractors or rubber-tire loaders. Figure 7-12 graphically illustrates the approximate in-place densities associated with the equipment mentioned.

The estimated costs of major mechanical equipment required for a solid waste disposal system are given in Table 7-18.

Equipment requirements for Irbid are substantial and include heavy landfill equipment, collection equipment, street cleaning carts, metal bins, and other miscellaneous items such as a hospital pathologic waste incinerator. Table 7-19 lists the manpower requirements and equipment requirements projected for the 20-year study period. All information on equipment and facility projection, and capital and operating cost estimates for the planning period are based on population forecasts and waste generation rates for Irbid. Accordingly, the degree of accuracy to which quantities and associated needs may be projected is directly related to the limitation inherent in population forecasting. Furthermore, the waste generation rate is empirically derived, but is considered to be within acceptable ranges.

Table 7-20 lists the recommended year of procurement and delivery for replacement equipment required for operation of the collection and disposal system. Storage system requirements are not listed because they entail minor purchases. Manufacturers sometimes suggest longer life expectancies, however, to avoid necessary downtime at the landfill; for collection vehicles, it is our recommendation that this equipment be replaced and maintained as stated.

Scheduling for additional equipment should be made at least 3 to 6 months prior to the required replacement date because of delays experienced in normal shipment and procurement orders.

7.5.3 Capital and Operating Cost Estimates

Tables 7-21, 7-22, 7-23 and 7-24 list the capital costs, as well as operating and personnel costs, estimated for implementation of the solid waste system. All labor costs include an incremental increase of 5.5 percent to cover merit raises associated with improved on-the-job skills.

Capital costs reflect initial duty-free purchase of equipment including shipping costs.

All costs presented in these tables reflect 1979 prices and do not account for inflation factors.

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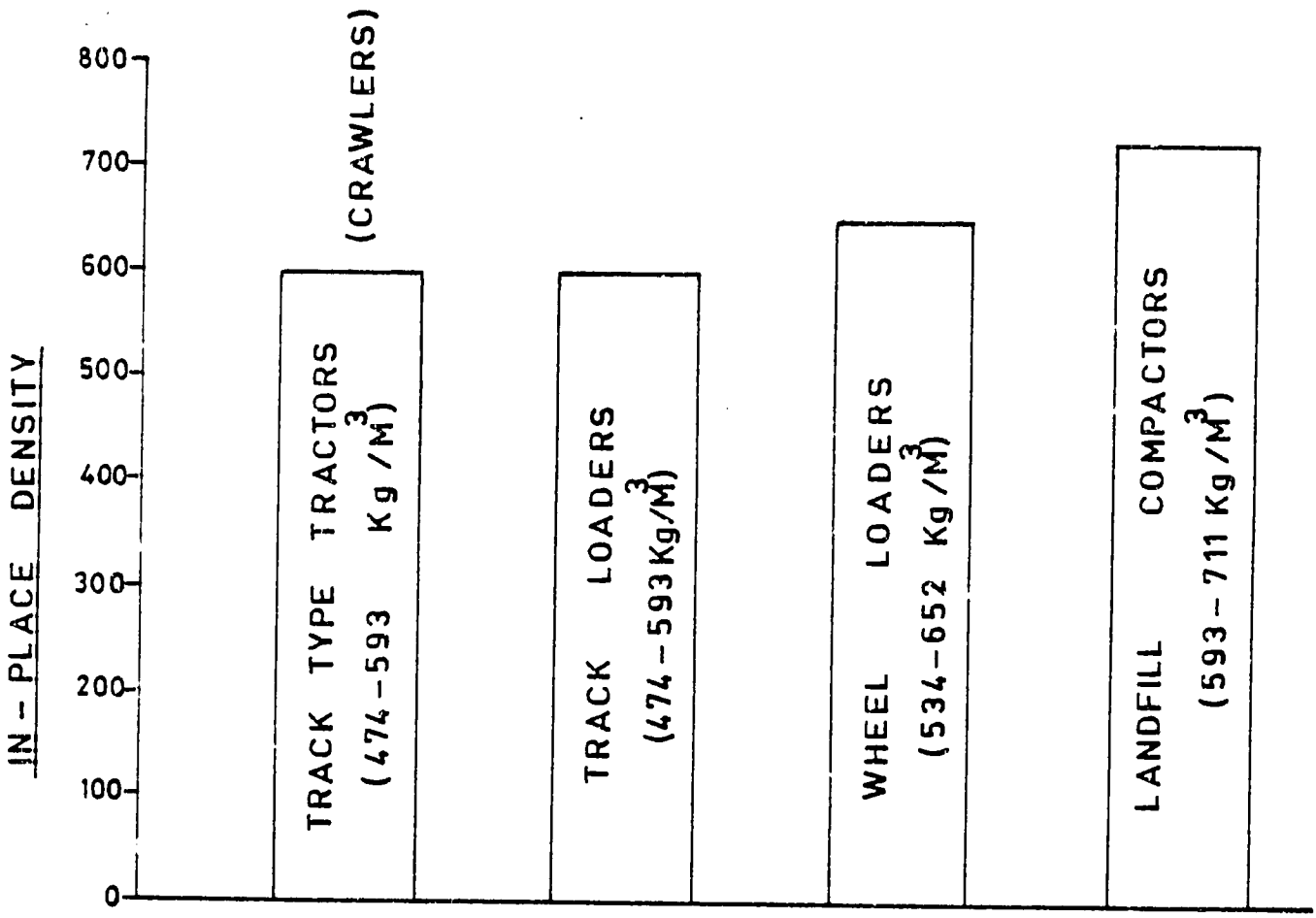
NOTE: THIS GRAPH REPRESENTS RELATIVE RANGES, ACTUAL DENSITIES MAY VARY, DEPENDING ON MOISTURE CONTENT, NO. OF PASSES ETC.



EQUIPMENT AND RELATED COMPACTION ABILITY

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 7-12
	DATE: SEPT. 1979	BY: A. TAYEH CHECKED: P. J. H.

Table 7-18

List of Equipment and Associated Costs

Type	Cost	Shipping Cost	Total Capital Cost	Yearly Operational Cost
Rubber-tired loader	20,650	1,350	22,000	7,500
Landfill compactor	23,500	1,500	25,000	6,900
Crawler/loader	33,500	2,500	36,000	5,400
Bulldozer	30,000	2,000	32,000	6,500
Dump truck	7,000	1,000	8,000	2,000
Front bin loader 30 cu yd (22.9 cu m)	22,000	1,500	23,500	6,000
Metal bins 8.0 cu yd (6.1 cu m)		180	80	260

Table 7-19

Equipment and Manpower Requirements for Irbid Solid Waste Disposal

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Equipment																					
Packer truck	4	4	5	5	5	5	5	6	6	6	6	7	7	7	7	7	7	7	7	7	7
Dump trucks	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Bin loaders	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Track loader	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Dozer/crawler	-										1	1	1	1	1	1	1	1	1	1	1
Rubber-tired loader	-			(1)	(1)	(1)	(1)	(1)	(1)		Will continue if composting is feasible										
Water wagon	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Hospital incinerator	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Manpower Requirements																					
Solid waste system engineer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Landfill supervisor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Collection manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Collectors	10	10	12	12	12	12	13	15	15	15	15	17	17	17	17	17	17	17	17	17	17
Collection drivers	7	7	7	7	7	7	8	9	9	9	9	10	10	10	10	10	10	10	10	10	10
Street sweepers	100	100	100	105	105	105	105	110	110	110	115	115	115	115	115	120	120	120	125	125	125
Landfill operator/labor	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
Heavy equipment operator	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Incinerator operator	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Truck driver	-	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3

Note: (1) indicates equipment required for composting operation.

Table 7-20

Estimated Procurement Projection for Irbid Solid Waste System

Procurement Year

Equipment[1]	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
Bin-loader	2						1			1	2						1					Replace every 10 years
Cu m packer truck (4 existing)			1			4		1				1	1			4		1				Replace every 10 years
Water spray truck	1											OH[2]										Overhaul every 10 years
Track loader	1							1							1							Replace every 7 years
Dozer/crawler													1									Replace every 7 years
Rubber-tired loader					1[3]																	Replace every 7 years
Dump truck	1							1							1							
Hospital incinerator	1										OH											Overhaul every 7 years

[1] No procurement is listed for storage containers.

[2] OH - Overhaul

[3] Used if compost facility is developed.

Table 7-21

Estimated Capital Expenditures for Irbid
Solid Waste System
(1000's of JD)

Cost Item	Phase I			Phase II			Total		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
Landfill Construction[1]									
Land Cost	330	-	330	-	-	-	330	-	330
Sanitary landfill construction and site preparation	169.2	-	169.2	-	-	-	169.2	-	169.2
Contingencies	25.4	-	25.4	-	-	-	25.4	-	25.4
Engineering and administration	13.0	12.4	25.4	-	-	-	13.0	12.4	25.4
Subtotal, Landfill Construction	537.6	12.4	550.0	-	-	-	537.6	12.4	550.0
Collection System Equipment									
Subtotal, Collection System Equipment	-	319.9	319.9	-	240.0	240.0	-	559.9	559.9
Disposal System Equipment[1]									
Subtotal, Disposal System Equipment	-	118.0	118.0	-	76.0	76.0	-	194.0	194.0
Total -- Solid Waste System	537.6	450.3	987.9	-	316.0	316.0	537.6	766.3	1,303.9

[1] Includes costs for pilot composting area and equipment.

Table 7-22

Estimated Equipment Capital Expenditures for Irbid Solid Waste System
(1980 to 1989)
(All costs in JD's)[1]

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Collection System										
Containers[2]	61,700	0	0	0	0	0	0	0	0	0
Bin loader	48,200	0	0	0	0	0	30,000	0	0	30,000
Packer truck	0	0	25,000	0	0	100,000	0	25,000	0	0
Collection System Cost	109,900	0	25,000	0	0	100,000	30,000	25,000	0	30,000
Disposal System										
Dump truck	8,000	0	0	0	0	0	0	8,000	0	0
Track loader	36,000	0	0	0	0	0	0	36,000	0	0
Rubber-tired loader	0	0	0	0	22,000	0	0	0	0	0
Water truck	8,000	0	0	0	0	0	0	0	0	0
Disposal System Cost	52,000	0	0	0	22,000	0	0	44,000	0	0
Total Capital Cost	161,900	0	25,000	0	22,000	100,000	30,000	69,000	0	30,000

[1] All costs are for imported equipment.

[2] Could be manufactured locally, but not presently available.

Table 7-23

Estimated Equipment Capital Expenditures for Irbid Solid Waste System
(1990 to 1999)
(All costs in JD's)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Collection System										
Containers	0	0	0	0	0	0	0	0	0	0
Bin loader	60,000	0	0	0	0	0	30,000	0	0	0
Packer truck	0	25,000	0	0	0	100,000	0	25,000	0	0
Collection system cost	60,000	25,000	0	0	0	100,000	30,000	25,000	0	0
Disposal System										
Dump truck	0	0	0	0	8,000	0	0	0	0	0
Dozer/crawler	0	32,000	0	0	0	0	0	0	0	0
Track loader	0	0	0	0	36,000	0	0	0	0	0
Rubber-tired loader	0	0	0	0	0	0	0	0	0	0
Water truck	0		0	0	0	0	0	0	0	0
Disposal system cost	0	32,000	0	0	44,000	0	0	0	0	0
Total Capital Cost	60,000	57,000	0	0	44,000	100,000	30,000	25,000	0	0

Table 7-24

Summary of Annual Cost for Irbid Solid Waste System[1]
(Excluding Amortization of Capital Equipment)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Collection and Storage System											
Manpower	25,100	25,100	27,100	27,100	27,100	27,100	29,700	33,500	33,500	33,500	33,500
Maintenance	11,000	11,000	11,000	13,000	15,000	15,000	16,000	16,000	18,000	18,000	18,000
Miscellaneous (20%)	7,200	7,200	7,600	8,000	8,400	8,400	9,200	9,900	10,300	10,300	10,300
Annual operating cost	43,300	43,300	45,700	48,100	50,500	50,500	53,900	59,400	61,800	61,800	61,800
Street Sweeping and Litter Control											
Manpower	77,400	77,400	77,400	81,300	81,300	81,300	81,300	85,200	85,200	85,100	89,000
Maintenance	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Miscellaneous (10%)	7,800	7,800	7,800	8,300	8,300	8,300	8,300	8,600	8,600	8,600	9,000
Annual operating cost	86,200	86,200	86,200	90,600	90,600	90,600	90,600	94,800	94,800	94,800	99,000
Disposal System											
Manpower	8,600	11,100	11,100	12,800	12,100	14,200	14,200	14,200	14,200	14,200	18,300
Maintenance	9,400	10,000	10,800	11,500	12,300	13,200	14,100	15,000	15,000	16,000	16,000
Cover	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Miscellaneous (20%)	5,600	6,200	6,200	6,900	6,900	7,500	7,700	7,800	7,800	7,900	8,900
Annual operating cost	33,600	37,300	38,100	41,200	41,300	44,900	46,000	47,000	47,000	48,100	53,200

[1] No salary increases or inflation added.

CHAPTER 8

ENVIRONMENTAL ASSESSMENT

8.1 DESCRIPTION OF THE PROPOSED ACTION

The City of Irbid, shown in Figure 8-1, is the primary urban center of northern Jordan. It is the third largest city in Jordan, and is a proposed center for future development. The Kingdom is encouraging Irbid to become a regional center of industrial, commercial, and cultural development. The site occupied by Irbid was inhabited as early as 3200 B.C. It is a very old settlement which has only recently begun to develop rapidly and spread from its old borders. It now covers nearly 18 sq km.

Irbid is the major city in an area dominated by rain-fed agriculture. This area is possibly the most productive nonirrigated agricultural region in Jordan, and therefore agriculture plays a very important role in the overall development. Production includes wheat, barley, watermelons, tomatoes and other vegetables, as well as chickens, eggs, goats, and cows. The Irbid area supplies produce to most of Jordan, and many of the products are exported to neighboring countries. Irbid has had a dramatic increase in population during the past 20 years. Due to an influx of persons after the political disturbances of 1967 and 1973, and a general trend of moving into the cities and adopting an urban lifestyle, the size of Irbid has greatly increased. Since the area has been chosen as an area of concentrated future development, the area will continue its dramatic growth.

While Irbid does not have a sewage collection and treatment system, it has an adequate water supply, both in quantity and quality, and an inadequate solid waste collection and disposal system. The purpose of the proposed project is to provide these basic human needs for population of Irbid in the year 2000, as well as for the present population.

8.2 ENVIRONMENTAL SETTING

8.2.1 Physical Characteristics

8.2.1.1 Geology.

The geological formations represented in the Irbid area, as reported in the Polytechna and Praha Hydroconsult Report, are of the Mesozoic Era, the Tertiary Period, and the Quaternary Period. The deposits of the Mesozoic Era are formed from limestones, marls, chalky limestones, and

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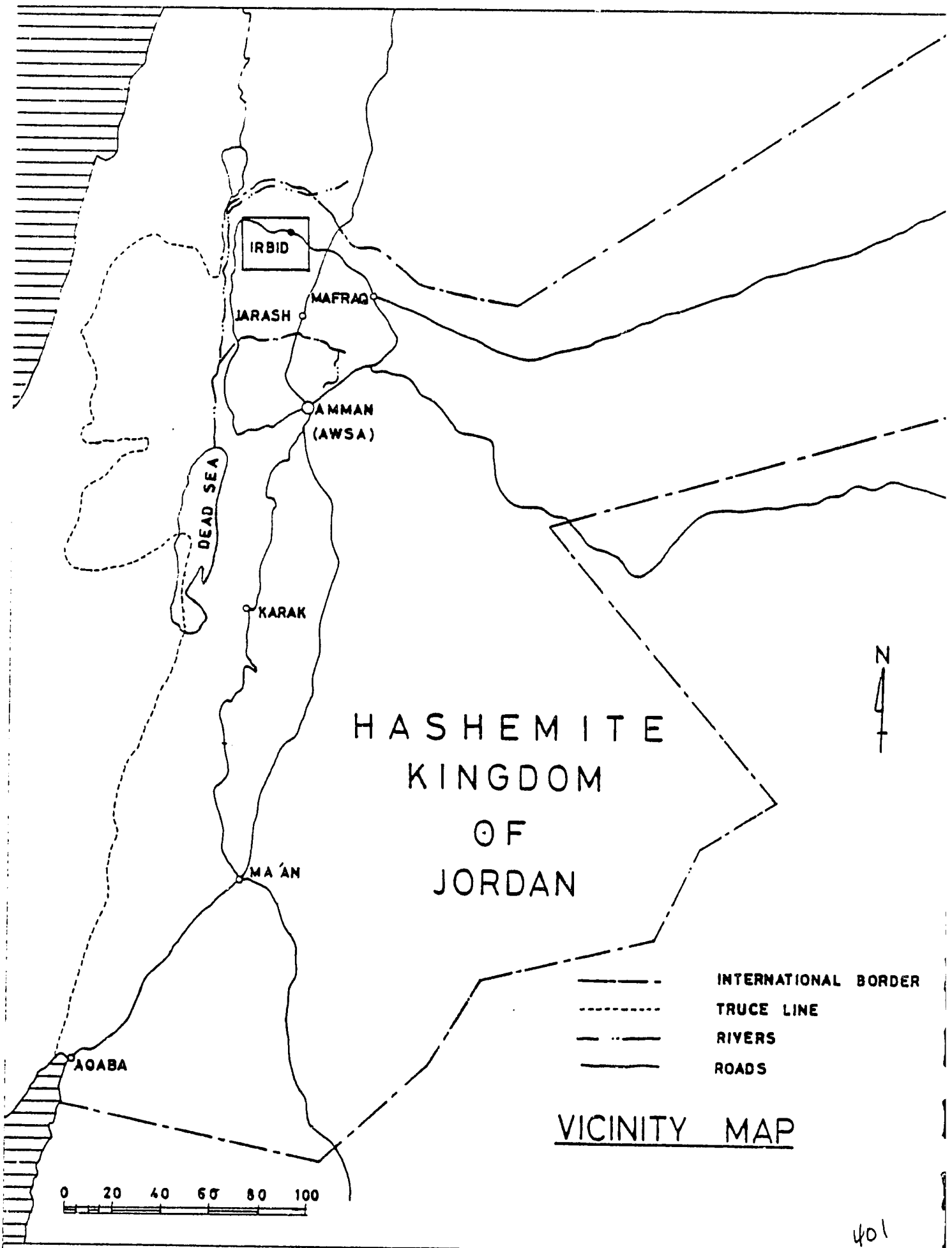

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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 8 DATE: SEPT. 1979 BY: A. TAYE CHECKED: P. J.

cherts. The Tertiary is undifferentiated limestones, chalky limestones, bituminous limestones, marls, and cherts. The Quaternary is made up of undifferentiated fluviatile deposits, colian sands, caliche, loess-like sediments, and mantle rocks.

8.2.1.2 Climate.

Irbid has a semiarid Mediterranean-type climate with average temperatures of 25°C in the summer, and 10°C in the winter. The climate is very dry as rainfall averages only 200-600 mm per year. Rainfall is normally limited to the winter months, November until April. The other months are usually dry, with the exception of May and October which sometimes receive rain. There are no perennial streams in the area. The prevailing winds are from the northwest; sometimes in winter the winds shift to the south and southeast for a few days.

8.2.1.3 Water.

Irbid is located in the Jordan River basin which has a drainage area of 18,000 sq km. The Yarmouk River is the largest tributary, with a drainage area of approximately 6,800 sq km located mostly in Syria.

There is no natural surface-water flow in the wadis near Irbid during the summer months. Wadi Tariq el Saum and Wadi el Hamam receive raw sewage discharged from the small existing sewer system in Irbid, and from the trucks that clean out cesspools. The water quality is extremely poor because of the large amount of untreated raw sewage dumped into the wadis. Some of this flow reaches the Wadi Arab, which is perennial and has an average annual flow of 29 million cu m. Total dissolved solids in the Wadi Arab are reported to average approximately 500 mg/L.

The Yarmouk River, which flows east to west to the Jordan River, lies approximately 30 km north or Irbid, and forms part of the Jordan-Syrian border. The average annual flow at Maqarin is 285 million cu m. There is a planned dam to be located at Maqarin which could possibly provide the water supply for Irbid.

Groundwater in the Irbid area is so deep that is economically nonexploitable. Currently, water supplied to Irbid comes from the groundwater sources at Azraq and Dhuleil. The aquifers at these sites are currently being mined, and cannot be further developed. A new and dependable water source must be obtained if Irbid is to grow as planned, and be able to protect its citizens from water-related disease.

Because of the present water distribution system's pressure problems, water quality in the system is very poor. During the past five years, Ministry of Health records show an average of 16 percent of the drinking water samples tested were found to be contaminated with bacteria that are indicators of possible water pollution.

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8.2.1.4 Soils.

The soils in the area surrounding Irbid are, for the most part, based on limestone. The soil is classified as Red Mediterranean which is found at elevations of 500 to 600 m. In this area of relatively high precipitation, the soils are a reddish-brown color, and contain little of the original limestone. These soils are excellent for agricultural use. This type of soil is located mostly south and east of Irbid. In the eastern and northeastern part of the City there are some areas of brown alluvial soils from basalt eruptions. This soil also contains boulders and gravel, but it is still used extensively for agriculture. Due to the presence of clay in the soils, water retention is low. This causes most of the moisture, falling as rain in the winter, to run off rather than be retained in the soil.

8.2.2 Socioeconomic/Demographic Characteristics

8.2.2.1 Socioeconomic.

The last complete census of Irbid prior to November 1979, was conducted in 1961. Since that year, no reliable population counts have been made. Population projections used for the proposed project are based on the population figures and projections used in the "Integrated Regional Development Study of North Jordan," Phase I, Draft Final Report, October 1978, by the Japan International Cooperation Agency. The base year (1975) has a population for Irbid of 128,000 persons. Using a growth rate of 4.5 percent until 1985, and 4.0 percent thereafter, the 1978 population is 146,000; 1979, 153,000; 1990, 248,000; and 2000, 360,000.

Preliminary results of a 1979 census indicate that the population of Irbid was 113,000, with 16,000 families and an average of seven persons per family.

All economic classes are represented in Irbid. According to the JICA report, most of the population (53 percent) was classified as belonging to the low-income families. There has been a trend recently in Jordan toward more affluence. This is largely due to the number of Jordanians working outside Jordan and sending money back to their families. Irbid city officials have estimated that as much as 20 percent of the skilled work force may be working outside Irbid and sending money back. Unemployment is not a problem in Irbid since the Kingdom enjoys full employment. Most citizens of Irbid are connected to municipal water. Thirty to 50 percent have flush toilets, and the trend is toward their increased use. Most homes have at least one faucet, and many homes have two or three faucets. Households tend to be large (7 to 11 persons per household), but many homes are large and spacious.

Irbid is a very productive agricultural area. It supplies produce to much of Jordan, and produces a large part of the products for export. With modern technology and farming techniques, Irbid could even increase its agricultural output.

8.2.2.2 Cultural.

The cultural environment of Irbid is enhanced by the fact that Irbid will be the home of Yarmouk University. This University will be the major institution for higher learning in north Jordan. Eventually there will be more than 20,000 people associated with the University including students, staff, and administrative personnel. Yarmouk University is currently located at a temporary site in south Irbid.

The ancient history of Irbid is another important cultural resource. Bronze Age remains have been found in Irbid dating back to 3200 B.C. Irbid has been inhabited for over 5000 years, with its most prosperous time during the Roman rule. Irbid was a part of the Decapolis which provided agricultural supplies for the region.

The archaeologically-significant areas are located in the center of the City, near the Citadel, and in the old village, El Bariha. These locations should provide many finds whenever excavation is initiated.

Recreation and tourism will play a significantly greater role in Irbid as many potential sites of interest are exploited. The majority of the tourists are from the Gulf States, enjoying the relatively mild climate of north Jordan.

8.2.2.3 Land Use.

Irbid has been designated as a planned major growth site by the Kingdom. The City has adopted a town plan to control construction and expansion. This plan includes improved and proposed streets. The plan does not include a design for water distribution, sewerage, or solid waste disposal. In order for Irbid to achieve its planned growth, these services must be provided in the interest of public health and welfare.

The land use in the area (see Figure 2-2) surrounding Irbid is predominantly agricultural. The City of Irbid encompasses approximately 18 sq km with the greatest urbanized area nearest the City center. Irbid is developing to the south, east, north, and northwest. Development is physically constrained on the west and southwest by wadis which drain eventually to the Jordan River. The topography of this part of north Jordan is gently rolling, increasing to steep wadis in a westerly direction. The City is located in this rolling countryside, and in and near Wadi Zabda, Wadi el Ghafar, Wadi Tariq Saum, and Wadi el Hamam. Wadi Tariq Saum and Wadi el Hamam converge, and along with Wadi Dalham, form the Wadi Arab.

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Drainage patterns in the City are such that all but the far eastern portion of the City drains to the west. Wadi Arab eventually receives the major portion of the run-off from irbid. Wadi Arab will be dammed to serve as a reservoir for irrigation water in the second phase of the Jordan Valley Authority irrigation project.

Land use in the City is controlled by a zoning ordinance which limits lot size and building coverage. There is a height limit of three stories for all buildings in Irbid. There is an industrial area set aside in the northwestern portion of Irbid, and there are plans for additional industrial areas, if necessary, in the eastern and south-eastern parts of the City. The industrial area covered 14 hectares in 1978, and further expansion is planned. There are many small industries spread througnout Irbid. Most have fewer than five workers, and are interspersed with residential and commercial areas.

The commercial areas of Irbid have been set aside to limit their size, and to provide services to the newly-developed areas as the City grows. The main existing commercial areas of Irbid include the town center, an east-west area along El Hashimi Street, and an area stretching in a southeasterly direction along the road to Amman. In the outlying, undeveloped areas of Irbid, there is significant agriculture. This will diminish as the land is developed and streets and houses are built. At this time, there is no land set aside for open space or recreational use within the municipal boundaries of Irbid.

8.2.3 Related Activities in the Irbid Area

8.2.3.1 Irbid Town Plan.

The Irbid Town Plan includes zoning regulations, street improvements, and designated industrial and commercial areas. This plan is the basis of the projected population disaggregation developed in this report for Irbid. It also guided the phasing of services for the City.

8.2.3.2 Jordan Valley Authority Water Supply Study.

Irbid will receive water from the Maqarin Dam on the Yarmouk River. The Jordan Valley Authority has a project underway to implement this supply. Since the King Talal Reservoir water quality has been determined to be unsatisfactory for Amman's water supply, some of the Maqarin Dam flow will be diverted to Amman via pumping stations and a pipeline from the East Ghor Canal. The JVA is studying providing water for Irbid and Amman, as well as other population centers in north Jordan.

8.2.3.3 Jordan Valley Authority Irrigation Project, Second Phase.

There is a plan to dam the Wadi Arab to provide water for irrigation in the Wadi Arab region. Since the Wadi Arab will eventually receive the effluent from the Irbid wastewater treatment plant, the implementation of this plan is related to the proposed project.

The effect of the proposed Irbid project on this related project is discussed in greater detail in the impact section.

8.3 PROJECT ALTERNATIVES

8.3.1 No Action

The first alternative to be considered is the no action alternative, or leaving the situation as is. There would be no improved water distribution, no sewage collection, and no waste treatment plant. This sytem would allow the existing problems to continue and to get much worse as development and population increase.

The increased public health problem would be unpredictable. It is safe to say that there would be an increased number of epidemics, that the endemic disease rate would be higher, and that overall well-being would be less. Village Water Supply, a World Bank Research Publication, states:

> "The hardship of the urban poor in circumstances where public water supply and sanitation assistance are unprovided is inevitably more severe, particularly when coupled with the intensified threat of epidemics as population density increases."

The problems created would affect the poor the most as they constitute the group most susceptible to public health problems. Increased affluence leads to greater water use, and better education which encourages better sanitation and the use of bottled water for drinking purposes when contamination problems exist. Increased affluence usually leads to less population density and smaller family sizes. All these factors tend to lessen the impact of water-related diseases and control their spread. For these reasons, the environmental benefits far outweigh the adverse effects of no action. It is recommended that the no action alternative not be considered further.

8.3.2 Water

8.3.2.1 Water Sources.

Irbid's water is presently supplied by the northern district of the Water Supply Corporation (WSC), a subnational technical and administrative area which extends from the escarpment on the east bank of the Jordan River to the desert, and from the Syrian border southward to Jerash and

Ajlun. The water is supplied from the well fields at Azraq and Dhuleil, through two pipelines, the longest being 120 km. This supply will no longer service Irbid if the current plan of the JVA is implemented. The JVA plans to supply water to Irbid from the Yarmouk River, Marqarin Dam project. The JVA has determined that there is enough water available in the Yarmouk River to meet the irrigation needs in the Jordan Valley, and the domestic needs of north Jordan, at least through the year 2000. They have determined that 12 million cu m of water per year will be available to Irbid upon completion of the Maqarin Dam project, and up to 23 million cu m/year will be available in the year 2000. Weston's estimate of the Irbid water demand is 19 million cu m/year in the year 2000. Contingency plans, including maintenance of the existing Water Supply Corporation pipeline, should be implemented to ensure the continued water supply for the Irbid area. A plan to rehabilitate and properly use the available water sources at the Azraq and Dhuleil well fields should be developed. The proposed Irbid water distribution project assumes an adequate supply of treated water will be available to the City.

8.3.2.2 Distribution.

Irbid is presently served by a water distribution system consisting primarily of small diameter, 4-inch (10 cm) and less, pipe. Alternatives were developed to reinforce and upgrade this system to serve the City's needs through the year 2000. The condition of the existing system was evaluated, consideration was given to development of pressure zones within the system, pipe materials were evaluated, and system flexibility to receive water from the proposed JVA supply project, as well as the existing and proposed WSC supply lines were evaluated.

Construction phasing to serve the immediate needs of the City, including the needs of the poorer districts in the first phase of the project, was evaluated.

8.3.3 Wastewater

Wastewater treatment system alternatives for the City of Irbid are shown on Figure 8-2.

8.3.3.1 Collection System.

Major alternatives for sewage collection include pressure and gravity sewers. Pressure sewers were dropped from further consideration because the relatively high level of technology required to install, operate, and maintain the extensive numbers of individual pumping units and force mains, and thus is considered inappropriate to the current Irbid situation.

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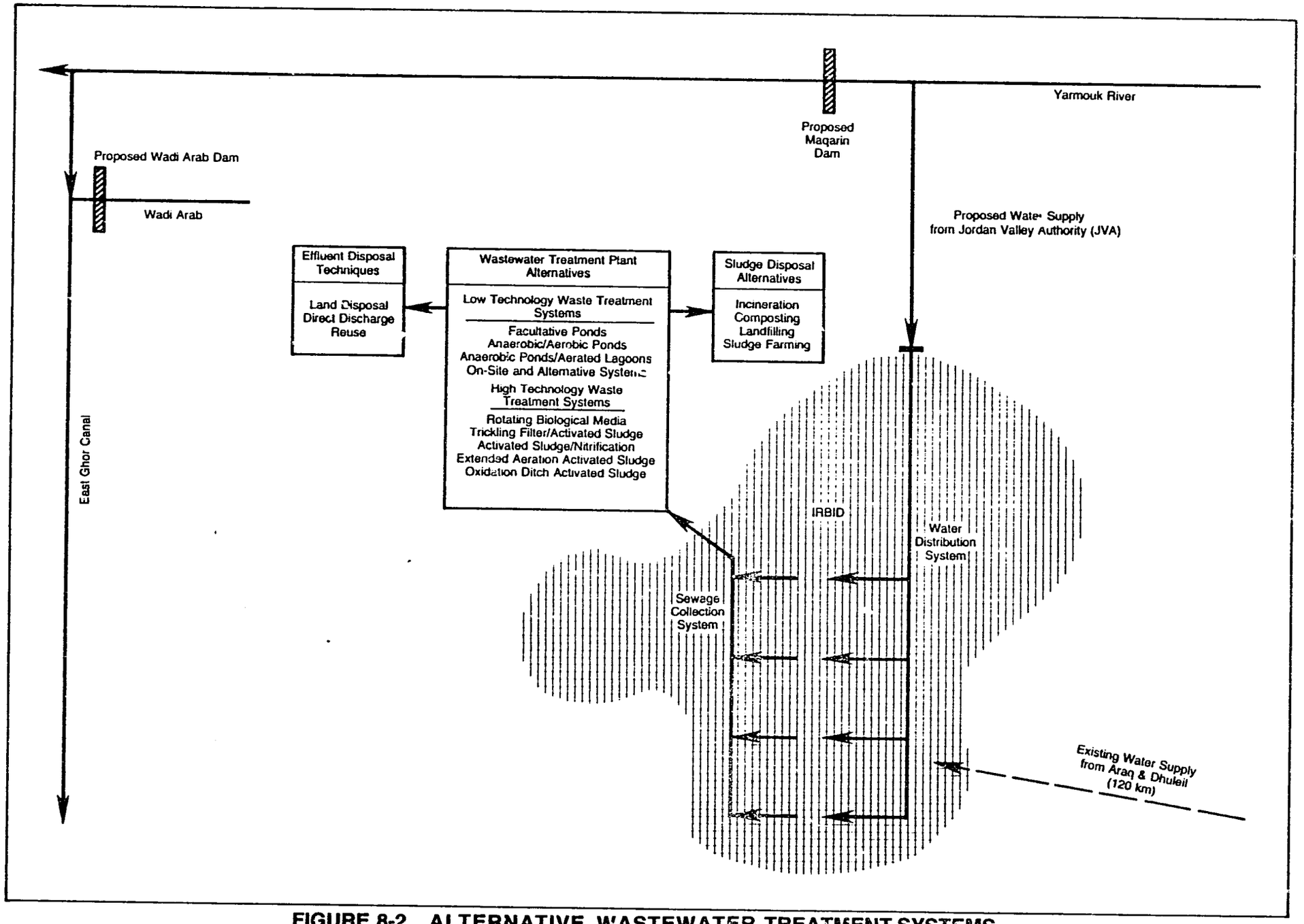

FIGURE 8-2 ALTERNATIVE WASTEWATER TREATMENT SYSTEMS SCHEMATIC FOR THE CITY OF IRBID

Gravity sewer routing is generally limited by natural topography. In several locations for the proposed Irbid system, alternatives of serving particular areas by routing gravity sewers along a relatively circuitous route versus providing pump stations and short force mains to serve the areas were considered. These alternatives were evaluated on the basis of cost, reliability, and the relative impacts of construction along the alternate routes.

A sewer construction phasing plan was developed to meet the immediate sewage collection needs of the City, as well as the projected needs through the year 2000. The effect of the phasing plan on providing service to the poor areas of the City, as well as serving the more affluent areas, was considered.

Sewer construction in Irbid is almost certain to uncover previously undisclosed antiquities. Procedures for mitigating adverse effects on these archaeological finds will be developed and incorporated into the project construction plans.

8.3.3.2 Wastewater Treatment Plant Sites.

Four wastewater treatment plant sites were considered in this study. Two of the sites require pumping of virtually all of the wastewater collected in the City. These sites have extensive undeveloped land areas available, however, so they were considered only for low technology treatment alternatives that require extensive land areas. The third site requires pumping of a portion of the wastewater flow from the City, while the fourth site will collect the wastewater flow from the City through gravity interceptors. Sites 3 and 4 do not have sufficient land available for construction of low technology alternatives.

The sites were evaluated on the basis of site topography, access, land, and interceptor sewer costs, land use, expansion, and effluent discharge.

8.3.3.3 Treatment Alternatives.

Renovation and/or upgrading of existing on-site disposal systems, cesspools and cesspits, were dropped from further consideration as treatment and disposal alternatives for the City of Irbid because:

1. High population density in the developed sections of the City makes these systems impractical.

2. The local limestone soils and bedrock are subject to solution cavities. Wastewater entering these solution cavities is not renovated by the time it reaches groundwater, or returns to the surface in downstream watercourses.

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Land treatment alternatives for wastewater were considered and discounted for the first phase of this project because of the following factors:

1. Water will be lost to further reuse through evaporation and infiltration to unexploitable groundwater.

2. Large land areas must be dedicated to wastewater renovation.

Alternatives considered for wastewater treatment and direct stream discharge in Irbid can be divided into two groups:

1. High technology waste treatment systems which are generally efficient and dependable, but are also costly and generally considered sophisticated.

2. Low technology waste treatment systems which require large land areas to provide treatment levels equal to the high technology alternatives.

Table 8-1 displays the analysis of alternatives considered for wastewater treatment systems with direct stream discharge. The alternatives were evaluated on the basis of environmental factors, costs, and implementability. The important environmental factors are public health, water quality, land use, odor potential, and reliability. Relative cost comparisons were made on the basis of estimated total annual costs. These costs are presented in Chapter 5.

All of the treatment systems evaluated can meet the effluent criteria for BOD, suspended solids and nitrogen set out in Chapter 3. The effluent will be disinfected, and will be suitable for agricultural purposes, but should not be considered for potable consumption without further treatment. The high technology alternatives produce greater amounts of sludge (or treatment residue which must be disposed of) than the low technology alternatives. All of the treatment options require that land be dedicated to treatment and sludge disposal. This land has previously been open space or agricultural land.

All of the treatment alternatives have the potential to generate objectionable odors if they are not operated and maintained in a proper manner.

8.3.3.4 Effluent Disposal.

Land disposal, direct discharge, and direct reuse of treated wastewater effluent alternatives were considered. These alternatives were evaluated based upon environmental, cost, and implementability factors. This evaluation is presented in Table 8-2.

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Table 8-1

Alternative Methods of Wastewater Treatment
for the City of Irbid

Alternative	Description	Major Environmental Factors[1]							Rank	
		Public Health	Water Quality	Land Use	Potential Odor Generation	Realibility	Relative Cost[2]	Implement-ability[3]	Total	Rank
	Low Technology Waste Treatment Systems									
1	Facultative ponds	2	2.5	4	4	1	3	1	17.5	4
2	Anaerobic/aerobic ponds	2	2.5	[illegible]	4	2	2	2	18.5	4
3	Aerated lagoons	1	2	3	3	2	4	2	17	3
4	Anaerobic ponds/aerated lagoon	1	2	3	4	2	3	2	17	3
	High Technology Waste Treatment Systems									
1	Rotating biological media	1	2	3	4	3	4	4	21	5
2	Trickling filter/activated sludge	1	1	3	4	3	2	4	18	3
3	Activated sludge/nitrification	1	1	4	3	2	2	4	17	3
4	Extended aeration activated sludge	1	1	3	2	2	1	2	12	1
5	Oxidation ditch activated sludge	1	1	3	2	2	2	3	14	2

[1] 1 = Beneficial impact ⟹ 4 = Detrimental impact

[2] 1 = Relative low cost ⟹ 4 = Relative high cost

[3] 1 = Ease of implementability ⟹ 4 = More difficult implementability

Table 8-2

Alternative Methods of Wastewater Treatment Plant
Effluent Disposal for the City of Irbid

Alternative	Description	Major Environmental Factors[1]				Relative Cost[2]	Implement-ability[3]	Score	Rank
		Public Health	Water Quality	Land Use	Reliability				
1	Land disposal	2	2	4	2	3	3	16	3
2	Direct discharge	2	2.5	1	2	1	1	9.5	1
3	Reuse	2	2	1	3	3	4	15	2

[1] 1 = Beneficial Impact → 4 = Detrimental Impact

[2] 1 = Relative low cost → 4 = Relative high cost

[3] 1 = Ease of implementability → 4 = More difficult implementability

Treated wastewater can be spread on land and allowed to percolate to groundwater as recharge, or used to irrigate agricultural crops. Land used for this purpose should be dedicated to wastewater disposal, or equivalent alternate sites should be identified to provide disposal for the life of the project.

Direct discharge of wastewater effluent in Irbid requires minimum treatment levels as indicated in Chapter 3. If the treatment plant is operated properly, this disposal alternative will provide increased flows in the Wadi Arab riverine system. This water can be used for irrigation downstream, particularly in the Jordan Valley.

Direct reuse was considered as an alternative, but implementability of this alternative would be very difficult at this time because no water-using industries are presently identified to use this water, and direct reuse for human consumption cannot be considered without extensive additional treatment.

8.3.3.5 Sludge Disposal.

Wastewater treatment facilities produce a residue, sludge, which requires disposal. Four alternative disposal methods were calculated. The results of this evaluation are summaried in Table 8-3.

Incineration of sludge only requies that a small amount of land be dedicated to this purpose. Land is required for the incinerator and for disposal of the residual ash. Incinerators require high technology for construction and for operation, and operating costs are high. The sludge ash has no residual benefits.

The by-product of sludge composting is an innocuous residue that has value as a soil conditioner. A composting operation requires mechanical equipment as well as competent trained operators. Implementation of composting requires acceptance and use of the by-product by farmers and gardeners in the Irbid area.

Landfilling of sludge requires dedication of sufficient quantities of land for this purpose throughout the project period. Completed landfills can be reclaimed for other productive uses in the future. Landfills require proper operation including sealing and covering to prevent leaching of contaminants into the groundwater and to avoid providing shelter for disease vectors.

Sludge farming is the direct application of liquid or dewatered sludge to agricultural land. Implementability of this alternative is considered very difficult at this time in the Irbid area. Farmers are reluctant to accept "human waste" on their fields. The Irbid sludge is primarily from domestic wastewater, and consequently can be expected to have a low

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Table 8-3

Alternative Methods for Sludge Disposal
for the City of Irbid

Alternative	Description	Major Environmental Factors[1] Land Use	Public Health	Potential Odor Generation	Agricultural Potential	Reliability	Relative Cost[2]	Implement-ability[3]	Total	Rank
1	Incineration	1	1	1	4	3	4	4	18	3
2	Composting	3	1	3	1	2	3	3	17	2
3	Landfilling	3	1	3	4	1	1	2	15	1
4	Sludge farming	3	2	3	1	2	2	4	17	2

[1] 1 = Beneficial Impact → 4 = Detrimental Impact

[2] 1 = Relative low cost → 4 = Relative high cost

[3] 1 = Ease of Implementability → 4 = More difficult Implementability

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metal content. This sludge can be valuable as a soil conditioner. It is recommended that demonstration projects be developed in cooperation with the Yarmouk University and Ministry of Agriculture, with the aim of demonstrating the value of sludge as a soil conditioner.

Sludge treatment and dewatering alternatives, including aerobic and anaerobic digestion and mechanical and sand bed dewatering, were evaluated with the various wastewater treatment alternatives.

8.3.4 Solid Waste

Collection alternatives including transfer stations, areal pick-up and door-to-door pick-up were considered. Transfer stations are not cost-effective because there is no need to transport solid waste long distances. A collection system including a combination of areal and door-to-door pick-up was developed.

Disposal alternatives evaluated included incineration with and without by-product recovery, composting, and compacted as well as noncompacted landfills.

Incineration alternatives are costly and require high technology. They were dropped from further evaluation for these reasons.

Composting is also a high technology alternative which requires trained operators.

Landfilling is a low technology alternative. Compacted landfills require less land area than noncompacted landfills.

Disposal sites were evaluated on the basis of their proximity to the City, existing land use, topography, and possible effect of solid waste disposal on exploitable groundwater resources.

8.3.5 Stormwater

Stormwater runoff presently causes little property damage or public health problems in Irbid. The principal stormwater-related public health problems result from discharge of wastewater to the existing storm drainage system.

The stormwater drainage facility alternatives to be considered include project phasing which is to be compatible with the overall development program and project economic feasibility.

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8.4 RECOMMENDED PLAN

The recommended project provides for water, wastewater, stormwater drainage, and solid waste facilities for Irbid. The facilities are planned to meet user demands to the year 2000, and to provide sufficient flexibility to be adaptable to demand beyond that time.

Although the system has been designed in an integrated fashion, it is most effectively described by component.

8.4.1 Water

Treated, disinfected water is supplied by pipeline from the Yarmouk River. It is recommended that the present water source from the well fields at Azraq and Dhuleil, and its conveyance system, be maintained in operating condition as a contingency. The feasibility of rehabilitating these well fields and using them for off-line storage of peak flows from the Yarmouk River is worthy of evaluation.

It is further recommended that the Municipality of Irbid investigate legal mechanisms to assure its right to the quantities of water proposed. This should be done in conjunction with a water response management plan for north Jordan.

The contracted scope of analysis for this project begins with the water distribution system.

The water distribution system is gravity fed. Four pressure zones will be established to:

1. Provide adequate system pressure at the individual user connections.

2. Limit the system pressures to reasonable levels to minimize distribution system leakage.

A major feature of the proposed water distribution system improvements is the construction of additional mains to complete distribution system loops. These loops will equalize water flow in the system, thereby ensuring adequate water quantities in all parts of the system.

The system has been designed to accommodate an anticipated growth in population of 214,000 persons. Twenty percent of the total capacity is provided for planned commercial and industrial growth.

It is intended that the existing rooftop tanks, which are considered to be disease agents, be abandoned. The pressurized nature of the system will eliminate infiltration of contaminated seepage.

8.4.2 Wastewater

The recommended collection system is primarily a gravity sewer system. The existing cesspools will be abandoned.

Since the potential impact on antiquities during collection system construction is significant, the proposed mitigation plan is important.

Treatment of sewage is by an extended aeration process which produces a disinfected effluent suitable for irrigation uses, and a stabilized sludge. Discharge is to the Wadi el Hamam which flow to the Wadi Arab.

Sludge from the treatment facility has a very small industrial component. It is most suitable for use as a soil conditioner, but this option is not socially acceptable yet. It is recommended that the sludge be landfilled until that time. It is suggested that a cooperative project be developed with Yarmouk University to establish pilot sludge farming areas.

8.4.3 Solid Waste

A collection system consisting of both areal and door-to-door collection is proposed.

Municipal trash and sludge disposal via a landfill located adjacent to the wastewater treatment facility is proposed. This landfill is to be operated by a daily fill and cover method.

8.4.4 Stormwater Drainage

Little health or property damage impacts result from poor stormwater drainage. A series of drainage facilities, including improvements to existing drainage systems in the Wadi Tariq Saum and Wadi el Hamam drainage areas, is proposed.

This component of the overall program has the least degree of urgency, and is thus the most adaptable to later phasing.

It should be noted that the infrastructure facilities provided by this program will make Irbid significantly more attractive for investment in commerce, industry, and residential development. It is recommended that a program of land use planning and management be initiated as a program of this type will be very important in positively guiding land development.

8.5 IMPACTS FROM THE RECOMMENDED PLAN

The long-term and short-term impacts of the recommended plan are shown on Table 8-4.

Table 8-4

Environmental Impacts
of Proposed Project
City of Irbid

	Beneficial Impacts	Detrimental Impacts
Short-Term Impacts		1. Cultural (Archaeological) 2. Noise 3. Air
Long-Term Impacts	1. Public health 2. Water quality 3. Socioeconomic	1. Land use 2. Water quality 3. Water demand

8.5.1 Public Health

The major long-term impact of the proposed project is the increased use of water by the people of Irbid. This increased use of water should lead to better hygiene, better food preparation, and less waterborne disease. The current cesspool/septic tank system will be eliminated, along with the problems of overflowing and leaking. The sewerage system will move contaminated waste away from the populated areas to be treated and disinfected. This will provide positive control of waterborne diseases which exist in the present cesspool system. The pressurized water distribution system will reduce contamination of drinking water caused by infiltration of cesspool leakage that occurs now when the water supply system is not pressurized. Roof tanks, which harbor disease vectors, can be eliminated. This will be a socialization process which will only occur when the population feels secure that a constant, abundant, and safe water supply system is available. If the water supply is not adequate, however, then the roof tank system will probably remain.

8.5.2 Water Quality

Another important aspect on which the proposed project will impact, is water quality. The quality of water available for use by each family, and the quality of wastewater generated will be affected. A fully pressurized water distribution system will provide a noncontaminated source of potable water for domestic use. The used water from houses, businesses, and industry will be collected, treated, and discharged. The treated effluent will be disinfected with chlorine. The effluent limitations which the treatment system must meet are as follows:

	Effluent Limitations	
Parameter	30-Day Average	7-Day Average
pH	6.0 - 9.0	6.0 - 9.0
BOD_5, mg/L	30	45
Total suspended solids, mg/L	20	30
Ammonia nitrogen, mg/L	1	2
Dissolved oxygen, mg/L	3.0	3.0

These effluent limitations (if met), along with disinfection, should provide water suitable for use in agriculture in the Jordan Valley downstream of the wastewater treatment plant. If these standards are not met, there will be contamination problems downstream of Irbid which could result in the water being unusable.

An adverse impact on water quality will be the increase of total dissolved solids (TDS) in the receiving stream. A waste product of human consumption and industrial water use, TDS is not removed by the wastewater treatment plant, and passes through in the effluent.

8.5.3 Socioeconomic

The proposed project will impact on the socioeconomic environment in a beneficial way by increasing the quality of life of the citizens of Irbid. Water has proven to be essential for continued economic success, so the proposed project should enhance the general welfare. Another benefit of the project is the relief of flooding problems by the installation of storm sewers.

Increased water supply, however, leads to increased demand and expectations; there is no absolute assurance that the future water needs can be met. Steps should be taken on a regional or national level to assure that the water supply will be available after the proposed project is implemented. Another potential problem in a water-short region, is that water used from one source eliminates that source for another use. Efforts should be encouraged to use the water as many times as possible before final discharge. Cooperation will be necessary among all groups to share the limited water resources available.

8.5.4 Cultural (Archaeological)

The potential long-term impact on the cultural environment will be the discovery of archaeological or historical sites during the excavation phase of the proposed project. Since Irbid is located in an archaeologically-rich area, there could be significant finds which could have beneficial or adverse impacts on the project.

8.5.5 Land Use

Land use of the area will be impacted because of the land requirements for the waste treatment plant, the sludge disposal site, and solid waste landfill. This land (28 hectares) will be taken out of open space and agricultural production. The decrease in agricultural production should be compensated for by increased production downstream of Irbid. A more serious loss of farm land will occur as the City develops and grows. Sewer and water lines will guide growth and control land that is removed from agricultural production. The town plan must be enforced in order to control this growth induced by the installation of water and sewerage.

8.5.6 Secondary Impacts

8.5.6.1 Water Quality.

The secondary impacts of the proposed project will be downstream on the Yarmouk River, on the well fields which will no longer be used by Irbid for water supply, and in the Wadi Arab downstream of Irbid where the effluent will be available for reuse.

Extracting water from the Yarmouk River has been planned by the JVA for the water supply of most of north Jordan, including Irbid. Taking water from the Yarmouk River at Maqarin Dam will make less water available in the Jordan Valley where it is used for irrigation and as potable water.

The JVA has concluded that there is enough water available for irrigation purposes and for the supply to north Jordan. If, in the future, not enough water is available, agricultural production or domestic consumption will suffer. This possibility should be mitigated by using all possible sources of water and having alternate water supplies available for domestic consumption.

The well fields which now supply most of Irbid's water will become available for use elsewhere or as an alternate water source for Irbid. This will have the beneficial effect of easing the water shortage in Jordan and giving the system some much needed flexibility.

Potentially, the most significant secondary impact of the proposed project is downstream of Irbid where the effluent will be available for agricultural use. The JVA plans to dam the Wadi Arab will increase the irrigation water available for agricultural production in the Jordan Valley. The potential uses of this water are being explored by the JVA at the present time. Because of the potential contamination of the Wadi Arab flow, there should be a positive mechanism for isolating this flow from the East Ghor Canal.

8.5.6.2 Noise.

There will be a short-term increase in noise levels due to construction in each area where excavation and construction are going on. After completion of construction, the treatment plant site will have some noise associated with it. Heavy equipment and pumps will be used at this site, but the increased noise levels should not be significant because of the location of the site.

8.5.6.3 Air.

The impact on the air environment by the proposed project will be short term. During excavation and construction there will be significant increases in airborne particulates. These effects will be ongoing during the construction phase of the project. After construction is completed, air quality in the project area should return to preproject conditions.

The effects of the increase in particulates should be local. However, since virtually every street in the City will be excavated, all persons will be exposed to the increased dust for the time that excavation is taking place in each locality.

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8.5.6.4 Land Use.

The short-term impacts on land use will be the disruption of normal uses during sewer and water main construction. These impacts will be limited to the time of construction, and will be mitigated by minimizing the amount of open trench. Water and sewer lines will be constructed, backfilled, and covered with temporary paving immediately to minimize traffic disruption.

8.6 STEPS TO MITIGATE ADVERSE IMPACTS

The water distribution system must be maintained to control water losses. An active leak detection and repair program, as well as a meter inspection and control program, should be implemented.

The existing Water Supply Corporation pipelines which presently serve Irbid should be maintained as an emergency supply. Studies should be made to determine the feasibility of recharging the Azraq and Dhuleil well fields with excess Yarmouk River water after construction of the JVA scheme.

The sewage collection system should be designed as a gravity sewer system, where possible, to minimize operating costs and maintenance problems.

The wastewater treatment plant should be provided with multiple treatment units to facilitate maintenance and minimize disruptions due to equipment failures. Adequate chlorination facilities should be provided to disinfect wastewater flows in the event all or portions of the plant are bypassed. Stand-by power generation facilities should be provided.

Methods for controlling or eliminating the flow from the Wadi Arab to the East Ghor Canal should be provided in the event there are occasional water quality problems in the Wadi Arab system.

Programs should be implemented to monitor proposed industrial discharges to the Irbid system, especially toxic or hazardous discharges. Programs should be established to either eliminate or satisfactorily pretreat these discharges.

Sewer and water construction contracts should be controlled to mitigate the adverse impacts of noise, air pollution, and traffic disruption. Excavation and construction should be limited to normal working hours. Open trenches should be kept to a specified minimum length.

Construction in the Irbid streets will impact on the cultural environment, specifically, the archaeological sites. Since sewer and water contractors are not normally sensitive to archaeological factors, and their construction workers are not generally adept at recognizing archaeologically-significant sites, it is recommended that an inspector be provided on-site to observe and stop work if significant sites are uncovered.

The Ministry of Antiquities is interested in all sites discovered, and requires inspection by a staff member. The procedure to follow requires notification of intent to excavate, work stoppage if a site is found, and contact with the Ministry of Antiquities. The Ministry will remove all significant artifacts, and then excavation will be allowed to continue.

8.7 UNAVOIDABLE ADVERSE IMPACTS

The only significant adverse environmental impact resulting from the proposed project is the slight decrease in water quality in the Wadi Arab. This adverse impact would be more than compensated for by the increased water supply and the public health benefit realized by the City of Irbid. By the year 2000, the flow from the wastewater treatment plant will provide approximately one third the flow into Wadi Arab. The water will be usable for irrigation purposes.

Other adverse impacts will be local, short-term impacts on the air quality and noise levels. Also during this time, there will be local community disruption as excavation for the sewer line and water mains is accomplished. These impacts will be localized as the construction crews work in neighborhoods. The entire construction period will last at least two years, so these impacts will be ongoing, but will change location with time.

8.8 LOCAL SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

At this point in Jordan's chronically short water supply situation, any time water is taken for some use, it must be diverted from some other potential use. It becomes a problem of balancing the benefits of the various uses, The proposed project attempts to increase long-term productivity by providing water for the City of Irbid, and then making the used water clean enough to be reused for irrigation purposes. In this manner, more people can be served by the same amount of water. The public health benefit to Irbid will also increase long-term productivity because less time will be lost to water-related diseases. Also, an increase in the general welfare of the population will provide an increase in productivity which will benefit the community.

There will be short-term uses of land during the construction phase which will disrupt the community. These short-term changes will revert to their former uses after the construction phase is complete.

8.9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF NATURAL AND CULTURAL RESOURCES

The proposed project will require six hectares of land for a waste treatment plant, and 22 hectares of land in the solid waste disposal system. These lands will be dedicated, but they could revert to other uses if there was a need for a change.

There will be a decreased amount of water available for irrigation at the source of Irbid's water supply. However, 64 percent of the water coming to Irbid will be available downstream of the waste treatment plant for irrigation purposes. This commitment of resources is also reversible if there were an extreme need.

The major cultural aspect of the proposed project is the possibility of discovering archaeologically-significant sites during excavation for the sewers and water lines. Irbid was occupied as early as 3200 B.C. Tombs of this age have been found during prior excavation, at a depth of only two meters. Interviews were held with the Inspector for the Ministry of Antiquities for the Governorate of Irbid, and with the Director of the Americans for Oriental Research concerning the possibility of finding significant sites in Irbid.

The two areas of interest are the center of the City, around the Citadel, and the old village of El Bariha. The City center is an ancient tell that was occupied from the Middle Bronze to the Iron Age, and will probably yield tombs. El Bariha is also a very ancient site where discoveries will probably be made.

8.10 INTERESTS AND CONSIDERATIONS WHICH AFFECT ADVERSE ENVIRONMENTAL EFFECTS

The adverse environmental effects are small when balanced against the potential public health benefit which would result from the proposed project. Provisions for the basic human needs for an area than has been designated a growth area will increase the public health and general welfare of the people of Irbid.

CHAPTER 9

ECONOMIC AND FINANCIAL FEASIBILITY ANALYSIS

9.1 INTRODUCTION AND PURPOSE

This chapter presents the analysis of the financial and economic aspects of the recommended facility improvements associated with satisfying the Phase 1 development needs for the City of Irbid through 1989. The chapter begins with a section on the costs of the recommended Phase 1 and subsequent Phase 2 facilities. Other sections of this chapter present the financial and economic analyses, including information on possible rate structures, possible needs for subsidies, and economic internal rate of return analysis based on 1979 costs. The financial analysis is summarized in financial statements for the first phase of the project.

The chapter is supported by several appendices which present the details of the methods and evaluations. These appendices substantiate the economic and financial evaluation objectives of this chapter. They are titled: Appendix D, "Utility Pricing Approaches and Policy Considerations"; Appendix E, "Cash Flow Analysis Model"; and Appendix F, "Analysis of Economic Benefits from Planned Project Development."

A cash flow model is used in this study to estimate escalated costs of capital and equipment, and operation and maintenance. The model is also used to determine user charges and fees that will generate sufficient revenues to cover the costs of operation. The model provides inputs to the conventional financial statements, but is not directly connected, and does not produce a balance sheet financial statement as may be misunderstood by the name of the model.

Special attention is directed to rates, fees, and charges. The purpose is to propose an affordable, cost-effective project for the residents of Irbid to meet existing and future needs. This analysis involves testing variables such as phasing, inflation rates, and user charges and fees as to their effects on the generation of revenues and costs over the analysis period.

During the preparation of this preliminary feasibility study, sources of grants and loans have been identified, including a $3 million (U.S. dollars) grant (910,000 JD) from USAID (not applicable to the solid waste project), and a $21 million (U.S. dollars) loan (6,360,000 JD). Financing the proposed project, according to discussions with National Planning Council staff, will depend on foreign sources for 70 percent of the investment needs, and local sources for the remaining 30 percent.

9.2 COST SUMMARIES BY CONSTRUCTION STAGE

This section presents the detailed capital and construction costs associated with the Phase 1 and Phase 2 project objectives for the proposed water distribution, wastewater collection and treatment, solid waste disposal, and stormwater drainage schemes. Cost data are presented as follows:

1. Basis of cost estimates.
2. Phase 1 costs.
3. Phase 2 costs.

Price escalation is discussed in this section, as well as selection of a discount rate suitable for evaluation of project alternatives. The cost estimates are used as inputs to the economic and financial analysis.

Table 9-1 summarizes the cost in constant 1979 JD for Phases 1 and 2, and provides total project costs.

9.2.1 Basis of Cost Estimates

9.2.1.1 Unit Costs.

Unit costs are used to derive the capital and construction cost for each proposed facility plan. These costs are presented in Jordanian dinars (JD), and are based on current (1979) price levels and exchange rates (0.300 JD per U.S. dollar).

1. Project Construction Costs.

Chapters 4, 5, 6, and 7 identify the selected facility plans for water supply, wastewater collection and treatment, stormwater management, and solid waste disposal. The project construction costs include civil works, mechanical and electrical equipment, land acquisition, contingencies, and engineering and administration.

a. Civil Works. Estimates of construction quantities, excavation and backfill were made on the basis of layouts for the proposed facilities. The unit prices were calculated for each item using standard equipment, conventional construction practices, geographical considerations, and experience. Figure 9-1 presents an example of civil works costs. This figure shows the unit cost for sewer pipe (in place) used in this report.

b. Mechanical and Electrical Equipment. Costs of major equipment for the wastewater treatment plant, and heavy equipment for the solid waste system are based on estimates received from manufacturers for equipment delivered to Jordan.

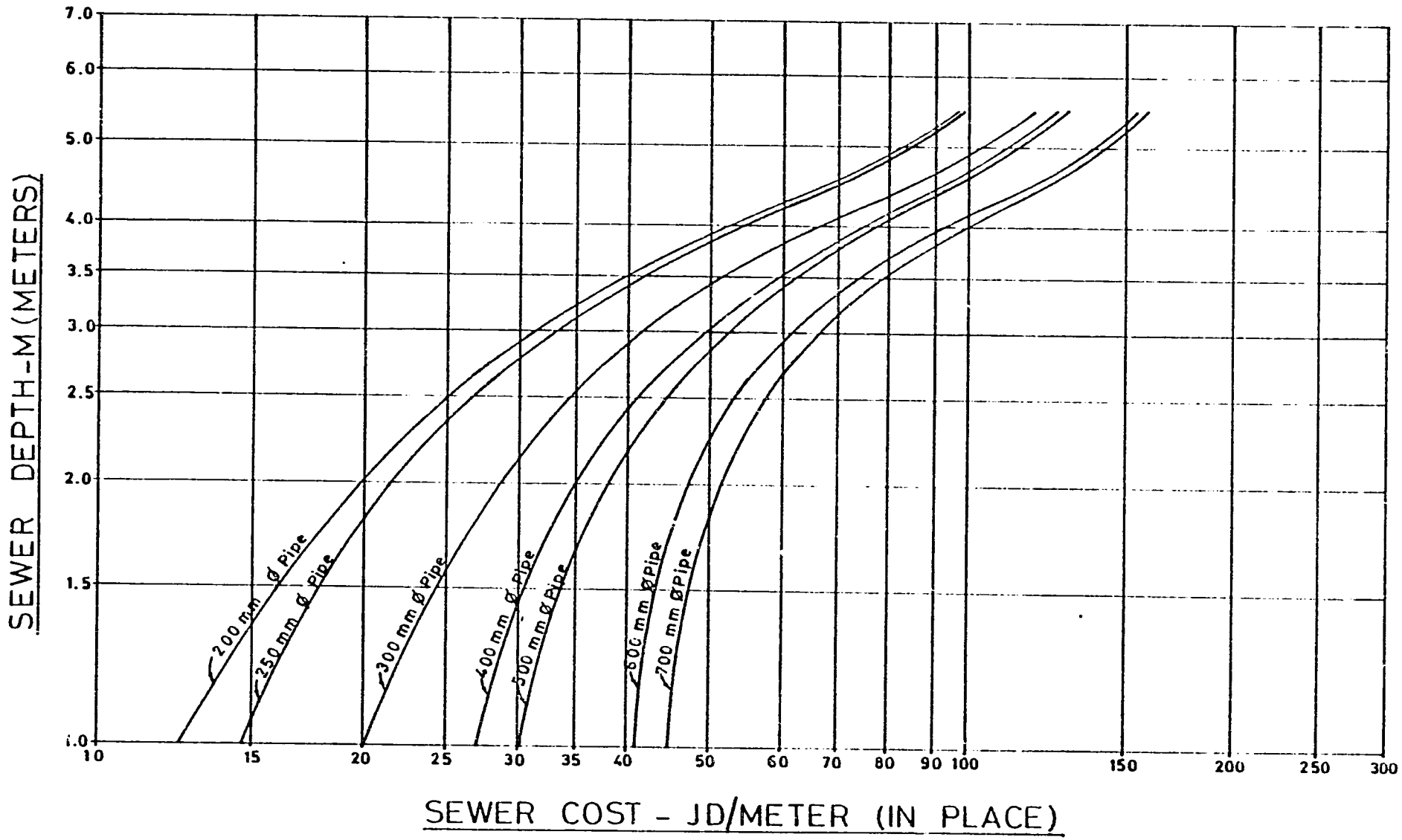
c. Other Costs. Costs of electricity are based on projected per kilowatt hour rates.

Table 9-1

Capital Cost Summary
(Costs - JD x 1,000)

Major Work Element	Phase I Local	Phase I Foreign	Phase I Total	Phase II Local	Phase II Foreign	Phase II Total	Total Project Local	Total Project Foreign	Total Project Total
Water Supply System									
Probable construction cost[1]	2,279	2,264	4,543	1,978	1,799	3,777	4,257	4,063	8,320
Contingencies	341	342	683	295	272	567	636	614	1,250
Engineering and administration	228	455	683	189	378	567	417	833	1,250
Subtotal	2,848	3,061	5,909	2,462	2,449	4,911	5,310	5,510	10,820
Wastewater System									
Probable construction cost[1]	4,170	1,910	6,080	3,025	1,367	4,392	7,195	3,277	10,472
Contingencies	625	345	970	454	205	659	1,079	550	1,629
Engineering and administration	625	345	970	454	205	659	1,079	550	1,629
Subtotal	5,420	2,600	8,020	3,933	1,777	5,710	9,353	4,377	13,730
Storm Drainage System									
Probable construction cost[1]	2,289	123	2,412	928	14	942	3,217	137	3,354
Contingencies	272	18	290	139	2	141	411	20	431
Engineering and administration	91	181	272 ✓	47	94	141	138	275	413
Subtotal	2,652	322	2,974	1,114	110	1,224	3,766	432	4,198
Solid Waste System									
Probable construction cost[1]	449	438	937	--	316	316	449	754	1,253
Contingencies	26	--	26	--	--	--	26	--	26
Engineering and administration	13	12	25	--	--	--	13	12	25
Subtotal	538	450	988	--	316	316	538	766	1,304
Total Project Costs	11,458	6,433	17,891	7,509	4,652	12,161	18,967	11,085	30,052
Equivalent U.S. $ Cost (U.S. $ = 0.300 JD)		59,637,000			40,537,000			100,174,000	

[1] Including right-of-way



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	UNIT COST FOR SEWER CONSTRUCTION	FIGURE 9-1 DATE SEPT. 1979 BY A. TAYEH CHECKED P. J. H.

Some costs are basic to the capital cost estimates for each proposed facility. These include:

a. Costs of skilled labor -- Truck drivers, heavy equipment operators -- 140 to 200 JD per month.

b. Costs of common labor -- 75 JD per month.

c. Land prices -- Land prices vary depending on the location. In the wastewater treatment analysis and solid waste system analysis, land costs of 1.5 JD/sq m were assumed.

d. Contingency -- 15 percent of construction cost.

e. Engineering and administration -- 15 percent of construction cost.

2. Price Escalation.

Although inflation is not considered in the evaluation of alternative facility plans, it is a significant factor affecting the total cost of the planned project. Capital equipment costs that will be sensitive to inflationary pressure, should be incurred with as little delay as possible to meet near future needs. Delay in construction will adversely affect the costs of the project. Specific assumptions concerning inflation are presented in the cash flow analysis (subsection 9.3.4).

3. Depreciation and Salvage.

Depreciation and salvage are important factors in planning municipal facilities. Depreciation is reflected in the scheduled purchasing of equipment. The rate and amount of depreciation are presented in the financial statements.

Net salvage values are normally considered to be zero, since the type of equipment supplied is generally custom designed and has a limited resale market. Most of the equipment is scheduled to be essentially consumed during the project life. Net salvage value could even conceivably be negative. In this case, the cost of disposing of discarded equipment could be a problem, or the cost of restoring land to a state where it is again suitable for public use could exceed the salvage value.

4. Discount Rate.

A 10-percent discount rate was selected for the purpose of determining the cost effectiveness of alternative water supply distribution, sewerage, stormwater drainage, and solid waste disposal plans. Since the objective of the cost-effectiveness analysis is to assess costs of alternatives in a common time period by assuming that each alternative produces the same benefits, the discount rate reduces the costs of alternatives to a present value. The present value of the costs of each alternative can then be compared to determine the most cost-effective solution.

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This 10-percent rate is identical to the rate selected for other recent projects in Jordan (Jordan Valley study, Potash study).

9.2.2 Phase 1 Costs

The initial Phase 1 capital costs, expressed in 1979 JD, are presented in Table 9-2. The scheduling of these costs reflects the plan for meeting the facilities needs of the residents of Irbid. Details of these costs are presented in Chapters 4, 5, 6, and 7. Total project costs and costs of each element are summarized as follows:

1979 Capital Costs

Water supply system.	5,909,000 JD
Wastewater system.	8,020,000 JD
Storm drainage system.	2,974,000 JD
Solid waste system	988,000 JD
Total Costs (1979 JD).	17,891,000 JD

For the financial analyses, 1979 capital costs are escalated at an annual inflation rate of 10 percent. This rate corresponds to recent historic experience and future projections for inflation of capital goods in the countries to which purchases will be directed. The escalated Phase 1 capital costs are presented in Table 9-3.

Phase 1 operation and maintenance costs, escalated at a 15-percent annual inflation rate, are presented in Table 9-4.

9.2.3 Phase 2 Costs

As with Phase 2 costs, the additional costs associated with planned future development in Irbid between 1990 and 2000 are expressed in 1979 JD. Depending on the year in which they are incurred, these costs will be higher than the 1979 estimates as a result of inflation. The additional Phase 2 project costs are as follows:

1. Water distribution system costs -- 4,911,000 JD.

2. Wastewater collection and treatment system costs -- 5,710,000 JD.

3. Stormwater drainage system costs -- 1,224,000 JD.

4. Solid waste disposal system costs -- 316,000 JD.

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Phase 1 Construction Funding Schedule
(Costs - JD x 1,000)

Description	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Total Phase 1 Cost
Water Supply System											
Water supply system costs	927	2,782	--	--	--	440	440	440	440	440	5,909
Wastewater System											
Wastewater treatment	283	1,131	1,131	--	--	--	--	--	--	--	2,545
Sewer construction	--	2,372	3,103	--	--	--	--	--	--	--	5,475
Subtotal--Wastewater System Costs	283	3,503	4,234	--	--	--	--	--	--	--	8,020
Storm Drainage System											
Storm drainage system costs	991	1,983	--	--	--	--	--	--	--	--	2,974
Solid Waste System											
Landfill development	440	110	--	--	--	--	--	--	--	--	550
Equipment procurement	162	--	25	--	22	100	30	69	--	30	438
Subtotal--Solid Waste System	602	110	25	--	22	100	30	69	--	30	988
Total Project Costs	2,803	8,378	4,259	--	22	540	470	509	440	470	17,891
Equivalent U.S. Dollar Cost (1.00 U.S. dollar = 0.300 JD)	9,343,000	27,927,000	14,197,000	--	72,000	1,800,000	1,567,000	1,697,000	1,467,000	1,567,000	59,637,000

Note: All costs in this table are constant 1979 costs.

Table 9-3

Phase 1 Construction Funding Schedule
Escalated Costs
(Costs - JD x 1,000)

Description	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Total Phase 1 Cost
Water Supply System											
Water supply system costs	1,019	3,366	--	--	--	779	857	943	1,037	1,141	9,142
Wastewater System											
Wastewater treatment	311	1,368	1,505	--	--	--	--	--	--	--	3,184
Sewer construction	--	2,870	4,130	--	--	--	--	--	--	--	7,000
Subtotal--Wastewater System Costs	311	4,238	5,635	--	--	--	--	--	--	--	1,018
Storm Drainage System											
Storm drainage system costs	1,090	2,399	--	--	--	--	--	--	--	--	3,489
Solid Waste System											
Landfill development	484	133	--	--	--	--	--	--	--	--	617
Equipment procurement	178	--	33	--	35	177	58	147	--	77	705
Subtotal--Solid Waste System	662	133	33		35	177	58	147	--	77	1,322
Total Project Costs	3,082	10,136	5,668	--	35	956	915	1,090	1,037	1,218	24,137
Equivalent U.S. Dollar Cost (1.00 U.S. dollar = 0.300 JD)	10,273,000	33,787,000	18,893,000	--	117,000	3,187,000	3,050,000	3,633,000	3,457,000	4,060,000	80,457,000

Note: All costs in this table are escalated from 1979 costs.

Source: Tables 9-8, 9-11, and 9-14.

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Table 9-4

Phase 1 Operation and Maintenance -- Escalated Costs

(Costs - JD x 1,000)

Description	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Total Phase 1 Cost
Water Supply System	137	158	182	209	241	277	319	367	422	485	2,797
Wastewater System	0	0	0	299	458	527	606	697	802	922	4,311
Storm Drainage System	3	3	4	4	5	6	7	8	9	11	60
Solid Waste System	187	220	296	314	410	661	585	825	717	950	5,165
Total Project Operation and Maintenance	327	381	482	826	1,114	1,471	1,517	1,897	1,950	2,368	12,333

9.3 FINANCIAL ANALYSIS

This section presents the preliminary financial analysis of the proposed facility plans for the Municipality of Irbid. The analysis is of sufficient depth to identify the financial feasibility of the proposed project. This section contains available financial information from the existing municipal departments which are currently serving the residents with water and solid waste management. It addresses tariff considerations, and assesses the adequacy of proposed financing arrangements, including grants, loans, repayment schedules, and fees and charges. An analysis of the sensitivity to change in the basic assumptions is included. Presentations of income and expenditure statements, balance sheets, and cash flow financial statements are included for the 10-year Phase 1 planning period. Since no audits of existing municipal department operations were available, and creating such information from partial records was of questionable value, financial statements are limited to the future project.

9.3.1 Basis for Pricing Policies

A major objective of the financial analysis is the determination of effective user charges and fees that will permit stable operation of the proposed facilities in Irbid. User charges are also important mechanisms for efficiently allocating scarce resources, and for achieving other economic and social objectives.

During this study, consideration was given to the existing progressive unit cost pricing policy for water, as well as theoretical and practical approaches that may be used. Pricing approaches which were considered are discussed more fully in Appendix D.

A multipart full-cost pricing approach was developed for the planned Phase 1 project water supply and wastewater elements. A flat-rate approach is used for the solid waste system. The drainage system will be financed by local municipal taxes.

9.3.2 Existing Municipal Operations

This section discusses operations of the Irbid Water Department and Department of Public Works with respect to water supply and solid waste disposal. The information is important since it reflects the ability of these departments to provide municipal services, and it can influence the selection of institutional alternatives to implement the proposed facilities plans. Some of the existing financial information is used as input to the cash flow analysis (costs of existing facilities and operations that will continue into the future). In addition to these municipal departments, this section provides details on municipal taxes which could be used to pay the costs of the storm-water collection system.

9.3.2.1 Water System/Irbid Water Department.

1. Rate and Fee Schedule.

Water consumption in Irbid is billed bimonthly. The current nationally-administered scale of charges that was introduced in May 1979 is applicable to all consumers, and is as follows:

Current Water Pricing Schedule

Water Consumption (cu m)	Consumption Charges (fils/ cu m)
0-5	80
6-15	120
16-25	220
26 and above	300

According to the same national pricing schedule, wholesale water prices are established at 65 fils/cu m.

Since many of the revenues and expenditures that are presented in this section were based on the previous pricing schedule, it is also included, as follows:

Previous Water Pricing Schedule

Water Consumption (cu m)	Consumption Charges (fils/cu m)
0-5	80
6-15	100
16-20	180
20 and above	250

Prior to May 1979, the wholesale water price was set at 60 fils/cu m.

The following tabulation presents the Water Department's record of water inflow, sold water, and revenues from water sales over the past several years.

Year	Total Water Inflow (cu m)	Total Sold Water (cu m)	Total Revenue From Sold Water (JD)	Average Price (JD/cu m)
1976	1,157,200	889,800	NA	NA
1977	1,591,000	1,085,000	110,400	0.102
1978	1,752,400	1,314,000	127,400	0.096
1979	2,054,000[1]	1,540,500[1]	(180,000)[2]	(0.116)
			(227,000)[3]	(0.148)

Total water inflow is the quantity of water that is purchased by the Water Department from the Water Supply Corporation. Each cubic meter of water cost the Water Department 60 fils for the years 1976 to 1978. The difference between total water inflow and total sold water is the quantity of unaccounted for water. This loss has been over 30 percent until recently when it decreased to 25 percent. It is significant since the Water Department pays the per unit wholesale price on total water inflow and cannot recover that cost unless it is able to sell water to its customers.

Based on the previous pricing schedule, revenue from water sales in 1977 (current and previous balance) amounted to 110,400 JD. Revenue increased to 127,400 JD in 1978, an increase of 15.4 percent. Projected 1979 water sales (1979 budget) will be approximately 180,000 JD. Between 1978 and 1979 water sales are expected to increase by 41 percent. This increase reflects the increase in water consumption, the new pricing schedule, and the effort of the municipality to provide water service to more residents. The average unit charge increased to approximately 148 fils/cu m.

The Water Department also administers various connection and administrative fees. The following charges are collected from each new customer:

---

[1] Projected annual quantity estimated from figures available for the first eight months of 1979.

[2] Estimated water sales from the Water Department 1979 budget.

[3] Estimated water sales based on late 1979 estimates; probably more accurate than budget estimate since it includes statements of actual revenue for the first eight months of 1979 (151,811 JD).

Type of Fee or Charge	Charge (JD)
Basic fee (nonrefundable)	5.000
Deposit (refundable)	5.000
New network	3.000
Meter	5.500
Meter installation	1.000
Pipe:	
Up to 30 meters	5.000
Additional length (per meter)	0.100
Gross Fee	24.500

Total revenue from new connections increased from 100 JD in 1977, to 1,500 JD in 1979.

Table 9-5 presents the Water Department income and expenditures for 1977, 1978, and 1979. This table identifies the water sale and connection revenues. It is interesting to note the rather significant differences between budgeted and actual revenues. In 1977, the difference was 14 percent, while in 1978 the budget overstated actual revenues by 36 percent. This difference is even more puzzling when budgeted and actual revenues are compared with operation expenses. Budgeted expenses and actual expenses vary by 134 percent in 1977, and 175 percent in 1978. Budgeted expenses exceeded actual expenses in both cases.

Much of the problem seems to occur in purchasing wholesale water. From the records available in 1977, e.g., budget expense for wholesale water was 63,000 JD, while expenses were 33,800 JD. For the same year, the wholesale water previous balance was 97,200 JD, an apparent debt that was carried forward yearly, and increased by the amount of the apparently unpaid wholesale water charge from the previous year. In 1978, the wholesale water previous balance increased by 37,000 JD, the amount of unpaid wholesale water charge from the previous year. Similar increases occur yearly for 1978 and 1979, as the wholesale water previous balance increased to 172,000 JD.

Because of the accounting practices used in Irbid, it is difficult to make a fair evaluation of the information in the budgeted and actual income and expenditure record. As a result, no attempt is made here to present a full evaluation of the information presented in Table 9-5.

Although officials suggest that municipal government is not subsidized by the national government, it appears that nonpayment of wholesale water costs is a form of municipal support. An evaluation of the Amman Water and Sewer Authority records, which was presented in the Amman

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Table 9-5

Irbid Water Department
Income and Expenditures
(JD x 1,000)

	1977		1978		1979
	Budget	Actual	Budget	Actual	Budget
Income					
Water sales					
Current	100.0	110.4	150.0	127.4	180.0
Previous balance	25.0		36.6		38.5
Connection fee	1.0	0.1	1.0	0.9	1.5
Reconnection fees	1.2	1.2	2.0	2.8	3.5
Meter maintenance	6.0	6.2	8.0	5.9	8.0
Individual participation for network extension	4.0	2.9	5.0	8.8	10.0
Purchasing forms	0.1	0.02	0.1	0.1	0.2
Miscellaneous	-	-	2.0	5.1	7.0
Total Income	137.3	120.82	207.7	151.0	248.7
Expenses					
Wages and salaries	18.6	15.6	21.4	18.2	24.4
Rent, building maintenance	6.0	5.7	8.0	6.7	7.0
Operation and maintenance					
Fuel	8.2	6.9	8.0	5.6	7.0
Maintenance	33.2	33.1	34.0	32.7	39.1
Chemicals	0.8	0.8	1.5	0.6	1.0
Wholesale water	63.0	33.8	75.0	37.3	75.0
Wholesale water--previous balance	97.2	-	134.9	-	172.0
Other Expenses	2.5	1.9	4.9	1.8	4.3
Total Expenses	229.5	97.8	287.7	102.9	329.8

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Sewer and Water Feasibility Study, November 1977, suggests a similar cumulative increasing deficit.

2. Wholesale Price of Water.

The wholesale price of water to the City of Irbid is currently 65 fils/cu m. The current price was administratively established, based on national policy to provide sufficient water to the entire Jordanian population. The current price is 38 percent below the price (105 fils/cu m) needed to cover all costs of providing wholesale water, according to a recent Water Supply Corporation report. The difference between earned revenues and expenses (240,000 JD) is the government subsidy paid to the Water Supply Corporation to balance costs of water production, and revenues collected to meet these obligations.

The wholesale price of water to the City of Irbid is expected to increase in future years as new, more expensive sources of water are developed.

Recent talks with Stanley Engineers concerning the anticipated cost of producing treated water through the future Jordan Valley Authority domestic water supply project, suggest that the cost can realistically rise to 250-270 fils/cu m. A wholesale price of 250 fils/cu m is used in this study to evaluate the future price of water to customers. The retail price of water includes the wholesale price, plus the costs of water distribution in Irbid.

3. Evaluation.

Irbid's water pricing and current billing practices are discussed in the following paragraphs.

a. Pricing. Existing Irbid water pricing schedules can be described as a multipart pricing schedule with two components:

- A fee schedule associated with the administration and technical aspects of providing service to a customer which reflects the true cost of individualized installation.

- A pricing schedule related to water use which imposes progressively higher charges for additional units of water consumption.

This water use pricing schedule is used throughout the Kingdom, with the exception of the City of Amman.

Wholesale prices at 65 fils/cu m are substantially less than the cost of providing the water. The actual charge apparently should be at least 105 fils/cu m. The major effect of these charges is to underprice scarce water resources, and to encourage inefficient use.

b. Effects of Current Billing Practices. The intent of the national water pricing policy is that the billing schedules reflect progressive unit rates administered on a monthly basis. Current practice, however, charges customers for service bimonthly. The effect of this practice is to charge customers at higher rates than is intended by the Kingdom's charge schedule. This problem is documented further in subsection 9.4.1 where municipal service rates and ability to pay are discussed.

c. Effective Water Price and Water Loss Problems. Based on information collected from the Irbid Water Department, it is apparent that the existing water system has experienced considerable loss of water, either due to leaks or unmetered water use. From this information, it appears that efforts are being made to reduce these losses which were estimated to be 32 percent in 1977 and 25 percent in 1978. The Municipality buys water from the Water Supply Corporation at the wholesale price of 0.065 JD, and sells water to the public at the progressive per unit costs. Since at least 25 percent of the water purchased from the Water Supply Corporation is lost, it is possible to calculate the effective price the Municipality obtains per cubic meter of sold water, assuming that these losses will be borne only by the existing water customers.

The Irbid Water Department currently employs 91 persons. Their duties are described in Chapter 4, subsection 4.2.2.

The Water Department is currently repaying loans for previous water system improvements. This study assumes that the current value of the Water Department assets to be carried forward to a proposed management agency is equal to the outstanding debt, 75,000 JD. This debt is payable in the amount of 18,000 JD in 1980 and 1981, and 13,000 JD per year in 1982 through 1984.

9.3.2.2 Solid Waste System.

1. Rate and Fee Schedule.

The solid waste section in the Municipality of Irbid is organized according to Ordinance No. 1, 1978 "Ordinance of Odor Prevention and Solid Waste for Collection Within the Limits of Municipalities" issued according to Article 41 of the Municipalities Law No. 29 of 1955.

Article 8 of this ordinance lists the current solid waste fee schedules for the Kingdom. These fee schedules are described in Appendix E.

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Data available indicate that the present solid waste department labor force includes 200 men who work approximately 6 hours/day, 6 days/week. The collection frequency is as follows:

a. Commercial waste is picked up daily (except Friday).
b. Residential waste is picked up every other day.
c. Some outlying areas are picked up every third day.

2. Income and Expenses.

Table 9-6 shows revenue and expense figures for the Municipality of Irbid solid waste department for 1977, 1978, and the first eight months of 1979.

The 6-JD annual fee charged to each residence is the principal revenue item. It accounts for over 90 percent of the solid waste system revenue. The amount collected from nonresidential customers has increased almost three times since 1977. This increase was caused by two factors:

a. Professional license rates were increased to between 10 and 20 JD per year from the previous rate of 2 to 6 JD per year.

b. The total number of businesses increased.

The largest expense item in the solid waste department is for staff salaries and wages. It accounts for approximately 90 percent of the total expenses.

In 1977, the net income generated from solid waste collection amounted to 20,800 JD. In 1978, a deficit of 14,000 JD was recorded. The solid waste system current assets are primarily collection vehicles. The estimated current net value of these assets to be carried forward to the proposed management agency is 35,000 JD.

9.3.2.3 Municipal Taxes.

Table 9-7 shows Municipality of Irbid taxes and fees for the period 1976 to 1979. Taxes and fees are categorized into three areas as follows:

1. Governmental Fees. A portion of the fuel oil fees collected by the central government are returned to the Municipality. This fee returned to Irbid increased from 60,000 JD in 1976, to 222,000 JD in 1979.

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Table 9-6

Solid Waste Revenues and Expenses
(JD x 1,000)

Description	1977	1978	1979
Income			
Residential fees	97.8	102.0	106.8
Subsidies	--	--	--
Taxes (commercial)	2.9	3.2	8.5
Other	2.0	2.0	2.0
Total Income	102.7	107.2	117.3
Expenses			
Salaries	74.5	108.0	72.0[1]
Building maintenance and rent	5.3	7.1	4.5[1]
Operation and maintenance	0.2	1.2	2.0[1]
Miscellaneous	0.8	1.0	0.8[1]
Other compensation	1.1	3.9	2.1[1]
Total Expenses	81.9	121.2	81.4[1]

[1] Expenses for eight months, January to September 1979.

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Table 9-7

Municipal Taxes -- Irbid

Description	1976	1977	1978	1979[1]
Governmental Fees (fuel oil tax)	60,000	130,000	182,000	222,000
Municipal Fees				
Building and property tax	68,600	61,000	42,300	81,000
Slaughtering fees	9,200	11,000	10,700	20,000
Fruit and vegetable fee	57,000	92,000	105,900	130,000
Health license fee	6,200	7,400	7,900	8,500
Construction fee	7,600	7,700	16,000	16,000
Refrigeration fee	9,000	19,000	21,600	35,000
Municipal court fee	27,000	38,700	30,300	31,000
Other Revenues				
Electricity	5,600	7,200	5,600	5,600
Rent	32,600	37,700	57,300	80,000
Septic tank	11,200	7,100	13,900	10,000
Total	294,000	418,800	493,500	639,100

[1]Preliminary figures estimated for 1979.

Source: Municipality of Irbid records

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2. Municipal Fees. Fees collected directly by the Municipality of Irbid are as follows:

   a. Building and property taxes -- These increased from 68,600 JD in 1976, to 81,000 JD in 1979.

   b. Slaughtering Fees -- Collected per animal slaughtered at the municipal slaughterhouse. Increased from 9,200 JD in 1976 to 20,000 JD in 1979.

   c. Fruit and vegetable fees -- Levied on the tonnage entering the central market in Irbid. Increased from 57,000 JD in 1976 to 130,000 JD in 1979.

   d. Health license fee -- Levied on every restaurant and trade shop.

   e. Construction fee -- Levied on new buildings. This fee is computed based on the square meters of new construction. It increased from 7,600 in 1976 to 16,000 JD in 1979.

   f. Refrigeration fees -- Fees for use of the municipal facilities.

   h. Municipal court fee.

3. Other Revenues.

   a. Electricity.
   b. Rent from municipally-owned property.
   c. Septic tank -- Pumping fees for emptying septic tanks.

The total amount of fees and taxes collected in Irbid increased from 294,000 JD in 1976, to an estimated amount of 639,100 JD in 1979. This is a 217 percent increase during this period.

9.3.3 Proposed Project and Future Operations

The following sections present analyses of the proposed water supply, wastewater collection and treatment, solid waste disposal, and storm drainage systems.

The cash flow model (see Appendix E) is used in each case where user charges are imposed to determine the most likely base conditions. The construction funding schedule (Table 9-2), user charges, and connection fees were inputed to the cash flow model to produce income and expenditure statements. The user charges and connection fees were manipulated

to produce positive accumulated surpluses on the income and expenditure statement as close to zero as possible.

Outputs from the model were used to produce cash flow statements, balance sheets, and income-expenditure statements which were checked for viability. Where outputs from these statements were unsatisfactory, user charges and connection fees were adjusted to produce new income-expenditure statements.

The model outputs, income-expenditure statements, balance sheets, and cash flow statements presented in this section are those of the final proposed structure and do not contain all of the iterations.

The cash flow model was then used to evaluate the sensitivity of the proposed facility to various factors.

The basic assumption in these analyses is that the municipal services are provided on a nonprofit basis, and are planned to be self-sufficient as soon as possible, relying on service charges and fees for the repayment of initial and future debt. why?

The "most likely" or base condition used in the analyses reflects the construction schedule as indicated in Chapter 10, a medium rate of inflation (10 percent capital and 15 percent for operation and maintenance), financing conditions that are likely to be used, as well as phasing of existing and new users into the system that is most feasible, based on current construction practices.

9.3.3.1 Proposed Water Supply System.

1. Existing Pricing Policy.

In each of the cash flow analyses for the proposed facilities in Irbid, existing pricing policy is first tested to see if sufficient revenues can be generated to cover at least the first several years of operation. Average net water use charges and fees (0.093 JD/month and 0.143 JD/month residential and nonresidential user charges, respectively; and 19.0 JD for the administrative and installation fee) from Appendix E were used initially. They are based on existing policy. Preliminary testing, however, indicated that these user charges were not sufficient to cover the costs of operation. The 19 JD administrative/ connection fee was maintained since it reflected a verified cost of providing this installation. Table 9-8a presents the anticipated revenues.

This table is the first of three tables which fully present the cash flow model analysis. The residential user charge of 0.500 JD/month and nonresidential user charge of 0.770 JD/month are required to generate the necessary revenues in the first two years of operation. The residential rate was increased in 1982 to 1.400 JD and again in 1987 to 1.600 JD in order to increase the revenues and to begin building reserves to support the facilities replacement plan beginning in 1985. Nonresidential charges are increased correspondingly. These fees and charges generate annual revenues which increase from 440,000 JD in 1980 to 1,364,000 JD in 1989.

In 1980, all residents of Irbid who are presently served by the existing water supply system will have to be reconnected to the new system. The 294,000 JD revenue from new customers reflects this reconnection, however, the connection fee generally applied to new system users (19 JD) was reduced to 14 JD since the existing meter would be salvaged. In subsequent years this annual revenue drops to reflect only the new customers entering the system at the 19 JD fee.

Table 9-8b is the anticipated expenditure schedule. Total annual expenses of new facilities increase from 137,000 JD to 1,376,000 JD over the 10-year analysis period.

Table 9-8c is the projected deficit-surplus analysis. User charges are adjusted to prevent the accumulated surplus (Table 9-8c) from becoming negative, and excessively large.

Tables 9-8a, 9-8b, and 9-8c present the base condition water supply system for Irbid.

DATE 22/08/1979

IRBID - THE HASHEMITE KINGDOM OF JORDAN

CASH FLOW ANALYSIS

WATER SUPPLY

WESTON INTERNATIONAL, AUGUST 1979

Table 9-8a

Water Supply
Anticipated Revenues

ASSUMPTIONS:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

FINANCING:
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

ANTICIPATED REVENUES (THOUSANDS OF J.D)

YEAR	NUMBER OF CUSTOMERS RESIDENT	NUMBER OF CUSTOMERS NONRSED	USER CHARGES J.D. / MONTH RESIDENT	USER CHARGES J.D. / MONTH NONRESD	REVENUE FROM CUSTOMERS RESIDENT	REVENUE FROM CUSTOMERS NONRESD	ADMINISTR. CONNECTION FEE (LD)	REVENUE FROM NEW CUSTOMERS	RATE OF HOUSEHOLD WATER USE INCREASE	TOTAL ANNUAL REVENUE
1980	17378	3688	0.50	0.77	104	34	14	294	1.062	440
1981	18272	3993	0.50	0.77	109	36	19	22	1.062	185
1982	19174	4227	1.40	2.15	322	109	19	21	1.062	537
1983	20201	4457	1.40	2.15	339	114	19	23	1.062	599
1984	21237	4701	1.40	2.15	356	121	19	24	1.062	668
1985	23441	4946	1.40	2.15	393	127	19	46	1.062	792
1986	24675	5189	1.40	2.15	419	133	19	27	1.062	860
1987	25922	5444	1.60	2.46	497	160	19	28	1.062	1091
1988	27304	5690	1.60	2.46	524	167	19	30	1.062	1217
1989	28825	5977	1.60	2.46	553	176	19	34	1.062	1364

NOTES:

(1) NUMBER OF CUSTOMERS : CALCULATED AS EQUIVALENT DEVELOPMENT UNITS BASED ON 92 PERCENT OF TOTAL POPULATION IN 1980 AND 97 PERCENT OF POPULATION IN 1990.
(2) EQUIVALENT NONRESIDENT USER CHARGE IS 1.54 OF RESIDENT CHARGE.
(3) RATE OF HOUSEHOLD WATER USE INCREASE, BASED ON PROJECTED PER CAPITA WATER CONSUMPTION AND DECREASING HOUSEHOLD SIZE.
(4) ADMINISTRATIVE CONNECTION FEE DOES NOT INCLUDE THE COST OF THE METER WHICH IS PASSED THROUGH.

DATE 22/08/1979

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* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* WATER SUPPLY                          *
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* WESTON INTERNATIONAL, AUGUST 1979     *
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Table 9-8b

Water Supply
Anticipated Expenditures

ASSUMPTIONS:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

FINANCING:
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

ANTICIPATED EXPENSES:THOUSANDS OF J.D)

YEAR	REVENUE REQUIRED FOR NEW FACILITIES TOTAL CAPITAL COST(1979 JD)	GRANT	NET CAPITAL COST	NET CAPITAL COST INFLATED(10PC)	GRACE PERIOD INTEREST PAYMENT	LOCAL DEBT ANNUAL PAY. (6.0PC+20YR) (1)	O+M IN 1979 (J.D)	O+M INFLATED (15PC) (2)	TOTAL EXPENSE OF NEW FACILITIES = 3 Dat / ... & OM
1980	927	0	927	1019	61	0	120	137	137
1981	2782	0	2782	3 66	267	0	120	158	158
1982	0	0	0	0	214	105	120	182	287
1983	0		0	0	0	454	120	209	663
1984	0	0	0	0	0	454	120	241	695
1985	440	0	440	779	0	525	120	277	802
1986	440	0	440	857	0	604	120	319	923
1987	440	0	440	943	0	691	120	367	1058
1988	440	0	440	1037	0	786	120	422	1208
1989	440	0	440	1141	0	891	120	485	1376

NOTES:

(1) CAPITAL COST FOR 1980 INCLUDES 7000 JD FOR TAPPING EQUIPMENT .
(2) NO GRANTS AT THIS TIME.
(3) GRACE PERIOD APPLIES ONLY TO MAJOR INITIAL INVESTMENTS.
FOR EXAMPLE NOT APPLICABLE TO 1985 THRU 1989 CAPITAL COSTS.

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* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
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* CASH FLOW ANALYSIS                    *
*                                       *
* WATER SUPPLY                          *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
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Table 9-8c

Water Supply
Deficit-Surplus Analysis

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

D E F I C I T - S U R P L U S A N A L I S I S (T H O U S A N D S J.D.)

YEAR	TOTAL REVENUE REQ. FOR NEW FACILITIES	DEBT SERVICE ON CURRENT FACILITIES	O+M ON CURRENT FACILITIES	TOTAL EXPENSES	TOTAL REVENUE	ANNUAL SURPLUS	ACCUMULATED
1980	137	18	50	205	440	235	235
1981	158	18	40	216	185	-31	204
1982	287	13	30	330	537	207	411
1983	663	13	20	696	599	-97	314
1984	695	13	10	718	668	-50	264
1985	802	0	0	802	792	-10	254
1986	923	0	0	923	860	-63	191
1987	1058	0	0	1058	1091	33	224
1988	1208	0	0	1208	1217	9	233
1989	1376	0	0	1376	1364	-12	221

NOTES:

(1) O+M ON CURRENT FACILITIES DOES NOT INCLUDE SALARIES OF PERSONEL,
THESE ARE PROJECTED FROM 1977, 78 , AND 79 MAINTANANCE COST ON EXISTING FACILITIES.

Because of the need to reconnect many presently connected residential and nonresidential users to the new water system, it is important to test the effect of a policy decision to either charge these residents or to reconnect them at no charge. The base case water supply analysis (Tables 9-8a, 9-8b, and 9-8c) includes a reduced 14 JD administrative/connection fee for reconnecting these users to the system. The revenue generated by this fee is 294,000 JD. One option is to redistribute the costs of reconnecting current users into an increased user charge.

Tables 9-9a, 9-9b, and 9-9c present this analysis, and show that residential user charges would have to be increased from the base case level (0.500 JD/month) in 1980 to 0.800 JD/month, an increase of over 60 percent. However, in general, future charges would require an increase of less than 10 percent, in which case they would increase from 0.400 JD to 1.500 JD/month.

2. Sensitivity Test.

The effect of parameter changes in the 1989 accumulated surplus of the water distribution system was analyzed using the cash flow model. The most important inputs to the cash flow: user charges, capital costs, inflation rates, user population, and per capita water consumption rate of increase were varied separately as indicated in Table 9-10.

Table 9-10 also shows the base conditions for the sensitivity test with a 1989 accumulated surplus of 221,000 JD, and presents the 1989 accumulated surpluses and deficits resulting from the variance in the input parameters. It can be seen that all of the tested parameters are sensitive. This test indicates that the operating agency must monitor parameters it does not directly control, such as inflation, per capita water use, and connected population, and adjust user charges as necessary to generate the revenues required to maintain the financial stability of the project.

9.3.3.2 Proposed Wastewater System.

An attempt was made to incorporate the national pricing structure into the analysis of the proposed wastewater collection and treatment system for Irbid. These charges, however, were not adequate to cover the wastewater system costs for Irbid.

Table 9-11a shows residential user charges of 1.000 JD/month and non-residential user charges of 1.230 JD/month are required to generate sufficient revenues for the proposed system in the first year of operation (1983). These fees, together with administrative/connection fees and septage dumping fees, generate annual revenues of 136,000 JD in the first year of operation (1983). Revenues increase to 2,056,000 JD in 1989.

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* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
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* CASH FLOW ANALYSIS                    *
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* WATER SUPPLY                          *
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* WESTON INTERNATIONAL, AUGUST 1979     *
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Table 9-9a

Water Supply
Anticipated Revenues
(No Connection Fee For
Existing Users)

ASSUMPTIONS:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

FINANCING :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

ANTICIPATED REVENUES (THOUSANDS OF J.D)

YEAR	NUMBER OF CUSTOMERS RESIDENT	NUMBER OF CUSTOMERS NONRESD	USER CHARGES J.D. / MONTH RESIDENT	USER CHARGES J.D. / MONTH NONRESD	REVENUE FROM CUSTOMERS RESIDENT	REVENUE FROM CUSTOMERS NONRESD	ADMINISTR. CONNECTION FEE (LD)	REVENUE FROM NEW CUSTOMERS	RATE OF HOUSEHOLD WATER USE INCREASE	TOTAL ANNUAL REVENUE
1980	17378	3688	0.80	1.23	166	54	0	0	1.062	233
1981	18272	3993	0.80	1.23	175	58	19	22	1.062	284
1982	19174	4227	1.50	2.31	345	117	19	21	1.062	574
1983	20201	4457	1.50	2.31	363	123	19	23	1.062	641
1984	21237	4701	1.50	2.31	382	130	19	24	1.062	715
1985	23441	4946	1.50	2.31	421	137	19	46	1.062	846
1986	24675	5184	1.50	2.31	444	143	19	27	1.062	921
1987	25922	5444	1.60	2.46	497	160	19	28	1.062	1091
1988	27304	5690	1.60	2.46	524	167	19	30	1.062	1217
1989	28825	5977	1.60	2.46	553	176	19	34	1.062	1364

NOTES:

(1) NUMBER OF CUSTOMERS : CALCULATED AS EQUIVALENT DEVELOPMENT UNITS BASED ON 92 PERCENT OF TOTAL POPULATION IN 1980 AND 97 PERCENT OF POPULATION IN 1990.
(2) EQUIVALENT NONRESIDENT USER CHARGE IS 1.54 OF RESIDENT CHARGE. (Basis?)
(3) RATE OF HOUSEHOLD WATER USE INCREASE, BASED ON PROJECTED PER CAPITA WATER CONSUMPTION AND DECREASING HOUSEHOLD SIZE.
(4) ADMINISTRATIVE CONNECTION FEE DOES NOT INCLUDE THE COST OF THE METER WHICH IS PASSED THROUGH

DATE 22/08/1979

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*****************************************
* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* WATER SUPPLY                          *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
*                                       *
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Table 9-9b

Water Supply
Anticipated Expenses
(No Connection Fee For
Existing Users)

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D E X P E N S E S (T H O U S A N D S O F J.D)

YEAR	REVENUE REQUIRED F OR NEW FACILITIES TOTAL CAPITAL COST(1979 JD)	GRANT	NET CAPITAL COST	NET CAPITAL COST INFLATED(10PC)	GRACE PERIOD INTEREST PAYMENT	LOCAL DEBT ANNUAL PAY. (6.0PC+20YR)	O+M IN 1979 (J.D)	O+M INFLATED (15PC)	TOTAL EXPENSE OF NEW FACILITIES
1980	927	0	927	1019	61	0	120	137	137
1981	2782	0	2782	3366	267	0	120	158	158
1982	0	0	0	0	214	105	120	182	287
1983	0	0	0	0	0	454	120	209	663
1984	0	0	0	0	0	454	120	241	695
1985	440	0	440	779	0	525	120	277	802
1986	440	0	440	857	0	604	120	319	923
1987	440	0	440	943	0	691	120	367	1058
1988	440	0	440	1037	0	786	120	422	1208
1989	440	0	440	1141	0	891	120	485	1376

NOTES:

(1) CAPITAL COST FOR 1980 INCLUDES 7000 JD FOR TAPPING EQUIPMENT .
(2) NO GRANTS AT THIS TIME.
(3) GRACE PERIOD APPLIES ONLY TO MAJOR INITIAL INVESTMENTS,
FOR EXAMPLE NOT APPLICABLE TO 1985 THRU 1989 CAPITAL COSTS.

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* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* WATER SUPPLY                          *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
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Table 9-9c

Water Supply
Anticipated Revenues
(No Connection Fee For
Existing Users)

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 2 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

D E F I C I T - S U R P L U S A N A L I S I S (T H O U S A N D S J.D.)

YEAR	TOTAL REVENUE REQ. FOR NEW FACILITIES	DEBT SERVICE ON CURRENT FACILITIES	O+M ON CURRENT FACILITIES	TOTAL EXPENSES	TOTAL REVENUE	ANNUAL SURPLUS	ACCUMULATED
1980	137	18	50	205	233	28	28
1981	158	18	40	216	284	68	96
1982	287	13	30	330	574	244	340
1983	663	13	20	696	641	-55	285
1984	695	13	10	718	715	-3	282
1985	802	0	0	802	846	44	326
1986	923	0	0	923	921	-2	324
1987	1058	0	0	1058	1091	33	357
1988	1208	0	0	1208	1217	9	366
1989	1376	0	0	1376	1364	-12	354

NOTES:
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(1) O+M OF CURRENT FACILITIES DOES NOT INCLUDE SALARIES OF PERSONEL,
THESE ARE PROJECTED FROM 1977, 78 , AND 79 MAINTANANCE COST ON EXISTING FACILITIES.

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Table 9-10

Parameter Sensitivity Analysis
Water Distribution System
(000 10 o)

Parameter	Accumulated	Range of 1989 Surplus (Deficit)
User Charge		
±10 percent of base	(502)	962
Capital Cost		
±10 percent of base	(112)	546
±20 percent of base	(437)	879
Inflation		
±10 percent of base	(81)	514
±20 percent of base	(595)	929
User Population		
±10 percent of base each year	(557)	1,000
Per Capita Water Consumption Rate of Increase		
±10 percent of base	(284)	708

Base Case for Sensitivity Analysis

Inflation rate, capital--10 percent
Inflation rate, operation and maintenance--15 percent
Per capita water consumption rate of increase = 1.062
User charges--see Table 9-8a
Capital cost scheduling--see Table 9-8b
User population--see Table 9-8a
Accumulated surplus--221,000

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IBRID -THE HASHEMITE KINGDOM OF JORDAN

CASH FLOW ANALYSIS

WASTEWATER COLLECTION AND TREATMENT

WESTON INTERNATIONAL, AUGUST 1979

Table 9-11a

Wastewater Anticipated Revenues

ASSUMPTIONS:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

FINANCING :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

ANTICIPATED REVENUES (THOUSANDS OF J.D.)

YEAR	NUMBER OF CUSTOMERS RESIDENT	NUMBER OF CUSTOMERS NONRSED	USER CHARGES J.D. / MONTH RESIDENT	USER CHARGES J.D. / MONTH NONRESD	REVENUE FROM CUSTOMERS RESIDENT	REVENUE FROM CUSTOMERS NONRESD	ADMINISTR. CONNECTION FEE (JD)	REVENUE FROM NEW CUSTOMERS	REVENUE FROM SEPTAGE DUMPING	RATE OF HOUSEHOLD WATER USE INCREASE	TOTAL ANNUAL REVENUE
1980	0	0	0.0	0.0	0	0	0	0	0	1.062	0
1981	0	0	0.0	0.0	0	0	0	0	0	1.062	0
1982	0	0	0.0	0.0	0	0	0	0	136	1.062	136
1983	4938	1089	1.00	1.23	59	16	32	192	152	1.062	439
1984	14815	3279	1.00	1.23	177	48	32	386	166	1.062	855
1985	22537	4713	2.50	3.04	670	171	32	286	180	1.062	1672
1986	23247	4884	2.50	3.04	697	178	32	34	195	1.062	1562
1987	24026	5046	2.50	3.04	720	184	32	30	216	1.062	1708
1988	24935	5201	2.50	3.04	748	189	32	34	223	1.062	1867
1989	25974	5386	2.50	3.04	779	196	32	39	238	1.062	2056

NOTES:

(1) NUMBER OF CUSTOMERS : CALCULATED AS EQUIVALENT DEVELOPMENT UNITS.
(2) USER CHARGES : AVERAGE MONTHLY USER CHARGES BASED ON EXISTING PRICING POLICY.
(3) ADMINISTRATIVE CONNECTION FEE: BASED ON WEIGHTED RENTAL VALUE OF HOUSING AND COMMERCIAL PROPERTIES ADJUSTED FOR INCREASING AFFLUENCE AND INFLATION.
(4) REVENUE FROM SEPTAGE DUMPING : REVENUES FROM PERIODIC PUMPING OF ONSITE SYSTEMS NOT SERVED BY SEWER SYSTEM.
(5) RATE OF HOUSEHOLD WASTEWATER INCREASE : INCREASE IN HOUSEHOLD WASTEWATER USED TO INCREASE ANNUAL REVENUES FROM USER CHARGES BASED ON INCREASING PER CAPITA WATER CONSUMPTION AND DECREASING HOUSEHOLD SIZE.

Over this 10-year study period, it was necessary to raise user charges in 1985 to balance the revenues against the increasing costs of the system. One-time administrative fees were held constant at 32 JD.

Anticipated capital costs and annual expenses associated with the proposed project are presented in Table 9-11b. Capital expenditures of 283,000 JD, 3,503,000 JD, and 4,234,000 JD are incurred in 1980, 1981, and 1982, respectively. Annual operation and maintenance costs begin in 1983 at 299,000 JD, and increase to 922,000 JD in 1989.

The 910,000 JD grant is applied to the wastewater system, and is used to offset the initial period capital expenditures. In 1980, a portion of the grant is used to purchase the 283,000 JD capital. In 1981, the remaining 627,000 JD portion of the grant is used to offset part of the second-year capital purchase.

The grace period interest payments are recapitalized to avoid the need for imposing user charges prior to system operation.

Table 9-11c presents the deficit surplus analysis. The proposed project shows a favorable annual surplus relationship, and the accumulated surplus reaches a maximum of 414,000 JD in 1989.

1. Household Connections.

Estimated engineering and construction costs of connecting individual units into the system will be as much as 200 JD. This cost is normally borne by the homeowner. It is proposed that the burden of this charge would be minimized by initiating a small loan repayment program. The details and impacts are described in subsection 9.4.1.

2. Sensitivity Test.

The effect of parameter changes on the 1989 accumulated surplus of the wastewater system was analyzed in a manner similar to the water distribution system.

Table 9-12 shows the base conditions for the sensitivity test, as well as the accumulated surplus (deficit) resulting from changes in the input parameters. It can be seen that the system is sensitive to all of the tested parameters.

3. Effect of Delay in Construction Schedule.

In addition to the sensitivity tests just presented, the possibility of slippage in the schedule of connecting to the wastewater system was also evaluated. This was modeled by postponing the entry of users into the system by one year. Tables 9-13a, 9-13b, and 9-13c show the impact of this change in schedule on the base condition case (Tables 9-11a, 9-11b, and 9-11c). This slippage creates an accumulated deficit which reaches a peak of -594,000 JD in 1985, and is equal to -212,000 JD in 1989, which compares to the base case surplus of 414,000 JD projected for 1989.

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* IBRID -THE HASHEMITE KINGDOM OF JORDAN *
*                                        *
* CASH  FLOW ANALYSIS                    *
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* WASTEWATER COLLECTION AND TREATMENT    *
*                                        *
* WESTON INTERNATIONAL, AUGUST 1979      *
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Table 9-11b

Wastewater Anticipated Expenditures

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D E X P E N S E S (T H O U S A N D S O F J.D)

YEAR	REVENUE REQUIRED FOR NEW FACILITIES TOTAL CAPITAL COST(1979 JD)	GRANT	NET CAPITAL COST	NET CAPITAL COST INFLATED(15PC)	GRACE PERIOD INTEREST PAYMENT	LOCAL DEBT ANNUAL PAY. (6.0PC*20YR)	O*M IN 1979 (J.D)	O*M INFLATED (15PC)	TOTAL EXPENSE OF NEW FACILITIES
1980	283	283	0	0	0	0	0	0	0
1981	3503	627	2876	3479	209	0	0	0	0
1982	4234	0	4234	5635	559	0	0	0	0
1983	0	0	0	0	593	0	171	299	299
1984	0	0	0	0	380	395	228	458	853
1985	0	0	0	0	0	1035	228	527	1562
1986	0	0	0	0	0	1035	228	606	1641
1987	0	0	0	0	0	1035	228	697	1732
1988	0	0	0	0	0	1035	228	802	1837
1989	0	0	0	0	0	1035	228	922	1957

NOTES:

(1) REVENUE REQUIRED FOR NEW FACILITIES : CAPITAL COSTS INCLUDE GRACE PERIOD INTEREST WHICH WAS REFINANCED ONLY DURING G RACE PERIOD AS A COST OF CONSTRUCTION.
(2) GRACE PERIOD APPLIES ONLY TO MAJOR INITIAL INVESTMENTS FROM THE TIME THEY ARE INCURRED.
(3) GRANT : INCLUDES US.AID GRANT.

DATE 22/08/1979

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* IBRID -THE HASHEMITE KINGDOM OF JORDAN *
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* CASH  FLOW ANALYSIS                    *
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* WASTEWATER COLLECTION AND TREATMENT    *
*                                        *
* WESTON INTERNATIONAL, AUGUST 1979      *
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Table 9-11c

Wastewater
Deficit-Surplus Analysis

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

D E F I C I T - S U R P L U S A N A L I S I S (T H O U S A N D S J.D.)

YEAR	TOTAL REVENUE REQ. FOR NEW FACILITIES	DEBT SERVICE ON CURRENT FACILITIES	O+M ON CURRENT FACILITIES	TOTAL EXPENSES	TOTAL REVENUE	ANNUAL SURPLUS	ACCUMULATED
1980	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	0	0	136	136	136
1983	299	0	0	299	439	140	276
1984	853	0	0	853	855	2	278
1985	1562	0	0	1562	1672	110	388
1986	1641	0	0	1641	1562	-79	309
1987	1732	0	0	1732	1708	-24	285
1988	1837	0	0	1837	1867	30	315
1989	1957	0	0	1957	2056	99	414

Table 9-12

Parameter Sensitivity Analysis
Wastewater System

Parameter	Accumulated	Range of 1989 Surplus (Deficit)
User Charge		
±10 percent of base	(363)	1,190
Capital Cost		
±10 percent of base	(215)	1,022
±20 percent of base	(844)	1,678
Inflation		
±10 percent of base	(7)	825
±20 percent of base	(788)	1,462
User Population		
±10 percent of base each year	(467)	1,315
±30 " " " "		
Per Capita Water Consumption Rate of Increase		
±10 percent of base	(209)	1,023

Base Case for Sensitivity Analysis

Inflation rate, capital--10 percent
Inflation rate, operation and maintenance--15 percent
Per capita water consumption rate of increase = 1.062
User charges--see Table 9-11a
Capital cost scheduling--see Table 9-11b
User population--see Table 9-11a
Accumulated surplus--414,000

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*                                        *
* CASH  FLOW ANALYSIS                    *
*                                        *
* WASTEWATER COLLECTION AND TREATMENT    *
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* WESTON INTERNATIONAL, AUGUST 1979      *
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Table 9-13a

Wastewater
Anticipated Revenues--
Delayed Connections

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D R E V E N U E S (T H O U S A N D S O F J.D)

YEAR	NUMBER OF CUSTOMERS RESIDENT	NUMBER OF CUSTOMERS NONRSED	USER CHARGES J.D. / MONTH RESIDENT	USER CHARGES J.D. / MONTH NONRESD	REVENUE FROM CUSTOMERS RESIDENT	REVENUE FROM CUSTOMERS NONRESD	ADMINISTR. CONNECTION FEE(JD)	REVENUE FROM NEW CUSTOMERS	REVENUE FROM SEPTAGE DUMPING	RATE OF HOUSEHOLD WATER USE INCREASE	TOTAL ANNUAL REVENUE
1980	0	0	0.0	0.0	0	0	0	0	0	1.062	0
1981	0	0	0.0	0.0	0	0	0	0	0	1.062	0
1982	0	0	0.0	0.0	0	0	0	0	136	1.062	136
1983	0	0	1.00	1.23	0	0	32	0	152	1.062	152
1984	4938	1089	1.00	1.23	59	16	32	192	166	1.062	459
1985	14815	3279	2.50	3.04	444	119	32	386	180	1.062	1373
1986	23247	4884	2.50	3.04	697	178	32	321	195	1.062	1849
1987	24026	5046	2.50	3.04	720	184	32	30	216	1.062	1708
1988	24935	5201	2.50	3.04	748	189	32	34	223	1.062	1867
1989	25974	5386	2.50	3.04	779	196	32	39	238	1.062	2056

NOTES:
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(1) NUMBER OF CUSTOMERS : CALCULATED AS EQUIVALENT DEVELOPMENT UNITS.
(2) USER CHARGES : AVERAGEMONTHLY USER CHARGES BASED ON EXISTING PRICING POLICY .
(3) ADMINISTRATIVE CONNECTION FEE: BASED ON WEIGHTED RENTAL VALU E OF HOUSING AND COMMERCIAL PROPERTIES ADJUSTED FOR INCREASING AFFLUE NCE AND INFLATION.
(4) REVENUE FROM SEPTAGE DUMPING : REVENUES FROM PERIODIC PUMPING OF ONSITE SYSTEMS NOT SERVED BY SEWER SYSTEM.
(5) RATE OF HOUSEHOLD WASTEWATER INCREASE : INCREASE IN HOUSEHOLD WASTEWATER USED TO INCREASE ANNUAL REVENUES FROM USER CHARGES BASED ON INCREASING PER CAPITA WATER CONSUMPTION AND DECREASING HOUSEHOLD SIZE.

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DATE 22/08/1979

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*****************************************
* IBRID -THE HASHEMITE KINGDOM OF JORDAN *
*                                        *
* CASH  FLOW ANALYSIS                    *
*                                        *
* WASTEWATER COLLECTION AND TREATMENT    *
*                                        *
* WESTON INTERNATIONAL, AUGUST 1979      *
*                                        *
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Table 9-13b

Wastewater
Anticipated Expenses--
Delayed Connections

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1992
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D E X P E N S E S (T H O U S A N D S O F J.D)

YEAR	REVENUE REQUIRED FOR NEW FACILITIES TOTAL CAPITAL COST(1979 JD)	GRANT	NET CAPITAL COST	NET CAPITAL COST INFLATED(10PC)	GRACE PERIOD INTEREST PAYMENT	LOCAL DEBT ANNUAL PAY. (6.0PC*20YR)	O+M IN 1979 (J.D)	O+M INFLATED (15PC)	TOTAL EXPENSE OF NEW FACILITIES
1980	283	283	0	0	0	0	0	0	0
1981	3503	627	2876	3479	209	0	0	0	0
1982	4234	0	4234	5635	559	0	0	0	0
1983	0	0	0	0	593	0	171	299	299
1984	0	0	0	0	360	395	228	458	853
1985	0	0	0	0	0	1035	228	527	1562
1986	0	0	0	0	0	1035	228	606	1641
1987	0	0	0	0	0	1035	228	697	1732
1988	0	0	0	0	0	1035	228	802	1837
1989	0	0	0	0	0	1035	228	922	1957

NOTES:
---
(1) REVENUE REQUIRED FOR NEW FACILITIES : CAPITAL COSTS INCLUDE GRACE PERIOD INTEREST WHICH WAS REFINANCED ONLY DURING G RACE PERIOD AS A COST OF CONSTRUCTION.
(2) GRACE PERIOD APPLIES ONLY TO MAJOR INITIAL INVESTMENTS FROM THE TIME THEY ARE INCURRED.
(3) GRANT : INCLUDES US.AID GRANT.

DATE 22/08/1979

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*****************************************
* IGRID -THE HASHEMITE KINGDOM OF JORDAN *
*                                        *
* CASH  FLOW ANALYSIS                    *
*                                        *
* WASTEWATER COLLECTION AND TREATMENT    *
*                                        *
* WESTON INTERNATIONAL, AUGUST 1979      *
*                                        *
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Table 9-13c

Wastewater
Deficit-Surplus Analysis--
Delayed Connections

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 3 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

D E F I C I T - S U R P L U S A N A L I S I S (T H O U S A N D S J.D.)

YEAR	TOTAL REVENUE REQ. FOR NEW FACILITIES	DEBT SERVICE ON CURRENT FACILITIES	O+M ON CURRENT FACILITIES	TOTAL EXPENSES	TOTAL REVENUE	ANNUAL SURPLUS	ACCUMULATED
1960	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0
1962	0	0	0	0	136	136	136
1963	299	0	0	299	152	-147	-11
1964	853	0	0	853	459	-394	-405
1965	1562	0	0	1562	1373	-189	-594
1966	1641	0	0	1641	1849	208	-386
1967	1732	0	0	1732	1708	-24	-410
1968	1837	0	0	1837	1867	30	-380
1969	1957	0	0	1957	2056	99	-281

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9.3.3.3 Proposed Solid Waste Disposal System.

1. Charges.

As with the previous cash flow model analyses, the existing nationally administered charges were tested to see if they would produce sufficient revenues to support the new facility program. The charges, 6 JD/year for residential users and 7 JD/year for nonresidential users, are not adequate and produce large deficits starting with 140,000 JD in 1980.

Charges were raised to generate sufficient revenues and make the solid waste system self sufficient. The monthly charges, shown in Table 9-14a, were increased in 1980 to 1.200 JD for residential customers, and 1.390 JD for nonresidential customers. These charges were increased again in 1983 to produce the required revenues. The monthly charges for 1983 through 1989 are 1.800 JD for residential customers and 2.150 JD for nonresidential customers. Tables 9-14a, 9-14b, and 9-14c present the results of the solid waste system cash flow analysis. The increased user charges are required because of the landfill purchase and construction costs, as well as the substantial equipment purchases.

This schedule of user charges produces annual revenues starting at 351,000 JD in 1980, and increasing to 825,000 JD in 1989. Residential customers represent the major source of revenues. In addition to revenues from nonresidential users (who produce nearly 20 percent of the annual revenues), a small amount of revenue is collected from hospitals and others for disposal of bulky and special wastes.

Total expenses associated with the new facilities are presented in Table 9-14b. These total expenses increase from 244,000 JD in 1980 to 1,018,000 JD in 1989. The initial annual cost represents a doubling of expenditures from the present 121,200 JD reported for 1978 (Table 9-6). The major component of the annual costs in Table 9-14b is operation and maintenance which primarily includes labor.

Table 9-14c integrates the new facility total annual expenses (referred to as total revenue requirements) with the carry-over expenses from the existing solid waste management program. The carry-over of operation and maintenance costs primarily reflects servicing needs for existing vehicles. These operation and maintenance costs are phased out by 1985.

2. Sensitivity Test.

The impacts of changes in a variety of cash flow inputs on the revenues of the solid waste system were analyzed in a manner similar to the water and wastewater systems. The analysis in this instance examined the effects of changes in user charges, capital costs, and inflation rates on capital and operational expenses and user population as they affected the accumulated 1989 surplus or deficit. These data are presented in Table 9-15.

DATE 22/08/1979

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*****************************************
* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* SOLID WASTE DISPOSAL                  *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
*                                       *
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Table 9-14a

Solid Waste
Anticipated Revenues

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 0 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D R E V E N U E S (T H O U S A N D S O F J.D)

YEAR	NUMBER OF CUSTOMERS RESIDENT	NUMBER OF CUSTOMERS NONRESD	USER CHARGES J.D. / MONTH RESIDENT	USER CHARGES J.D. / MONTH NONRESD	REVENUE FROM CUSTOMERS RESIDENT	REVENUE FROM CUSTOMERS NONRESD	ADMINISTR. CONNECTION FEE (JD)	REVENUE FROM NEW CUSTOMERS	SPECIAL SERVICE (J.D)	RATE OF HOUSEHOLD WATER USE INCREASE	TOTAL ANNUAL REVENUE
1980	18889	4009	1.20	1.39	272	66	0	0	13.70	1.000	351
1981	19753	4317	1.20	1.39	284	72	0	0	14.40	1.000	370
1982	20611	4545	1.20	1.39	296	75	0	0	15.00	1.000	386
1983	21605	4769	1.80	2.15	466	123	0	0	15.80	1.000	604
1984	22592	5001	1.80	2.15	487	129	0	0	16.60	1.000	632
1985	24805	5234	1.80	2.15	535	135	0	0	18.00	1.000	688
1986	25974	5457	1.80	2.15	561	140	0	0	18.90	1.000	719
1987	27143	5681	1.80	2.15	586	147	0	0	19.70	1.000	752
1988	28442	5933	1.80	2.15	614	153	0	0	20.60	1.000	787
1989	29870	6194	1.80	2.15	645	159	0	0	21.60	1.000	825

NOTES:
---

(1) NON RESIDENT CUSTOMERS CHARGES ARE BASED ON 10 PERCENT OF ACTUAL OCCUPATIONAL LICENCE FEE WHICH IS AVERAGED TO BE 70 JD / YEAR / LICENCE
(2) ADMINISTRATIVE CONNECTION FEE NOT APPLICABLE .
(3) SPECIAL SERVICES INCLUDE THE DISPOSAL OF ANIMALS, BULKY WASTE AND SPECIAL WASTE SUCH AS HOSPITAL WASTE.....ETC.
(4) RATE OF HOUSEHOLD WATER USE INCREASE NOT USED IN THIS ANALYSIS.

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DATE 22/08/1979

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*****************************************
* IRBID - THE HASHEMITE KINGDOM OF JORDAN*
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* SOLID WASTE DISPOSAL                  *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
*                                       *
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Table 9-14b

Solid Waste
Anticipated Expenses

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 0 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

A N T I C I P A T E D E X P E N S E S (T H O U S A N D S O F J.D)

YEAR	REVENUE REQUIRED FOR NEW FACILITIES TOTAL CAPITAL COST(1979 JD)	GRANT	NET CAPITAL COST	NET CAPITAL COST INFLATED(10PC)	GRACE PERIOD INTEREST PAYMENT	LOCAL DEBT ANNUAL PAY. (6.0PC+20YR)	O+M IN 1979 (J.D)	O+M INFLATED (15PC)	TOTAL EXPENSE OF NEW FACILITIES
1980	602	0	602	662	0	57	163	187	244
1981	110	0	110	133	0	68	167	220	288
1982	0	0	0	0	0	68	195	296	364
1983	0	0	0	0	0	68	180	314	382
1984	0	0	0	0	0	68	204	410	478
1985	0	0	0	0	0	68	286	661	729
1986	0	0	0	0	0	68	220	585	653
1987	0	0	0	0	0	68	270	825	893
1988	0	0	0	0	0	68	204	717	785
1989	0	0	0	0	0	68	235	950	1018

NOTES:

(1) NO GRACE PERIODS APPLIED SINCE THERE IS A COLLECTION SYSTEM PRESENTLY.
(2) NO GRANTS AVAILABLE AT THIS TIME.
(3) O+M COSTS INCLUDE SALARIES AND EXPENSES PLUS AMORTIZED CAPIT AL EXPENDITURES FOR TRUCKS AND HEAVY EQUIPMENT DEPRECIATED OVER 7 YEAR PERIODS.
(4) TOTAL CAPITAL COST FOR 1980 INCLUDES LAND COST OF LANDFIL SITE AND CONSTRUCTION COST .

DATE 22/08/1979

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*****************************************
* IRBID - THE HASHEMITE KINGDOM OF JORDAN:
*                                       *
* CASH FLOW ANALYSIS                    *
*                                       *
* SOLID WASTE DISPOSAL                  *
*                                       *
* WESTON INTERNATIONAL, AUGUST 1979     *
*                                       *
*****************************************
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Table 9-14c

Solid Waste
Deficit-Surplus Analysis

A S S U M P T I O N S:
CONSTRUCTION PHASING COMPLETED :1982
INFLATION RATES :LOW MEDIUM HIGH

F I N A N C I N G :
REPAYMENT PERIOD : 20 YEARS.
GRACE PERIOD : 0 YEARS.
LOAN INTEREST RATE: 6 PERCENT(PC).

D E F I C I T - S U R P L U S A N A L I S I S (T H O U S A N D S J.D.)

YEAR	TOTAL REVENUE REQ. FOR NEW FACILITIES	DEBT SERVICE ON CURRENT FACILITIES	O+M ON CURRENT FACILITIES	TOTAL EXPENSES	TOTAL REVENUE	ANNUAL SURPLUS	ACCUMULATED
1980	244	0	5.50	249	351	102	102
1981	288	0	5.50	293	370	77	179
1982	364	0	4.50	368	386	18	197
1983	382	0	3.50	385	604	219	416
1984	478	0	2.50	480	632	152	568
1985	729	0	1.50	730	688	-42	526
1986	653	0	0.0	653	719	66	592
1987	893	0	0.0	893	752	-141	451
1988	785	0	0.0	785	787	2	453
1989	1018	0	0.0	1018	825	-193	260

NOTES:
---
(1) O+M CURRENT FACILITIES : VALUES INCLUDE O+M ON EXISTING FACILITIES ONLY. NO SALARIES.
(2) CURRENT FACILITIES HAVE NO OUTSTANDING DEBTS.
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Table 9-15

Parameter Sensitivity Analysis
Solid Waste Collection and Disposal System

Parameter	Accumulated	Range of 1989 Surplus (Deficit) (JD 000)
User Charge		
±10 percent of base	(362)	882
Capital Cost		
±10 percent of base	191	329
±20 percent of base	122	388
Inflation		
±10 percent of base	(68)	520
±20 percent of base	(762)	1,117
User Population		
±10 percent of base each year	(339)	852

Base Case for Sensitivity Analysis

Inflation rate, capital--10 percent
Inflation rate, operation and maintenance--15 percent
User charges--see Table 9-14a
Capital cost scheduling--see Table 9-14c
User population--see Table 9-14a
Accumulated surplus--260

Because of the nature of the solid waste management project, construction timing and delays are not very important to the project financing. Users are already in the system. The only problem that will arise through construction delays is the concern for equity. Users may be receiving a lower level of service than is consistent with the higher proposal charges.

The results of the sensitivity test reveal that the 1989 accumulated surplus (deficit) is highly sensitive to changes in user charges and user population, and relatively insensitive to changes in capital costs. The response to a change in rate of inflation was intermediate.

This analysis shows that increases in user charges and user population on the order of 10 percent can produce a quadrupling of the accumulated surplus over a 10-year period. Careful monitoring of changes in both of these parameters is therefore required throughout the operation of the solid waste collection and disposal system.

9.3.3.4 Proposed Stormwater Management System.

A cash flow analysis was not conducted for the stormwater system since the costs for this system are expected to be paid out of general tax revenues. In this section, however, we have developed the total annual costs and the annual costs per equivalent dwelling unit (EDU) required to repay the stormwater system construction costs, and the annual operation and maintenance costs.

The estimated Phase 1 construction cost for the stormwater system is 2,974,000 JD. It is assumed this cost will be incurred in 1980 and 1981 (991,000 JD and 1,983,000 JD), and will be paid back over a 19-year period, starting in 1981, at an interest rate of 6 percent. The annual cost of labor required for operation and maintenance of the stormwater system is estimated at 2,600 JD in 1979 prices, and is escalated at 15 percent over future years.

From Chapter 2 the total number of EDU's, both residential and nonresidential, available to pay for the stormwater costs increase from 24,000 JD in 1981 to 36,000 JD in 1989. The total annual stormwater system costs rise from approximately 270,500 JD in 1981 to approximately 277,500 JD in 1989. Because of the projected increase in EDU's over this period, the annual cost per EDU (the cost that must be collected from the taxes paid by each EDU to pay the stormwater system costs) drops from 11.3 JD in 1981 to 7.7 JD in 1989.

9.3.3.5 Summary.

Table 9-16 summarizes the annual user charges and fees that will be required from an average residential user in Irbid from 1980 to 1989. These are the fees required to pay back the capital obligations required to finance the project and pay the annual operation and maintenance charges.

Table 9-16

Summary of Household Average Annual
User Charges and Fees for Proposed Municipal Services
(1980-1989)

(in JD)

	Water Supply		Wastewater		Solid Waste	Stormwater	
Year	Administrative Connection Fee	Annual User Charge	Administrative Connection Fee	Annual User Charge	Annual User Charge	Annual User Charge	Total Annual User Charge
1980	14	6.00	0	0	14.40	0	20.40
1981	19	18.00	0	0	12.00	11.30	43.70
1982	19	18.00	0	0	21.60	10.70	50.30
1983	19	18.00	32	12.00	21.60	10.30	61.90
1984	19	18.00	32	12.00	21.60	9.70	61.30
1985	19	18.00	32	30.00	21.60	9.30	78.90
1986	19	18.00	32	30.00	21.60	8.90	78.50
1987	19	18.00	32	30.00	21.60	8.50	78.10
1988	19	18.00	32	30.00	21.60	8.00	77.60
1989	19	18.00	32	30.00	21.60	7.70	77.30

The total user charges to be paid by the average user will increase from 20.40 JD/year to an estimated 77.30 JD/year in 1989. For these increased charges, the Irbid resident will receive an improved water supply, a modern sewage collection and treatment system, improved solid waste disposal facilities, and adequate stormwater drainage facilities.

The charges listed in Table 9-16 are based on the assumption that 910,000 JD will be received in grants, and the remaining capital costs for Phase 1 of the project (17,891,000 JD) will be obtained through 20-year loans at 6 percent interest that will be repaid through user charges. The annual user charges can be reduced if either the amount of loans is reduced through an increase in the amount of grants made available for the project, or the loan interest rate is reduced and/or the payback period is increased.

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9.3.4 Financial Statements

This subsection presents the financial statements which describe in greater detail the base case conditions for water supply, wastewater, and solid waste management systems. The following tables are included in this section:

Table 9-17 Water Supply Income and Expenditure Statement
Table 9-18 Wastewater Income and Expenditure Statement
Table 9-19 Solid Waste Income and Expenditure Statement
Table 9-20 Water Supply and Wastewater Balance Sheet
Table 9-21 Solid Waste Balance Sheet
Table 9-22 Water Supply and Wastewater Cash Flow Statement
Table 9-23 Solid Waste Cash Flow Statement

Income and expenditure statements were prepared individually for each element except stormwater (this project is financed through municipal tax revenues). This approach offers the opportunity for analysis of the revenue projected for each element, and avoids the possibility that one element could subsidize another if they were combined initially. Balance sheets and cash flow statements are provided jointly for water supply and wastewater because they will probably be implemented jointly in a district authority arrangement as recommended in Chapter 10. Solid waste, however, will most likely be managed by another arrangement, and therefore is presented separately.

The following is a list of notes which describe various assumptions used in preparing these financial statements.

1. Prior period balance sheet items including existing debt for water supply were not included on the balance sheet. Revenue from prior operations was included on the income and expenditure statement.

2. The cost of water supply meters, which will be passed on to the customers, was not included in revenue or expense.

3. The wholesale cost of water, which will be passed on to the customers, was not included in revenue or expense.

4. Grace period interest of 2,283 JD was financed. This interest was expensed. Had the interest been capitalized, the deficit of 2,181 JD in 1989 would have been much smaller.

5. The stormwater system is not included in the balance sheet or cash flow statements. The stormwater system has no cash flow impact as tax revenues will be used to cover the salary costs, operating and maintenance expenses, and principal and interest payments. Since tax revenues are used to cover costs, there is no

material income and expenditure or balance sheet effect. The stormwater system would show an equity deficit resulting from interest and depreciation exceeding principal payments. A loan of 2,974,000 JD will be received for the stormwater system.

One of our prime objectives in preparing the financial statements was to balance revenues, considering the ability of the customers to pay, with a stable cash flow position.

This objective, along with expressing the grace period interest, high interest in the initial years of the debt service and liberal depreciation estimates, caused a negative equity position for the years presented on the financial statements. These are noncash flow items which impact the income and expenditure statement, but do not affect the cash flow statement. Over the period of debt service, these items will reverse and the equity at the end of the debt service period will become positive.

Table 9-17

Water Supply Income and Expenditure Statement

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Revenue										
Resident	110	123	386	431	481	564	631	804	900	1,009
Nonresident	36	40	130	145	163	182	202	259	287	321
New customers	294	16	15	17	18	34	20	21	22	25
Total	440	179	531	593	662	780	853	1,084	1,209	1,355
Operating Costs										
Salaries and wages	127	145	167	192	221	254	293	336	387	445
Operating and maintenance	53	52	44	36	28	21	24	29	32	37
Depreciation	-	51	219	219	219	219	258	301	348	400
Total	180	248	430	447	468	494	575	666	767	882
Surplus Before Interest	260	(69)	101	146	194	286	278	418	442	473
Interest	61	267	282	293	282	319	357	400	443	492
Surplus (deficit)	199	(336)	(181)	(147)	(88)	(33)	(79)	18	(1)	(19)
Average Net Fixed Assets	-	2,677	4,224	4,006	3,787	3,957	4,537	5,157	5,822	6,538
Rate of Return on Average Net Fixed Assets (%)	-	-	2.4	3.6	5.1	7.2	6.1	8.1	7.6	7.2
Cash Operating Ratio (%)	40.9	110.1	39.7	38.5	37.6	35.3	37.2	33.7	34.7	35.6

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Table 9-18

Wastewater Income and Expenditure Statement

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Revenue										
Resident	-	-	-	75	238	961	1,062	1,164	1,285	1,421
Nonresident	-	-	-	20	65	245	271	298	325	358
New customers	-	-	-	192	386	286	34	30	34	39
Septage dumping	-	-	136	152	166	180	195	216	223	238
Total	-	-	136	439	855	1,672	1,562	1,708	1,867	2,056
Operating Costs										
Salaries and wages	-	-	-	175	201	231	266	306	352	405
Operating and maintenance	-	-	-	109	249	292	336	386	445	511
Depreciation	-	-	-	501	501	501	501	501	501	501
Total	-	-	-	785	951	1,024	1,103	1,193	1,298	1,417
Surplus Before Interest and Grants	-	-	136	(346)	(96)	648	459	515	569	639
Interest	-	209	559	593	628	642	618	593	567	539
AID Grant	283	627	-	-	-	-	-	-	-	-
Surplus (deficit)	283	418	(423)	(939)	(724)	6	(159)	(78)	2	100
Average Net Fixed Assets	-	-	-	9,774	9,273	8,772	8,271	7,770	7,269	6,768
Rate of Return on Average Net Fixed Assets (%)	-	-	-	-	-	7.4	5.5	6.6	7.8	9.4
Cash Operating Ratio (%)	-	-	-	64.7	52.6	31.3	38.5	40.5	42.7	44.6

Table 9-19

Solid Waste Income and Expenditure Statement

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1985	1989
					JD (thousands)					
Revenue										
Resident	272	284	296	466	487	535	561	586	614	645
Nonresident	66	72	75	123	129	135	140	147	153	159
Special service	14	14	15	16	17	18	19	20	21	22
Total	352	370	386	605	633	688	720	753	788	826
Operating Costs										
Salaries and wages	128	150	176	212	242	283	333	407	468	538
Operating and maintenance	66	76	88	107	127	148	176	209	249	291
Equipment	-	-	38	-	44	231	79	211	-	121
Depreciation	-	31	39	38	39	38	39	38	13	13
Total	194	257	341	357	452	700	627	865	730	963
Surplus Before Interest	158	113	45	248	181	(12)	93	(112)	58	(137)
Interest	39	46	44	43	42	40	38	36	35	33
Surplus (deficit)	119	67	1	205	139	(52)	55	(148)	23	(170)
Average Net Fixed Assets	N/A	289	381	343	304	266	227	189	163	150
Rate of Return on Average Net Fixed Assets (%)	-	39.1	11.8	72.3	59.5	-	41.0	-	35.6	-
Cash Operating Ratio (%)	55.1	61.1	78.2	52.7	65.2	96.2	81.7	109.8	91.0	115.0

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Table 9-20

Water Supply and Wastewater Balance Sheet

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Assets										
Current Assets										
Cash	192	216	499	509	412	374	242	200	201	243
Inventories	7	8	9	25	35	41	47	54	62	71
Accounts receivable	66	28	101	156	228	370	363	420	463	513
Total Current Assets	265	252	609	690	675	785	652	674	726	827
Fixed Assets										
Water supply	1,019	4,385	4,385	4,385	4,385	5,164	6,021	6,964	8,001	9,142
Less depreciation	-	51	270	489	708	927	1,185	1,486	1,834	2,234
Net water supply	1,019	4,334	4,115	3,896	3,677	4,237	4,836	5,478	6,167	6,908
Sewerage	-	-	10,024	10,024	10,024	10,024	10,024	10,024	10,024	10,024
Less depreciation	-	-	-	501	1,002	1,503	2,004	2,505	3,006	3,507
Net sewerage	-	-	10,024	9,523	9,022	8,521	8,020	7,519	7,018	6,517
Work-in-process	283	4,389	-	-	-	-	-	-	-	-
Total Fixed Assets	1,302	8,723	14,139	13,419	12,699	12,758	12,856	12,997	13,185	13,425
Total Assets	1,567	8,975	14,748	14,109	13,374	13,543	13,508	13,671	13,911	14,252
Liabilities										
Current Liabilities										
Accounts payable	5	4	4	13	23	27	30	36	41	46
Deposits	-	6	12	18	24	36	43	50	58	67
Total Current Liabilities	5	10	16	31	47	63	73	86	99	113
Long-Term Debt										
Loans -- water supply	1,080	4,713	4,890	4,729	4,557	5,130	5,740	6,392	7,086	7,828
Loans -- sewerage	-	3,688	9,882	10,475	10,708	10,315	9,898	9,456	8,988	8,492
Total Long-Term Debt	1,080	8,401	14,772	15,204	15,265	15,445	15,638	15,848	16,074	16,320
Equity										
Equity, retained earnings, and capital contribution	482	564	(40)	(1,126)	(1,938)	(1,965)	(2,203)	(2,263)	(2,262)	(2,181)
Total Liabilities	1,567	8,975	14,748	14,109	13,374	13,543	13,508	13,671	13,911	14,252

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Table 9-21

Solid Waste Balance Sheet

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Assets										
Current Assets										
Cash	19	90	103	269	416	361	420	272	270	71
Accounts receivable	88	93	97	151	158	172	180	188	197	207
Total	107	183	200	420	574	533	600	460	467	278
Fixed Assets										
Land	363	363	363	363	363	363	363	363	363	363
Facilities and equipment	178	432	432	432	432	432	432	432	432	432
Less depreciation	-	31	70	108	147	185	224	262	275	188
Net facilities and equipment	178	401	362	324	285	247	208	170	157	144
Work-in-progress	121	-	-	-	-	-	-	-	-	-
Total Fixed Assets	662	764	725	687	648	618	571	533	520	507
Total Assets	769	947	925	1,107	1,222	1,143	1,171	993	987	785
Liabilities										
Current Liabilities										
Accounts payable	6	6	7	9	11	12	15	17	21	24
Total	6	6	7	9	11	12	15	17	21	24
Long-Term Debt										
Loans	644	755	731	706	680	652	622	590	557	522
Total	644	755	731	706	680	652	622	590	557	522
Equity										
Equity, retained earnings, and capital contribution	119	186	187	392	531	479	534	386	409	239
Total Liabilities	769	947	925	1,107	1,222	1,143	1,171	993	987	785
Debt-Equity Ratio	84:16	80:20	80:20	64:36	56:44	58:42	54:46	50:40	58:42	69:31

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Table 9-22

Water Supply and Wastewater Cash Flow Statement

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Internal Cash Generation										
Net revenue before depreciation and interest										
Wastewater	-	-	136	155	405	1,149	960	1,016	1,070	1,140
Water supply	260	(18)	320	365	413	505	536	719	790	873
Total	260	(18)	456	520	818	1,654	1,496	1,735	1,860	2,013
Operating Requirements										
Working capital	68	(42)	68	56	66	132	(11)	51	38	45
Debt service - interest	61	476	841	886	910	961	975	993	1,010	1,031
Debt service - repayment	-	-	37	161	319	599	664	733	811	895
Total Debt Service	61	476	878	1,047	1,229	1,560	1,639	1,726	1,821	1,926
Total Operating Requirements	129	434	946	1,103	1,295	1,692	1,628	1,777	1,859	1,971
Total Available From Operations	131	(452)	(490)	(583)	(477)	(38)	(132)	(42)	1	42
Construction Costs and Equipment										
Project - wastewater	283	4,106	5,635	-	-	-	-	-	-	-
Project - water supply	1,019	3,366	-	-	-	779	857	943	1,037	1,141
Total Construction Costs and Equipment	1,302	7,472	5,635	593	380	779	857	943	1,037	1,141
Balance to be Financed	1,363	7,948	6,408	593	380	779	857	943	1,037	1,141
Surplus (Deficit)	192	24	283	10	(97)	(38)	(132)	(42)	1	42
Cash Balance at End of Year	192	216	499	509	412	374	242	200	201	243
Debt Service Coverage	4.3	-	0.5	0.5	0.7	1.1	0.9	1.0	1.0	1.0

Table 9-23

Solid Waste Cash Flow Statement

Year Ending December 31	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
					JD (thousands)					
Internal Cash Generation										
Net revenue before depreciation and interest	158	144	122	286	264	257	211	137	71	(3)
Operating Requirements										
Working capital	82	5	3	52	5	13	5	6	5	7
Debt service-interest	39	46	44	43	42	40	38	36	35	33
Debt service-repayment	18	22	24	25	26	28	30	32	33	35
Total Debt Service	57	68	68	68	68	68	68	68	68	68
Total Operating Requirements	139	73	71	120	73	81	73	74	73	75
Total Available From Operations	19	71	51	166	191	176	138	63	(2)	(78)
Construction Costs and Equipment										
Land	363	-	-	-	-	-	-	-	-	-
Equipment	178	-	38	-	44	231	79	211	-	121
Project-solid waste	121	133	-	-	-	-	-	-	-	-
Total Construction Costs and Equipment	662	133	38	-	44	231	79	211	-	121
Balance to be Financed	662	133	-	-	-	-	-	-	-	-
Surplus (Deficit)	19	71	13	166	147	(55)	59	(148)	(2)	(199)
Cash Balance at End of Year	19	90	103	269	416	361	420	272	270	71
Debt Service Coverage	2.8	2.1	1.8	4.2	3.9	3.8	3.1	2.0	1.0	-

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9.4 ECONOMIC ANALYSIS

This section presents an economic analysis of the proposed project and the individual plan elements. The analysis includes review of the incremental revenues and costs associated with each plan element, analysis of ability to pay, and project internal rate of return.

9.4.1 Ability to Pay

A basic objective of this study is to provide municipal services that are affordable to all citizens of Irbid. This objective is consistent with Kingdom policy, and implies that the percentage of total household income that will be spent on municipal services should not exceed some maximum levels. As a result, the analysis of ability to pay is a key factor in determining what the residents of Irbid can afford, and in determining what priorities will be set with regard to construction of individual project elements, if residents cannot afford the entire project.

With respect to the ability to pay, this section:

1. Establishes guidelines for determining the maximum percentage of total household income that should be spent on municipal utilities.

2. Evaluates the present household income in Irbid.

3. Identifies the present water consumption by income group, and estimates the percentage of total household income spent on water and solid waste.

4. Develops a progressive water rate structure.

5. Determines the future (1985) ability to pay of income groups.

6. Establishes the need for subsidies and grants.

The data used in preparing these analyses include inputs from socio-economic surveys of Irbid which, among other things, identify household income and water meter billing numbers. From the water billing records, corresponding to the survey samples, information regarding water use over the past six months was collected.

9.4.1.1 Ability to Pay Guidelines.

The basis for determining the percentage of household income that should be spent on municipal utilities varies from place-to-place. It is depen-

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dent on the relative prices of goods and services available, current expenditure patterns, and real family income (after accounting for price level changes). A frequently used rule-of-thumb is that a near-subsistence level family should not have to spend more than 5 percent of its income on water. The figure is referenced in "Village Water Supply," a World Bank research publication prepared by Robert J. Saunders and Jeremy J. Warford (1976). Although many urban area water users pay much less than this for their public water supply, this 5 percent figure is reasonable for Irbid, and is used as a ceiling for all low income municipal service users in Irbid.

9.4.1.2 Present Household Income.

An income versus water use survey was conducted in Irbid as part of this study, and serves as the source of information for identifying income distribution. The income survey results are summarized in Table 9-24. The sample size is 105, and the survey average annual household income is 1,834 JD.

Income is distributed in a generally normal pattern into five income groups. A low-income group is identified as having an annual household income below 600 JD, and represents about 12 percent of the Irbid population. The household income increases for the majority of the sample; 51 percent are in the 1,001 to 3,000 JD group, and are clustered around the group average of 1,793 JD which is lower than the overall survey mean. The distribution tapers off as household income continues to increase with the upper distribution somewhat smaller than the lower, i.e., income is skewed to lower income households.

The table includes the average number of workers who generate household income, and the size of households they support. The trend shows an increasing number of workers, as income group and family size increase, and then a decline in the number of workers at the highest income levels. This is consistent with general findings of family income requirements and the tendency for higher income families to have smaller families. Associated with these trends is the increasing average per capita income, which increases consistently as the number of workers per household and family size change.

9.4.1.3 Current Ability to Pay by Income Group.

From the information presented on household income and family size, it is expected that per capita water use will increase as income increases, and that total household consumption will be affected by family size.

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Table 9-24

Irbid Household Income Distribution and Characteristics --
1979 Socioeconomic Survey Results

Income Group (JD)	Number In Sample	Distribution Percent	Average No. of Workers Per Household	Average No. of People Per Household	Annual Average Household Income (JD)	Annual Average Per Capita Income (JD)
0 to 600	13	12.4	1	7.3	507	69.5
601 to 1,000	22	21.0	1.1	10.50	877	84.3
1,001 to 3,000	54	51.4	1.4	8.20	1,817	208.5
3,001 to 5,000	14	13.3	2.25	10.60	4,130	232.0
5,001 and up	2	1.9	1	5.5	6,000	1,090.0

Total number in sample -- 105 households

Survey average annual income -- 1,834 JD

Table 9-25 presents the analysis of the current ability to pay, based on the effect of user charges on income groups. The water use consumption categories are those used in the current water use billing schedules, as are the water charges per cubic meter. From existing water records and survey information, the number of households, average income per household, and total annual revenue are identified for each water use consumption category. The average water cost per household is determined from the fee schedule and average water consumption for the group. Revenue by group, ability to pay, and distribution of revenue by group are calculated within the table. The check on the accuracy of the analysis is provided by comparing the sum of the revenues provided by all groups with the total revenue from residential customers.

Table 9-25 shows that the present low-income water system customers, represented by the 0 to cu m/month consumption group, currently pay 0.28 percent of their income for water. This group consumes 10.3 percent of the water sold in Irbid, and contributes 6.7 percent of the revenue.

Percent of household income spent on water distribution and wholesale water purchases increases to 0.48 percent for the 5 to 15 cu m/month group, and to 2.25 percent and 3.05 percent for the next consumption groups. The table also shows an apparent anomaly, where average household income increases then decreases to 1,275 JD for the 15 to 25 cu m/month group. This is explained by the variation in household size and the greater water consumption of large families.

The analysis required for determining the effect of present solid waste collection and disposal fees is much simpler. Since the charge is 6.00 JD/year, the test is a matter of comparing this fixed annual charge with the present annual income categories. Referring to Table 9-24, at the lowest income group the 6.000 JD annual charge for garbage collection is 1 percent of the 600 JD level and 1.3 percent for the 450 JD low-income group average.

9.4.1.4 Future Ability to Pay Based on Averages.

Table 9-16 summarized the household average annual user charges for the proposed facility plans. These new user charges for 1980 (and including the first wastewater charge), are compared here with the average household income for Irbid (1,834 JD) obtained from the survey (Table 9-24):

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Table 9-25

Existing Conditions
Current Ability to Pay Analysis

Water Use Consumption Group (cu m/month)	Average Household Water Use (cu m/month)	Unit Cost of Water (JD/cu m)	Number of Households	Average Water Use Per Household (cu m/year)	Average Household Income (JD/year)	Average Water Cost Per Household (JD/year)	Ability to Pay[1] (%)	Annual Revenue By Group (JD)	Total Water Sold (cu m/year)
0 to 5	3.4	0.080	3,820	40.80	1,150	3.260	0.28	10,725	134,232
5 to 15	9.7	0.120	5,277	77.60	1,452	6.910	0.48	36,464	409,495
15 to 25	18.6	0.220	1,759	232.20	1,275	28.700	2.25	50,483	392,609
More than 25	28.2	0.300	1,096	338.40	1,870	57.100	3.05	62,582	370,886
Totals			11,412					160,254[2]	1,307,222[2]

[1] Ability to pay is the percent of annual income required for purchase of water. Ability to pay equals average water cost divided by average household income.

[2] This table contains information from the socioeconomic survey conducted in the summer of 1979. It also uses the existing water rate structure to determine the annual revenue by water consumption group and water sold (each group). As a test, the totals compare favorably with reported values in subsection 9.3.2 of this chapter.

	% Income (1979)[1]	?
Water supply	0.33	1.32
Wastewater	0.65	0.65
Solid waste	0.79	0.79
Stormwater	0.62	0.62
Total	2.39	3.38

This analysis implies that, on the average, the project can be afforded by the residents of Irbid. This analysis, however, masks the problems of low-income users.

The following subsections develop a rate structure for water supply and analyze the ability to pay based on the annual costs to the user for the water consumed, as well as the other services proposed in this project. This approach focuses on the ability to pay problems of the low-income users.

9.4.1.5 Future Water Supply Unit Costs.

Based on the findings of the water use and household income survey (Table 9-24), the relationship between household income level and water consumption was determined. This relationship is important, since the percent of income spent on water depends on the quantity of water consumed by an income group. In addition, this relationship was important for determining the ability to pay, and was the key to structuring a progressive rate charge that would be affordable to low-income users.

Table 9-26 indicates how the average monthly user charges from the water and wastewater cash flow analyses for 1985 were converted to a progressive pricing structure similar to that presented in subsection 9.3.2. for existing water services. For this study, 1985 was selected as the year for which the rates would be structured because it is the midpoint in the planning period, and rates would presumably be set for periods of time for institutional stability and administrative reasons. Also, a 0 to 15 cu m/month water consumption group was formed from the previous 0 to 5 and 6 to 15 groups. This was done because of the apparent concentration of low-income households in these groups.

Table 9-26 presents a water rate structure which is progressive and is consistent with the percentages of income currently spent by each consumption group for water. The analysis considers water rates both "with" and "without" the wholesale price of water.

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[1] Calculations are presented twice to show the impact of the wholesale price of water. The first column water supply ability to pay estimate reflects annual charges, exclusive of wholesale costs. The second column water supply ability to pay estimate includes 0.250 JD/cu m future wholesale cost assumed in this report.

Table 9-26

Water Charges Per Cubic Meter
By Income Group -- 1985

Water Use Consumption Group (cu m/month)	Average Household Income[1] (JD/year)	Number of Households	Revenue by Consumption Group (JD/year)	Average household Water Use (cu m/year)	Partial Unit Cost (fils/cu m)	Wholesale Unit Cost (fils/cu m)	Water Charge (fils/cu m)
0 to 15	2,367	17,581	166,456[2]	118	80	250	330
16 to 25	2,259	3,610	183,487[3]	301.3	168	250	418
More than 25	3,313	2,250	214,057[4]	456.8	208	250	458
Total		23,441[5]	564,000[5]				

[1] Average annual income from Table 9-18, weighted by number of users for the 0 to 15 water use group and inflated 10 percent per year. Variation in income by group is explained in the text.

[2] Based on 1979 weighted average ability to pay -- 40%.

[3] Based on 1979 ability to pay -- 2.25%.

[4] Determined by difference in ability to pay -- 2.87%.

[5] From Table 9-8a, required total revenue by consumption group based on water consumption revenue for residential users, exclusive of wholesale water cost.

This unit cost water system pricing structure is very similar to the previous Kingdom pricing structure (which included a subsidized price) for wholesale water. These rate schedules are compared in the following tabulation:

Water System Unit Costs

Water Consumption Group (cu m/month)	Proposed Unit Costs	Previous Kingdom Policy Unit Costs	Proposed/With Wholesale Water Unit Costs
0 to 5	-	80	-
0 to 15	80	100	330
16 to 25	168	180	418
More than 25	208	250	458

Table 9-27 summmarizes the monthly user charges for water supply and wastewater services. Table 9-28 summarizes all of the user charges by income group, and identifies what percentage of a group's average income (ability to pay) would be spent on each service. The table also presents a combined estimated ability to pay for all services.

In order to demonstrate the ability to pay impact of wholesale water charges on the proposed system, charges are presented for water supply with and without the proposed wholesale unit cost; combined charges are also presented in this manner. The analysis indicates that the proposed project is affordable to each water use consumption group where the wholesale costs of water are omitted from the analysis. Subsidies would be required, however, if the wholesale water cost is included.

The significance of the wholesale water unit cost is apparent in Table 9-28, which causes the ability to pay to exceed the 5 percent guideline for the 16 to 25 and the more than 25 cu m/month water consumption groups. The ability to pay for these two water consumption groups is 5.57 and 6.31 percent, respectively, of the average group incomes. Without considering the wholesale water cost, however, the table indicates that the new system is affordable to all groups, and the maximum percent of annual income spent on the new water system is 2.87 percent.

For the purpose of identifying the need for subsidies concerning the proposed project, it appears appropriate to consider the Irbid project separately from the issue of wholesale water. This is appropriate for two reasons:

1. The wholesale cost per unit of sold water from Table 9-26 ranges from 55 to 75 percent of the total unit cost.

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Table 9-27

Monthly User Charge (1985) Water and Wastewater
By Water Use Consumption Group

Water Use Consumption Group (cu m/month)	Water Charge: Unit[1] Charge (JD/cu m)	Water Charge: Monthly Charge (JD)	Wastewater Charge: Unit Charge (JD/cu m)	Wastewater Charge: Monthly Charge (JD)	Combined Water[1] and Wastewater Charge (JD)
0 to 15	0.330	3.200	0.047	0.368	3.570
16 to 25	0.418	10.500	0.060	1.205	11.700
More than 25	0.458	17.400	0.066	2.007	19.400

[1] Water charge includes estimated wholesale water cost, 250 fils/cu m.

[2] Costs based on medium inflation rates.

Table 9-28

Ability to Pay Annual User Charges For Municipal Services Based on Projected 1985 Costs and Income

Water Use Consumption Group (cu m/month)	Average Household Income (JD/year)	Water Supply[1]		Water Supply[2]		Wastewater		Solid Waste		Stormwater		Combined Charge[1]		Combined Charge[2]	
		Monthly User Charge (JD)	Percent Income	Monthly User Charge (JD)	Percent Income	Monthly User Charge (JD)	Percent Income	Monthly User Charge (JD)	Percent Income	Monthly User Charge (JD)	Percent Income	Monthly User Charge (JD)	Percent Income	Monthly User Charge	Percent Income
0 to 15	2,367	3.200	1.65	0.780	0.40	0.368	0.20	1.800	0.91	0.780	0.39	6.15	3.10	3.70	1.90
16 to 25	2,259	10.500	5.57	4.220	2.25	1.205	0.60	1.800	0.95	0.780	0.41	14.28	7.60	8.00	4.40
More than 25	3,313	17.400	6.31	7.920	2.87	2.007	0.70	1.800	0.65	0.780	0.28	22.00	7.80	12.50	4.50

[1] Charge includes the wholesale price of water.

[2] Charge does not include wholesale price of water.

2. Currently, wholesale water is priced by national policy, which does not now cover the costs of water (subsection 9.3.2). Also, it is likely that the current national subsidies will continue to be applied to wholesale water in the future.

As a result of this analysis, the proposed project elements and the total project are within the 5% of annual income guidelines established by the World Bank.

Assistance, however, will be needed to permit low-income households to connect into the system without undue hardship. The following table summarizes all of the administrative and connection fees:

Fees In First Year of System Operation

	Administrative Fee	Connection Fee	Total Fees	Ability To Pay[1]
Water supply	19	0[2]	19	1.0
Wastewater	32	200	232	12.6
Solid Waste	0	0	0	0
Stormwater	0	0	0	0
Total	51	200	251	13.7

The ability to pay in this table is represented by the average income. The charges will have a greater impact on families with incomes below this level. As a result, a "short-term" installment loan program should be established that will reduce the burden on low-income families. This is typically a 12 to 18-month loan, but in this case, a longer period should be considered.

Grants to connect low-income families to the system should also be considered since one-third of the Irbid households may have incomes below 1,000 JD/year (Table 9-24). The 251 JD combined administrative and connection fee represents 25 percent of the annual income for the highest income level in this group. This is not affordable even with installment loans. The 1983 grants to these low-income households would be 409,000 JD, and would increase to 1,227,000 JD in 1984. An ongoing grant program will probably be needed throughout the project period.

[1] Based on 1,834 JD average income (1979), Table 9-17.

[2] Included in administrative fee.

9.4.2 Analysis of Incremental Revenues and Costs

As defined by the facility's plans and financial analysis sections, this project includes the relevant costs and revenues to satisfy the needs in Irbid for water supply, wastewater, solid waste and stormwater services. Associated with the increased services in these systems, are incremental revenues and costs.

The constant JD incremental revenues and costs were evaluated. Because of the nature (lumpiness) of the investment program, however, the fluctuations in new users coming into the system, changes in fees and charges, and the effects of inflation, the analysis was of little value in determining the relationship between incremental units of service and the associated real incremental costs and revenues. Over a longer analysis period (possibly 20 or 30 years) when the construction program, grace periods, and other interruptions are stablized, this analysis would be useful in making decisions as to the effective level of service that the system should provide and other matters concerning financing, fees, and charges.

9.4.3 Internal Rate of Return Analysis

The economic internal rate of return, or rate of return over costs, is an indicator of the benefit that can be realized by various investments. The gain in income and other benefits in each of the future years is discounted to the present, relative to the cost (foregone income) in the initial phase of the project. This can be expressed in percentage terms, and ranked for various projects in which the investment might otherwise be used.

The general procedure is to determine the rate of return for the Irbid project, i.e., water supply, wastewater collection and treatment, solid waste collection and disposal, and stormwater management, according to the following formula:

$$C = \frac{R1}{1+r} + \frac{R2}{(1+r)^2} + \ldots \frac{Rn}{(1+r)^n} + \frac{S}{(1+r)^n}$$

Where:

r = Rate of return on earned investment
C = Supply price or cost of the project
R = Future cash inflow and other benefits of the project
S = Salvage value or residual
n = Number of years

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This a common expression which equilibrates costs and expected future returns. In this analysis, the future cash inflows and annual revenue outputs of the cash flow analysis are expressed as 1979 revenues instead of inflated revenues. These future returns also include an estimate of the results of the "with" and "without project" analysis benefits. Salvage values have been ignored as previously described in Section 9.2. The analysis period is the project life for each system; 20 years for solid waste and 40 years for stormwater, water distribution, and wastewater.

Other benefits of the proposed project were identified and discussed in Appendix F, "Analysis of Economic Benefits from Planned Project Development." These benefits are attributed to the planned water and wastewater systems which are the most significant proposed improvements. Because of the limited information available on the other benefits, it was not possible to identify them specifically to each part of the project.

Table 9-29 summarizes the results of the internal rate of return analysis. The internal rate of return for the water and wastewater elements of the project is 9.82 percent. This is 3.82 percent greater than the interest rate (6 percent) assumed for the project. The overall rate of return for all project elements is 8.74 percent, significantly more than the project interest rate. This overall rate of return is influenced by the stormwater element analysis. For the stormwater analysis, we have been unable to quantify the benefit that will result from flood protection, consequently the rate of return for this element is understated and the total project rate of return is also understated.

9.5 SUMMARY AND RECOMMENDATIONS

The Phase 1 capital costs are 17,891,000 JD in constant 1979 costs, phased as listed in Table 9-2. Escalated Phase 1 capital costs are 24,137,000 JD as indicated in Table 9-3. Escalated operation and maintenance costs (given in Table 9-4) associated with implementing the project, increase from 327,000 JD in 1980 to 2,368,000 JD in 1989 due to phasing into service proposed facilities and projected inflation rates. Estimated average annual user charges that would be paid by the residents of Irbid for Phase 1 facilities are given in Table 9-16, with selected costs tabulated as follows:

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Table 9-29

Internal Rate of Return Analysis -- Summary
(Revenues in 1979 JD x 1000)

Item	Water Supply[1]	Wastewater[1]	Combined Water and Wastewater[1]	Solid Waste[2]	Storm-Water[1]	Total
Project Benefits						
Revenues						
1980	400	0	400	305	0	705
1981	153	0	153	280	270	703
1982	403	102	505	254	269	1,028
1983	409	300	709	345	271	1,325
1984	414	530	944	314	167	1,525
1985	447	943	1,390	297	279	1,966
1986	441	801	1,242	270	280	1,791
1987	508	796	1,304	246	279	1,829
1988	516	791	1,307	224	275	1,806
1989	525	791	1,316	204	271	1,791
⋮	⋮	⋮	⋮	⋮	⋮	
2019	661	791	1,316	204	271	
Other Benefits	136	205	341	-	-	341
Project Costs	5,909	8,020	13,929	988	2,974	19,891
Internal Rate of Return - %	9.81	9.8	9.82	28.6	8.43	8.74

[1] Project life -- 40 years.

[2] Project Life -- 20 years.

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Average Annual User Charges
(JD)

System	1980	1985	1989
Water supply[1]	6.000	18.000	18.000
Wastewater	0	30.000	30.000
Solid waste	14.400	21.600	21.600
Stormwater	0	9.300	7.700
Total	20.400	78.900	77.300

In general, the average annual user charges increase due to implementation of new facilities plans and inflation of operations and maintenance costs. The stormwater charge (tax revenue requirement) decreases as a result of increased population.

One time administrative charges based on Kingdom policy are charged to new residents. Together these charges, with the exception of those for wastewater facilities, cover all expenses including principal and interest on debt, assumption of existing liabilities from existing water and solid waste operations, and future operation and maintenance costs for complete service to the residents. According to existing policy, wastewater connection costs for connecting from the building to the property line are the responsibility of the homeowner, and short-term installment loans and grants are recommended to ease the burden on low-income families.

With the exception of the poorest residents of the City of Irbid, these charges are affordable and do not exceed the suggested World Bank 5 percent limit of family income.

Sensitivity analyses of each recommended facility plan address the significance of inflation, capital costs escalation, increased water use, and construction phasing variations on associated costs and revenues.

The sensitivity analyses indicate the project revenues are generally very sensitive to variations in user charges, inflation rates, water use rates, and customer connection rates. The operating agency must be aware of those sensitivities and have the authority to vary user charges and fees to generate the required project revenues.

Based on the analysis of this chapter, the following recommendations are offered:

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[1] Water supply average user charge does not include the wholesale price of water.

1. The project is affordable by the people of Irbid, and should be financed based on the benefits that will accrue.

2. Recommended project elements should be financed and work initiated as soon as possible since projected inflation factors have significant effects on overall project costs.

3. Guidelines and procedures should be adopted by the new implementing agency for accounting and cost control in accordance with the methods and procedures of the Financial Accounting Standards Board, Stamford, Connecticut, USA. The new agency should be audited annually.

4. For purposes of maintaining institutional stability, user charges and rate schedules should be established and the frequency of rate changes minimized to provide a positive image to the public.

5. Decisions regarding the new water system should be made concerning reconnection of residents who are currently part of the existing water supply system. Residents are likely to resist if they are required to pay for reconnection to the new system.

6. Grants should be made available to low-income families who cannot afford the costs of connection to the wastewater collection system.

CHAPTER 10

INSTITUTIONAL ARRANGEMENT AND PROJECT IMPLEMENTATION

10.1 INTRODUCTION AND PURPOSE

Project implmentation is addressed in this chapter, including construction phasing and analysis of institutional needs to ensure the proper installation, operation, and maintenance of proposed facility plans. Unless these institutional needs are satisfied, the facility plans will not provide the level of service intended. To meet these needs, consideration is given to existing institutional capabilities and responsibilities, as well as the need for new institutions, ordinances, and policies to properly control the implementation and continued management and operation of programs.

National policies concerning engineering, economics, and finances are considered, as are present institutional arrangements, and new policies, management techniques, and institutional development being proposed to influence future growth of the nation.

This chapter has three purposes:

1. Review the existing institutions that might be considered for implementing the facility plans for Irbid, and evaluating their capabilities for assuming these responsibilities.

2. Propose new arrangements that might also be considered for implementing these proposals.

3. Develop a recommended implementation plan.

The analysis that follows evaluates institutional arrangements for managing the public facilities proposed in this report. Alternatives are evaluated with respect to implementation capabilities and overall feasibility, and a recommended institutional arrangement with the needed implementation capabilities is identified.

10.2 METHODS OF ANALYSIS

Two basic principles underlie the analysis of institutions that can implement the facilities proposed in this report. The recommended

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arrangements must be:

1. Practical and appropriate to the needs and skills available in the North Jordan area.

2. Capable of efficiently utilizing human and natural resources.

These principles, if embodied in a management agency, will ensure an effective means of providing municipal services to Irbid.

An effective agency will build on the concepts of management currently in use in Jordan, and will utilize skills and methods that are appropriate for the area. The principle of efficient utilization of resources will help promote an institutional arrangement that uses scarce resources wisely. It is the intention of this report that all existing Irbid Water Department and Public Works Department staff will be utilized in the recommended institutional arrangements.

A four step procedure was employed to develop the institutional alternatives:

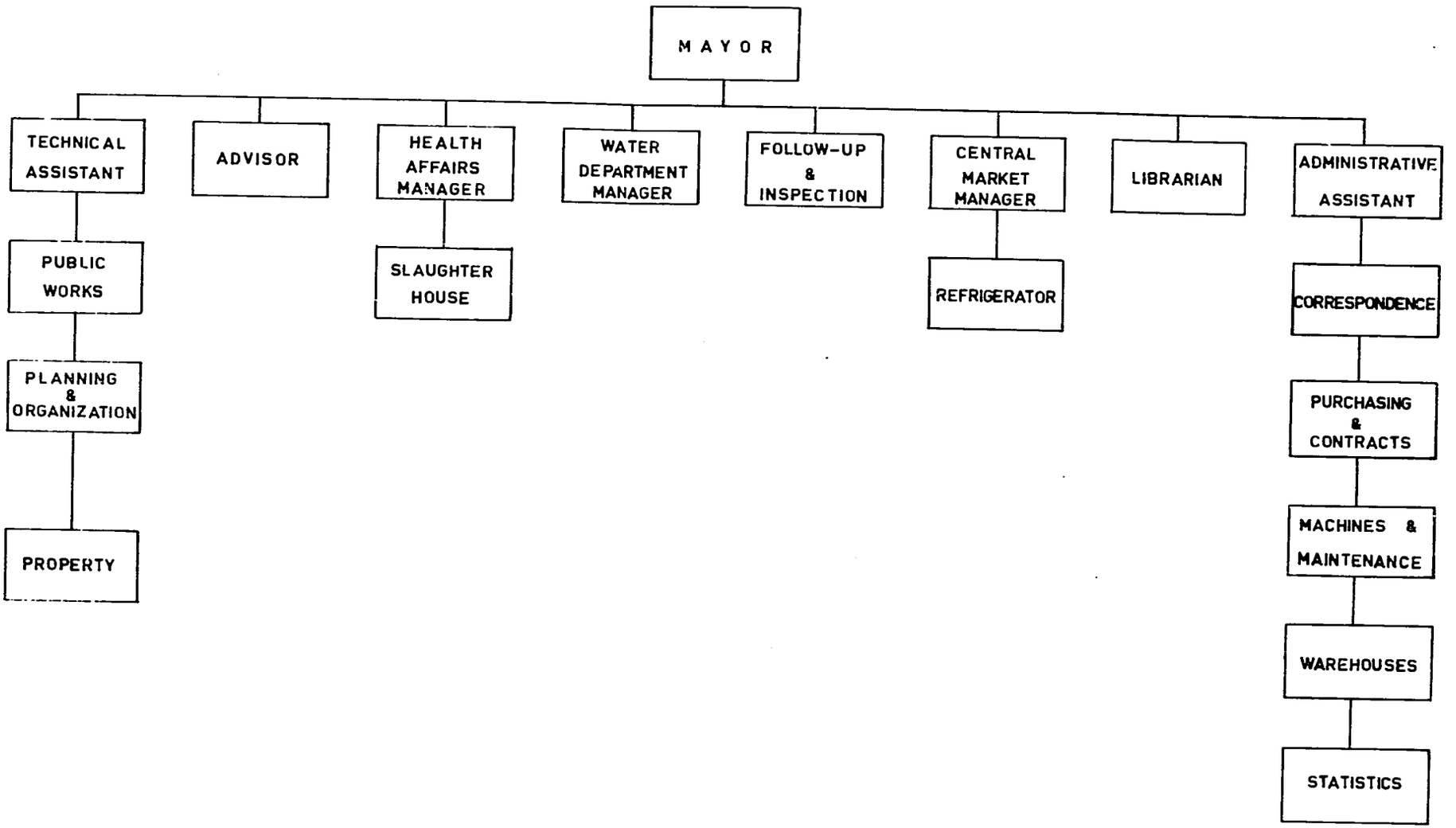
1. Review existing institutions.
2. Develop evaluation goals and criteria.
3. Propose feasible institutional arrangements.
4. Formulate a recommended implementation plan.

Much of the basic information used in this chapter was obtained through interviews with government officials, as well as from periodicals and research documents.

10.3 EXISTING INSTITUTIONS AND PROGRAMS

At present two Irbid municipal agencies, the Water Department and Department of Public Works, have responsibility for community water supply distribution and solid waste disposal. Although wastewater collection is provided for only a small part of the City (with no treatment), and pumping services for septic tanks and cesspools are also provided by the private sector, there has been no real assignment of responsibility to assure adequate service. The installation costs of the very limited sewerage system and any related maintenance that may have been required, as well as any work related to stormwater drainage, have been minor and funded from general City budgets. These departments were created and operate within the Irbid municipal law. The departments report to the Mayor of Irbid as indicated in Figure 10-1.

The Irbid Governorate and the Irbid Urban Region Planning Group are the only existing regional government units that could assume partial or total project implementation responsibility. The legal basis of these agencies is described in the following test.



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	ADMINISTRATIVE STRUCTURE FOR THE MUNICPALITY OF IRBID	FIGURE 10 – 1 DATE: SEPT. 1979 BY: A. TAYEH CHECKED: P. J. H.

The Jordan Valley Authority and the Amman Water and Sewerage Authority are described in this section because they are examples of institutions that can be developed to serve the Irbid area.

10.3.1 Irbid Water Department

The Irbid Water Department was created in 1966. Its functions are described in the City Water Department Regulations No. 41, 1978. They include:

1. Operation of water distribution.
2. Collection of fees.
3. Enforcement.
4. Maintenance.

Administrative and technical affairs of the Department are managed by a mechanical engineer, who is directly responsible to the Mayor of Irbid. The Department currently maintains Irbid's water distribution system, and serves 13,000 customers. The Department employs between 125 and 135 personnel.

Water Department functions are divided into seven sections:

1. Clerk's Section -- Main duties include: coordinate between the Water Department and other departments, and overall external coordination; maintain Department files.

2. Accounting Section -- Main duties include:

   a. Control of finances and preparation of revenue and expenditure reports.

   b. Prepare annual budgets.

   c. Prepare salary tables and review financial statements.

   d. Audit purchasing documents.

   e. Control of related divisions.

      - Revenue division
      - Typing division
      - Meter division
      - Warehouse

3. Stations Section -- Main duties include:

   a. Control of water supply pump stations.

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b. Prepare daily reports about water pumping quantities and related energy consumption and expenditures.

c. Maintain water stations.

4. Network Division -- Main duties include:

a. Repair and maintain network lines.

b. Install primary and secondary water lines for houses.

c. Emergency water provisions.

5. Surveying Division -- Main duties include:

a. Prepare charts for proposed new lines.

b. Design systems and prepare system maps.

6. Meter Workshop -- Main duties include:

a. Repair and maintain old meters.

b. General inspection/checking meters.

7. Dispatch Section -- Main duties include:

a. Dispatch repair services.

b. Dispatch water trucks.

c. Department transportation.

10.3.2 Irbid Department of Public Works

The Irbid Department of Public Works is responsible for collecting and disposing of the municipality's solid waste. The Department currently employs approximately 200 personnel for these tasks. Its functions and responsibilities, however, are not set out in a document such as the Water Department Regulations.

10.3.3 Regional Agencies and Authorities

Five regional agencies are described here. These agencies, which either exist or could be created, are:

1. The Irbid Governorate.
2. The Irbid Urban Region Planning Group (IURPG).
3. The Jordan Valley Authority (JVA).

4. The Amman Water and Sewerage Authority (AWSA).
5. Water Councils (provided for under the Water Supply Corporation Law No. 56 of 1973).

Although only the Irbid Governorate and the Irbid Urban Region Planning Group could play a direct role in providing municipal services in Irbid, the JVA, AWSA, and Water Councils are existing institutions that provide models of institutional arrangements that could be created in the Irbid region. Figure 10-2 locates Irbid with respect to the Irbid Governorate, the IURPG, and the JVA regions.

10.3.3.1 Irbid Governorate.

Nationally, five governorates were created to administer regional affairs throughout the country. The governorates are responsible to the Ministry of Interior. The Irbid Governorate has the capability to assume some of the project implementation responsibilities for Irbid, although its major role is internal regional administration.

10.3.3.2 Jordan Valley Authority (JVA).

In 1977, pursuant to the Jordan Valley Development Law No. 18, the Jordan Valley Authority came into effect, as an outgrowth of several predecessor agencies, most recently the Jordan Valley Commission which functioned from 1974 until 1977. The JVA is entrusted with the responsibility to develop the economic and social aspects of the Valley, including carrying out all works necessary to achieve this goal. In addition, the JVA is given authority to:

1. Carry out studies required to evaluate water resources.

2. Plan, design, construct, operate, and maintain irrigation, hydro-power, and water projects including reservoirs, water delivery and water distribution networks, and also surface and subsurface drainage works.

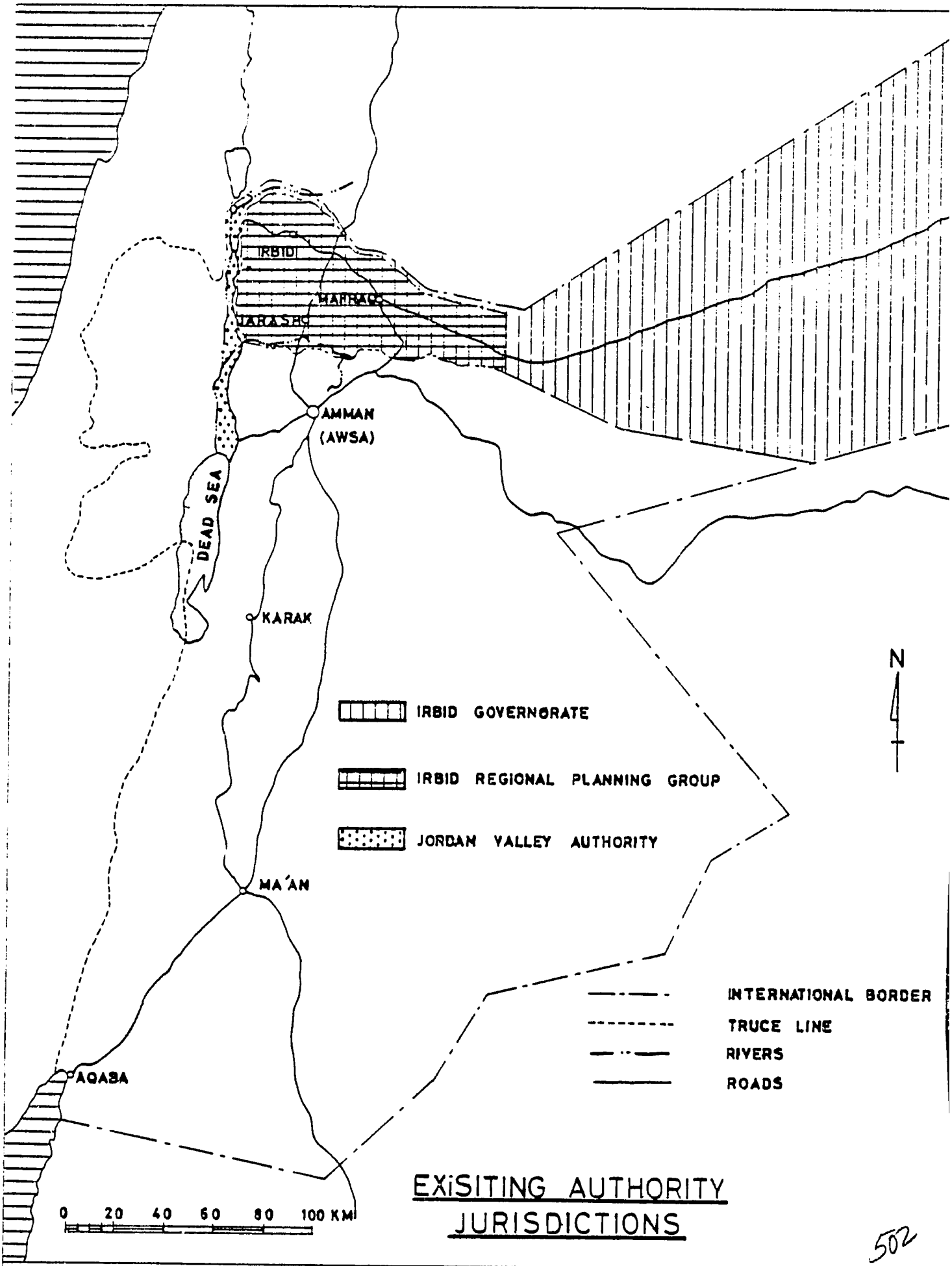
3. Settle water use disputes.

4. Organize and direct construction of private and public works.

5. Plan, design, and construct domestic water supply and distribution projects.

6. Implement all of the JVA projects regardless of whether these projects are within the jurisdiction of any other governmental unit.

After a project is completed (with the exception of water resources development and irrigation projects), the JVA transfers operation to the appropriate ministries, departments, governmental agencies, and other organizations including municipal, local, and village councils.



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WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co.Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	FIGURE 10- DATE: SEPT. 1979 BY: A. TA CHECKED P. J.

Since the Authority has been in operation for a very short time, its organizational structure has not been fully developed. However, the JVA is already engaged in the construction of some large irrigation projects, dams, and water supply projects. JVA has very broad capabilities and could assume many of the responsibilities for project planning and implementation in the Irbid region.

10.3.3.3 Amman Water and Sewerage Authority (AWSA).

At the recommendation of the World Bank, the Amman Water and Sewerage Authority was created in 1973. Prior to that time, water services were managed by a municipal water department. This change was suggested because of the rapid growth in the Amman area, the resulting sharply increased demand for water supply and wastewater disposal services, and the corresponding need for a comprehensive institutional arrangement.

In 1973, the government passed the Amman Water and Sewerage Law No. 19, which was replaced in 1977 by the Amman Water and Sewerage Authority Law No. 48, under which AWSA is currently operating. AWSA has the following duties and responsibilities:

1. Ensure the supply and distribution of sufficient quantities of water to meet the needs of the population within the Authority's area.

2. Protect such water from pollution and impose restrictions on its use, and pass instructions for taking water samples for necessary analysis.

3. Prevent wasting water, and pass pertinent instructions on water use.

4. Ensure the drainage of sewage effluents, surface water, and stormwater for sanitary scientific methods, and obtain the maximum possible benefit out of it.

5. Plan and execute general schemes for water and sewerage in order to meet future needs.

6. Locate the boundaries of the water basin, subject to approval of the Council of Ministers.

7. Locate restricted areas to protect the water basin and recharge areas with the approval of the Ministry of Urban and Rural Affairs and the Natural Resources Authority (NRA).

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8. Limit and restrict the use of water and prevent or restrict the extraction of water within the Authority's area, as well as within the Water Basin, subject to approval of the Natural Resources Authority.

9. Supply water to the consumer within the existing potentialities, and keep the quality of supplied water (up to the house connection point) according to the defined standard for domestic use.

10. Provide for drainage of sewage entering the sewage network.

11. Ensure the normal drainage of surface water and stormwater through suitable sewers.

The authority has six departments:

1. Administration.
2. Finance.
3. Engineering.
4. Water.
5. Sewerage.
6. Sewage department.

The operations of AWSA are administered by a Board of Directors which is responsible for the Authority's management and supervision. AWSA is chaired by the Lord Mayor of Amman. The Board includes a General Manager of the Authority who is a member and a Vice Chairman; two members of the Council of Amman Municipality; one member from the Ministry of Health; one member from the Natural Resources Authority; and two members from the private sector who are appointed to renewable terms by the Prime Minister.

AWSA is currently staffed by approximately 1,100 employees, and has 55,000 water supply customers, and 15,000 customers for the sewerage system which is being expanded to serve 35,000 customers. More than half of the staff are in the Water Department, and approximately 200 personnel are responsible for the Authority's administration. The remaining staff include 32 engineers and other technical people. AWSA provides an example of the kind of authority that could be created in the Irbid area.

10.3.3.4 Water Councils.

According to a paper presented at Jordan's National Water Symposium in 1978, "Present Water Legislations and Institutional Framework in Jordan,"

prepared by the Director General -- NRA, the Amman Water and Sewerage Authority will probably be detached from the Lord Mayor of Amman and attached to the Water Supply Corporation (WSC) to function as the Water Council of the Amman area. This is a legal specification of the WSC law, which identifies the WSC responsibilities as follows:

1. Prepare water policy.

2. Provide water for drinking, domestic, and industrial uses through Water Councils.

3. Control water pollution, flood water, and wastage.

4. Layout and design water and sewerage distribution systems, and supervise all matters related to their operation and maintenance.

5. Cooperate with the Ministry of Health in handling water-related health matters.

The role of a Water Council is very similar to that of AWSA, however, its relationship to the government would be more direct than that of AWSA, which is currently an extension of the City of Amman. An Irbid Region Water Council could be created to administer, plan, and assist in implementing water and wastewater projects in the Irbid area.

10.3.3.5 Irbid Urban Region Planning Group (IURPG).

IURPG is an extension of the Ministry of Municipal and Rural Affairs (MMRA). Its responsibilities, as an independent regional planning agency, have not been formulated. Currently, this objective of developing IURPG into an effective regional agency is under consideration.

The potential objectives identified for IURPG in the Integrated Regional Development Study of North Jordan, by the Japan International Cooperation Agency (JICA), are as follows:

1. To formulate a regional development plan in accordance with long-range development perspectives and strategies.

2. To coordinate and integrate various individual projects proposed by the respective sectoral ministries, and expedite their implementation.

IURPG would, according to the North Jordan report, undertake certain responsibilities relevant to the planning and development of the region. Activities proposed for IURPG include:

1. Receive all detailed information on proposed development projects including costs and specifications from branch offices and headquarters of Ministries.

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2. Formulate, submit, and revise periodically:

   a. Regional development plan to NPC.

   b. List of recommended projects for government financing to the Department of Budget.

   c. Regional land use plan to MMRA (MMRA has land use regulation responsibility and will prepare the land use regulation map).

3. Monitor project implementation for projects approved by the NPC, the MMRA, and the Department of Budget.

10.3.3.6 Summary and Evaluation.

Local municipal departments have traditionally provided municipal services in Jordan. The regional authorities and councils described are new and have not had the opportunity to adequately demonstrate their potential. Each has certain problems of which we want to be aware.

The local municipal departments in Irbid have incurred annual deficits that are paid by government subsidies. AWSA has had similar difficulties in generating sufficient revenues to cover its full costs.

10.4 IMPLEMENTATION FRAMEWORK AND CRITERIA

This section has two objectives:

1. To identify the general national resources management framework within which the Irbid municipal facilities will be managed.

2. To specify various criteria that will be used to screen alternative institutional arrangements and select an effective approach for Irbid.

10.4.1 National Resources Management Framework

During the past several years, many researchers and public officials have recognized the need for a stronger resources management program in Jordan. The general objective appears to be the development of two programs that are fully integrated and can best plan for and manage the nation's scarce resources. One plan relates to water, and the other to socioeconomic development.

Although the details of these programs are not complete, assumptions have been made for the purposes of this study as to how this framework

will be structured. This hypothesized resources management program is based on the paper presented by Y. F. Nimry, NRA Director General, at Jordan's National Water Symposium in 1978 ("Present Water Legislation and Institutional Framework in Jordan"), and recent articles which have described the views of His Royal Highness Crown Prince Hassan and National Planning Council President, Dr. Hanna Odeh, on the subject of regionalization. The proposed institutional arrangement is similar to that developed in other nations, for example, the United States with the national U. S. Water Resources Council and regional river basin commissions, and the United Kingdom, where responsibilities for water and wastewater management are within regional boards.

The water management program assumed in this report includes a high level National Water Board that is directly under the Council of Ministers, and a number of regional authorities throughout the Kingdom. The National Water Board's responsibility is to formulate basic water policy (broadly interpreted to include planning, development, use, and conservation of surface and subsurface water resources, as well as water quality, i.e., wastewater and stormwater drainage). In addition, the Board's responsibility would be to allocate water consistent with national long-term development objectives, which are provided to the Water Board (possibly from a National Economic Development Board). The formulated plans and allocation programs would be subject to approval of the Council of Ministers. This approach has the advantage of centralizing basic policy and coordinating national development.

At the regional level, a number of regional agencies can be created. Their roles would be to implement the Water Board's policy. They could own, finance, administer, operate, maintain, and replace the facilities used in local resource development projects. These authorities would be coordinated with the Water Board, as well as with regional and local agencies and government units. This approach has the advantage of ensuring the coordinated development of regions, and efficiently using highly qualified administrative and technical personnel that are too specialized and expensive for smaller, more localized agencies. For the Irbid region, such an authority could be created to include the entire North Jordan area.

10.4.2 Specific Implementation Criteria

Certain basic criteria have been developed that are essential to selection of an institutional arrangement. Although all criteria are not equally important, a responsive institution will satisfy most of them. It is the objective of this chapter to select an alternative that can best achieve these criteria.

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The criteria are grouped into three major categories as follows:

1. Implement the proposed facility plans.

2. Coordinate with National Resources management policy.

3. Achieve regional development and satisfy local interests and objectives.

The details of each category are discussed in the subsections which follow.

10.4.2.1 Facility Implementation Criteria.

Probably the most basic and important criteria are those that "get the job done." An institutional arrangement will have to provide the following functions:

1. Administration.
2. Financing.
3. Operation and maintenance.
4. Planning.
5. Monitoring and surveillance.
6. Enforcement.
7. Training.

1. Administration.

Administration includes the administrative, managerial, and associated functions that establish day-to-day policy and direction, monitor agency performance, and coordinate interagency facility implementation. Administration is singled out as a key requirement which should be very carefully planned when developing a proposed institutional arrangement.

Administrative personnel establish the public image and reputation of the institution, and are responsible for creating the internal morale and spirit to accomplish the assigned task. Efforts should be made to acquire top-level personnel for the directorate and department head positions, and to ensure stability in these positions through appropriate remuneration and incentives.

2. Financing.

Financing the capital investment and arranging for repayment should be a responsibility of the implementing institution. These responsibilities are closely associated with program administration and can be coordinated with basic institutional objectives. The implementing agency should have the authority to issue bonds and other obligations, collect charges and fees, and otherwise be capable of financing the program it implements.

3. Operation and Maintenance.

Operation and maintenance are a responsibility of the implementing agency. Trained operators, service, and repair personnel are required to ensure the satisfactory operation of the planned facilities and support equipment. Although in general, facility designs have been planned with equipment that requires minimum maintenance, certain equipment failures are inevitable. In these cases, back up equipment has been planned. Faulty equipment would be repaired, tested, and returned to service.

Wages for skilled operation and maintenance personnel have to be competitive with neighboring cities and regions to avoid high personnel turnover rates.

4. Planning.

Planning future facilities to meet the needs of Irbid beyond the year 2000 and to incorporate other changes into the investment and operation and maintenance plans are continuing responsibilities of an implementing institution. Capital investment plans, financing plans, and other well thought out strategies for achieving the institution's objectives are essential to an effective program.

5. Monitoring and Surveillance.

Monitoring and surveillance of environmental impacts are responsibilities of the implementing agency. System malfunctions and illegal use, or avoidance of municipal services, are primary concerns. These functions will be coordinated with the planning, and operation and maintenance objectives since the purposes of the monitoring and surveillance effort are to identify detrimental impacts and to remedy them.

By identifying problems, a monitoring and surveillance effort can help to ensure the municipal service is functioning at its highest capability. This is an important effort since it addresses system problems that are also evident to the public. In this way, the public perceives the institution as responsive, and effective in carrying out its objectives.

6. Enforcement.

Enforcement is closely associated with monitoring and surveillance. It ensures that ordinances requiring mandatory hook-up and payment of charges are obeyed and violators are dealt with. Unless program enforcement is provided, the facilities implementation program will be haphazard.

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7. Training.

Training of personnel in all functions should be an ongoing objective of the implementing agency. Training will include:

a. Specialized instruction in the use of treatment plants, pumps, generators and other mechanical and operations-related equipment.

b. Training in sampling techniques, and use and care of monitoring and surveillance equipment.

c. Instruction in internal agency procedures and methods, including planning principles, accounting techniques, and other aspects of providing effective service to the public.

10.4.2.2 Coordination Criteria.

Since this study assumes that a national resources framework will be developed, and that basic policies and gross allocations of resources will be administered at that level, it will be necessary to coordinate the activities of the region with the National Planning Council objectives. Coordination will therefore include ties between:

1. National and regional/local policy.

2. National resource allocation plans and regional development.

3. National funding programs and regional/local investment planning.

These coordination measures are necessary to ensure the implementation of national objectives. They also allow regions to refrain from developing facilities beyond the needs of the region (i.e., extending wastewater collection service into areas that are water-limited based on national water allocation restrictions). This coordination will assist the regions in implementing basic principles that promote more efficient use of resources. Funding and grant policies can be used as incentives to encourage areas to develop in a manner consistent with the National Planning Council objectives.

10.4.2.3 Regional and Local Development Criteria.

An effective program must satisfy local needs in a manner acceptable to the public. The following criteria are considered important to the public and should be incorporated into an institutional arrangement

proposed for Irbid:

1. Utilize existing staff from the Irbid Water Department and Department of Public Works in meeting staffing requirements.

2. Be responsive to local needs to general service and emergency conditions.

3. Be affordable to the public.

10.5 PROPOSED INSTITUTIONAL ARRANGEMENTS

Based on the principles and planning criteria established earlier in this chapter, and the descriptions of existing institutional arrangements and consideration for future institutional/management needs, it is possible to structure several feasible institutional arrangements that can implement the facilities plans proposed for Irbid. Three conceptual institutional arrangements are presented and evaluated in this section. They represent a spectrum of capabilities, from a highly regionalized approach, very much like the regional authorities envisioned to implement the national resources management policy, to a localized arrangement, very similar to those already providing water distribution and solid waste collection services in Irbid.

Each alternative is described in terms of basic responsibilities and jurisdiction, and then evaluated with respect to relative advantages and disadvantages. From this evaluation a recommended implementation plan is identified.

10.5.1 Regional Authority Alternative

The regional authority is the most comprehensive of the institutional alternatives considered in this chapter. Because all of the functions outlined in Section 10.4 are provided by one agency, this alternative has the greatest capability for coordinating the necessary administrative and operational functions to provide municipal services. Figure 10-3 identifies the subregional and interagency relationships.

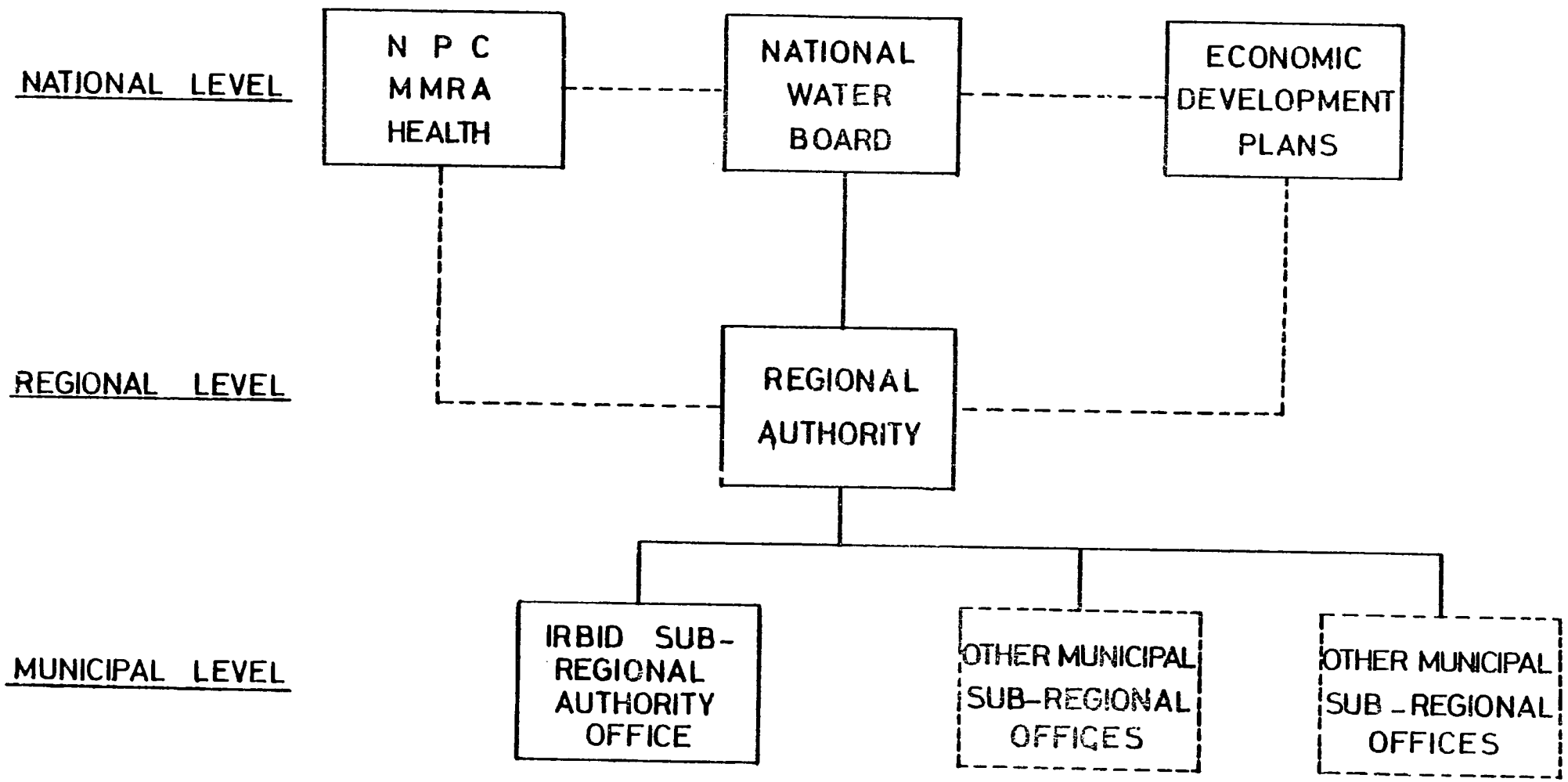
Table 10-1 lists the characteristics of the regional authority alternative, including information regarding the institution's jurisdiction, program elements, and responsibilities. This table also identifies the significant advantages and disadvantages of the alternative.

A variation within this alternative could use the existing municipal departments to provide the subregional office responsibilities. Services provided by these municipal departments could be limited to local billing, meter reading, accounting, public contact, and system monitoring.

The most important advantages of the regional authority are:

1. Its ability to effectively manage scarce resources, including skilled manpower to administer, operate, and maintain the proposed facilities.

2. To integrate with a national resources management and planning program that may be developed in the future.



——— DIRECT RELATIONSHIP

------ INDIRECT RELATIONSHIP

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co. Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	REGIONAL AUTHORITY ALTERNATIVE	FIGURE 10-3 DATE: SEPT. 1979 BY: A. TAYEH CHECKED: P. I. H.

Table 10-1

Regional Authority Alternative

Institutional Arrangement	Single, comprehensive agency responsible to the National Water Board, with subregional offices in areas with facilities.
Jurisdiction	North Jordan region, including the City of Irbid and its suburbs.
Program Elements	Water resources and supply, wastewater collection and treatment, stormwater drainage and solid waste.
Responsibilities	1. Implementation of natural resources/management policy. 2. Preparation of policies and plans for regional/local development to solve regional and local water resources problems. 3. Operation and maintenance of facilities. 4. Administration and finance of proposed facilities. 5. Monitoring, surveillance, and enforcement.
Evaluation	
Advantages	1. Consistent with broad National Planning Council concepts. 2. Coordinate with national resources management policy. 3. Characterized as an authoritative agency -- strong and comprehensive. 4. Authority over large financial resources for financing resource investments. 5. Utilize subregional offices to maintain close contact with service users. 6. Provides for most efficient use of resources and skilled personnel.
Disadvantages	1. Service to large region could dilute attention to individual municipalities.

The efficiency aspects of the regional authority alternative, relate to the "economies of scale," will be realized by having a single agency provide manpower and services to a large region.

This single large agency, with responsibility for possibly the entire North Jordan area, will take the place of numerous independent agencies that otherwise provide or will provide, services for each community. It has ability to employ specialized skilled people whom the small community institutions will not be able to afford. The size and power of the authority are keys for interfacing with the national government, and demonstrating the significance of proposed local and regional programs and investment plans.

10.5.2 Regional Planning/District Authorities Alternative

The regional planning/district authorities alternative separates the responsibilities for planning and managing municipal services into two levels.

Figure 10-4 suggests how this institutional arrangement could be structured. Under the National Water Board will be a Regional Planning Board. This planning board will be the center for planning in the area, and will develop plans based on National Water Board policies, resource allocation limitations, and economic development objectives established by national authority. Plans prepared at the regional level will be approved for implementation by the National Water Board.

District authorities will be structured under the Regional Planning Board. They will implement the proposed plans, and operate and maintain the facilities for each municipality. These municipal authorities will be capable of providing all of the functional requirements associated with serving the public in each community.

Table 10-2 summarizes the proposed regional planning/district authorities alternative. The planning jurisdiction of this institutional arrangement will be identical to that proposed for the regional authority. The planning area can include possibly the entire North Jordan area, but can also be restricted to a smaller region immediately around Irbid. The other regional authority responsibilities are localized in the district authorities. The jurisdiction of district authorities is restricted to the specific municipalities where facilities are constructed. These authorities are structured on an as-needed basis.

Regional plans correspond to National Planning Council objectives. Once approved by the National Water Board, they are implemented by the district authorities. The authorities provide the water supply, wastewater collection and treatment, stormwater drainage, and solid waste disposal services, including:

1. Operation and maintenance.
2. Administration and finance.

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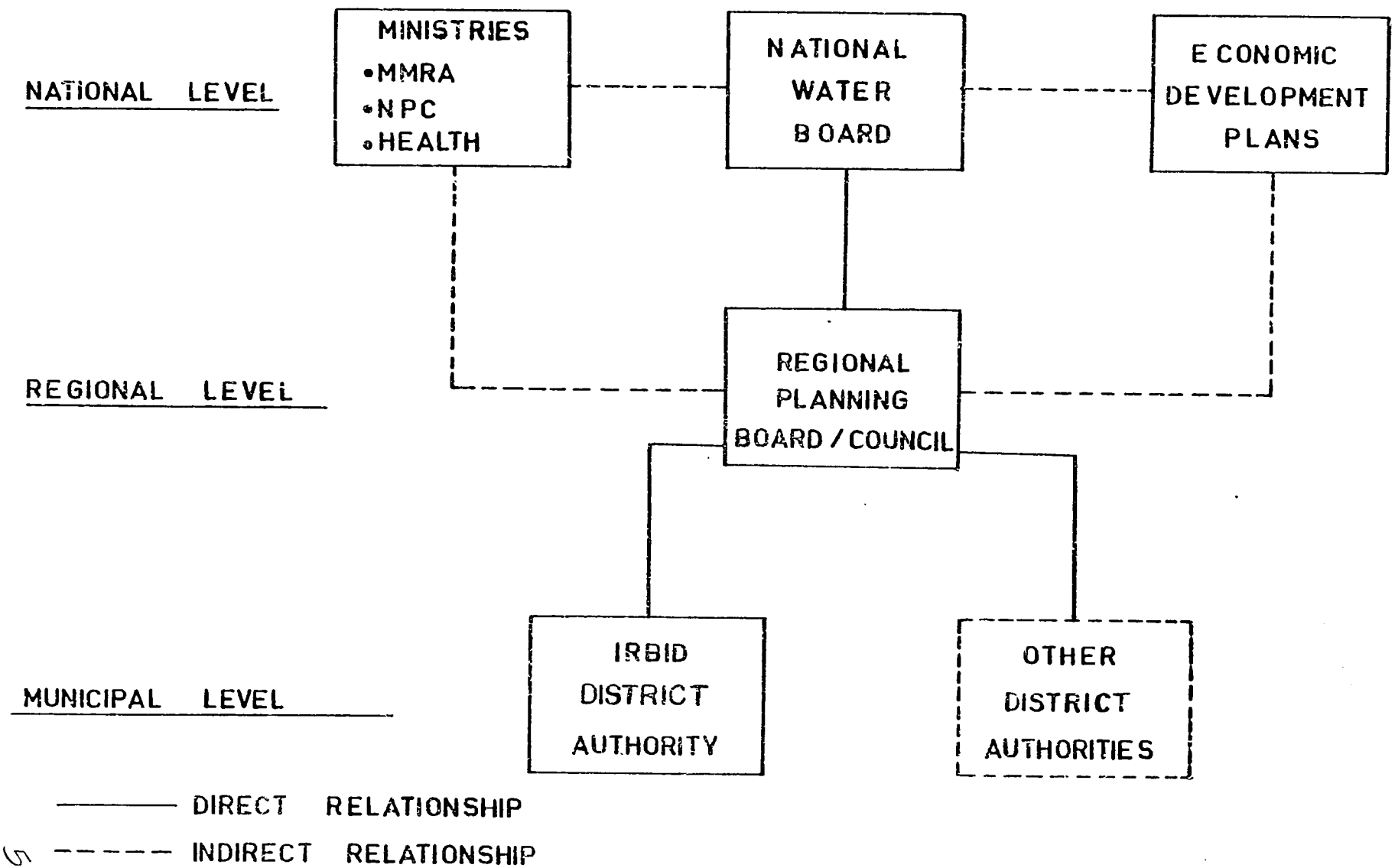

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IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE

REGIONAL PLANNING DISTRICT AUTHORITY

FIGURE 10-4

DATE

BY A.TAYEH

Table 10-2

Regional Planning/District Authorities Alternative

Institutional Arrangement	Single planning agency with responsibilities to the National Water Board. Several district authorities to implement facility plans in each municipality.
Jurisdiction	North Jordan region, including the City of Irbid and its suburbs.
Program Elements	Water supply, wastewater collection and treatment, stormwater drainage, and solid waste.
Responsibilities	
Regional planning agency	1. Coordination with national resources management policy. 2. Preparation of policies and plans for regional/local development. 3. Coordination with local authorities and programs review.
District authorities	1. Operation and maintenance of facilities. 2. Administration and finance of facilities. 3. Planning coordination with regional planning agency. 4. Monitoring, surveillance, and enforcement.
Evaluation	
Advantages	1. Consistent with broad National Planning Council concepts. 2. Coordinated with national resources management policy. 3. Maintains maximum authority in the National Water Board since the Regional Planning Board provides only planning services. 4. Utilizes a local approach to provision of municipal services, more adequately responding to customer needs.
Disadvantages	1. Requires duplication of talents in district authorities, and therefore is less efficient than a single regional authority. 2. Creates (possibly) many small authorities which would function independently and based on local resources could provide poor service. 3. Restricts authority and enforcement only to municipalities with facilities on an as-needed basis (i.e., less comprehensive).

3. Planning coordination.
4. Monitoring, surveillance, and enforcement.

This alternative is capable of implementing national planning concepts and policy at the regional-level, but retains overall planning authority at the national level rather than dispersing it to the regions as does the regional authority alternative. This approach provides relatively strong individual district authorities which will permit municipalities a large degree of home rule and self-determination in facilities operation.

The regional planning role can be assumed by the Irbid Urban Regional Planning Group. In addition to the responsibilities proposed for the IURPG as part of the North Jordan report (subsection 10.3.3.5), their responsibilities should be expanded to cover planning for municipal services.

National interest in regional planning has recently been demonstrated by the Ministry of Municipal and Rural Affairs. On 19 July 1979, the Ministry released regulations concerning regional planning. The MMRA will undertake the responsibility for direct control and review of regional planning and coordinate efforts with the NPC, and other ministries, and public corporations. The MMRA will:

1. Develop a framework of principles and rules for regional development.

2. Prepare regional development plans for various areas of the Kingdom.

3. Prepare studies and research required for economic regional planning.

4. Prepare structural designs for facility plans in urban areas.

5. Develop rules and regulations related to regional planning and construction.

6. Supervise regional planning activities.

The MMRA Regulations also describe the structure of a typical regional planning department. It would have four sections under a regional planning manager:

1. Research Section -- To analyze economic, social, and environmental factors and compile information concerning regional growth.

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2. Planning Section -- To prepare regional plans including projects, natural resources, and land use.

3. Drawing Section -- To prepare specialized drawings and maps.

4. Administrative Section -- To provide administrative support to the department, including report preparation, library services, and general secretarial and clerical services.

The regional planning department will work closely with cities and villages in organizing local plans which will be in agreement with the regional plan.

The regional water policy and planning role could also be assumed by an Irbid regional water council created pursuant to the Water Supply Corporation Law.

This approach requires duplication of technical personnel to provide technical and administrative capability to each municipality equivalent to that provided in the regional authority alternative.

A district authority can include three departments under the director, as shown in Figure 10-5. The engineering and planning department can closely review and implement regional plans and proposals.

The department will be engineering oriented and assure that regional plans are implemented in the manner intended by the Regional Planning Board.

The operations department will be the largest department in the authority. It will include three sections (as needed) for: water supply, wastewater and stormwater drainage, and solid waste management.

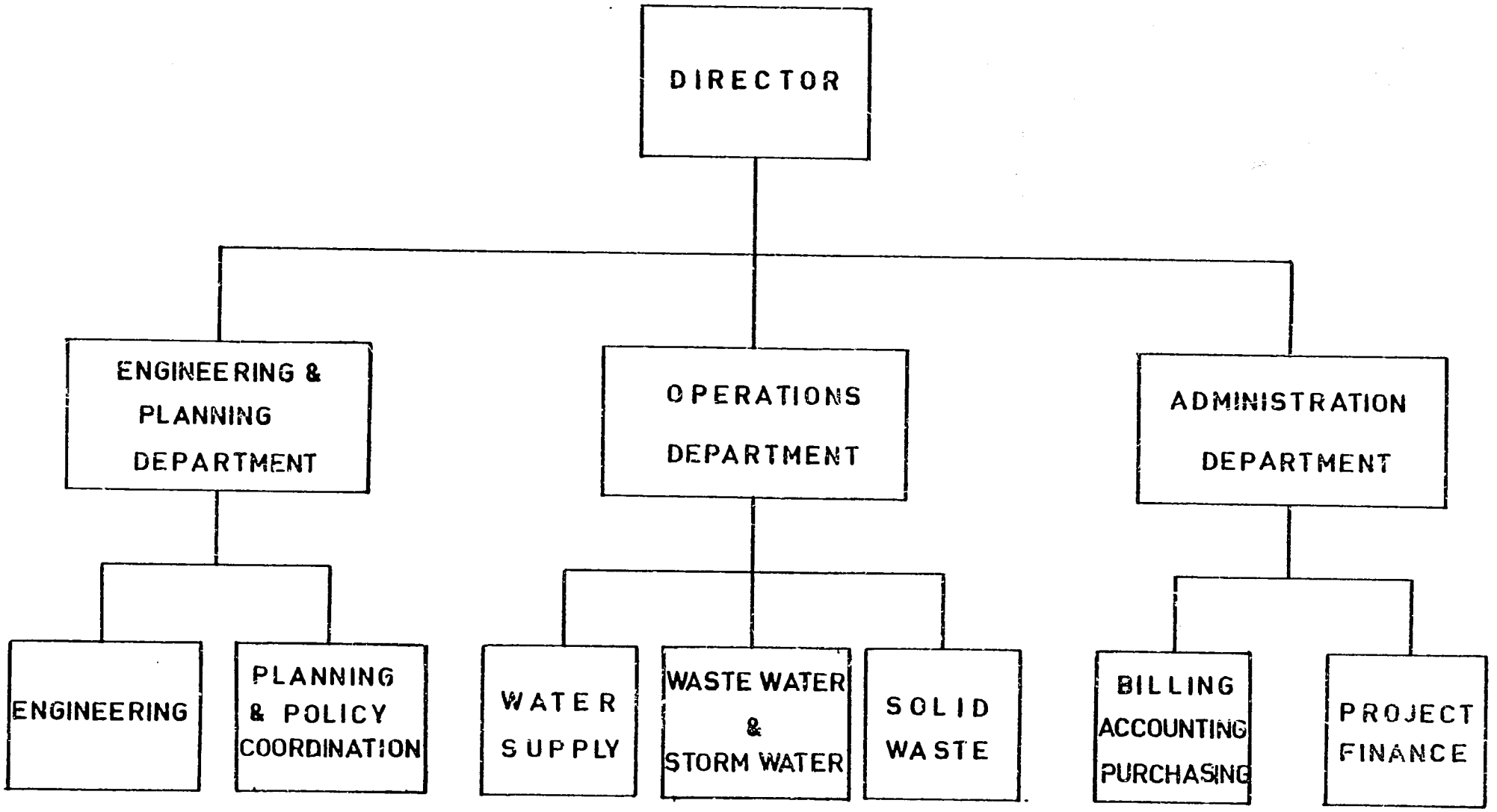
The administration department serves three major functions: billing (including meter reading), accounting and purchasing, and project financing.

All three departments are closely coordinated internally in order to provide maximum efficiency and to fully integrate the department objectives.

10.5.3 Municipal Departments Alternative

A third alternative for implementing the municipal facilities plans in Irbid is the continued use of municipal departments within the City government structure. These institutional structures are in existence and can be expanded to accommodate additional responsibilities.

The current City organizational chart, Figure 10-1, was presented earlier in this chapter. The existing organization should be modified slightly as shown in Figure 10-6, if these services are to be managed by municipal services. Two departments will manage the municipal services in Irbid:



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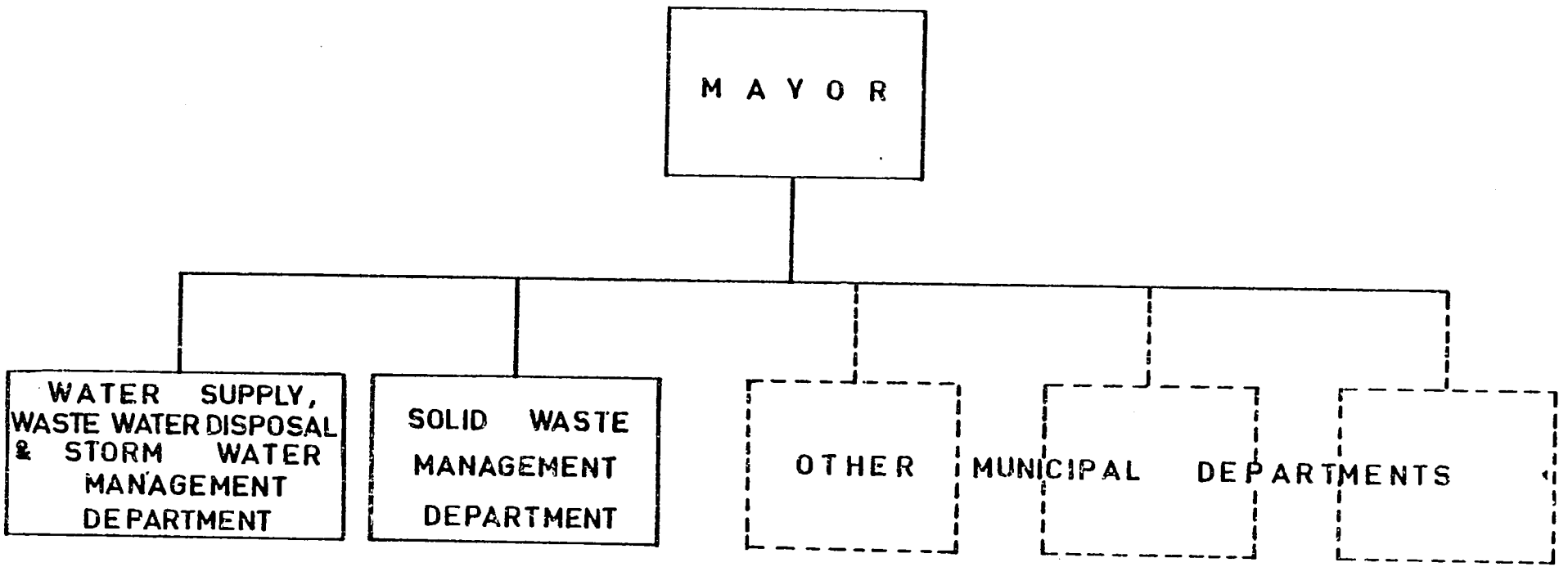
IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE

DISTRICT AUTHORITY ARRANGEMENT

FIGURE 10 – 5

DATE: BY: TAYEH



WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS Co., Ltd.	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE DISPOSAL PROJECT	MUNICIPAL DEPARTMENTS ALTERNATIVE	FIGURE 10-6 DATE SEPT. 1979 BY A. TAYEH CHECKED P. J. H.

1. Water supply, wastewater disposal, and stormwater management department.

2. Solid waste department.

These departments build on the existing Water Department and Department of Public Works, and expand their current responsibilities. The two departments are equal in authority and report directly to the Mayor.

Water supply, wastewater disposal, and stormwater collection programs are organized within one department. Each system contains common elements, such as pipelines, and water-related facilities and equipment. In addition, the charges for wastewater disposal are partially based on water use. Solid waste disposal is managed in a single purpose department.

Table 10-3 presents the jurisdiction and responsibilities of these municipal departments. Because of the local nature of municipal departments, they do not have the ability to coordinate well with National Planning Council policies. Many of the responsibilities associated with the regional agencies proposed in alternatives 1 and 2 must, as a result, continue to be assumed by the national government.

Based on descriptions of the existing Water Department and Department of Public Works presented in Sections 9.3 and 10.3, and conversations with local officials in Irbid, it appears that the existing departments require considerable reorganization to achieve the project implementation requirements. The major advantages of the municipal department approach is the close contact between the department and the customers (Irbid officials will serve Irbid customers), thus ensuring responsiveness to public needs. This alternative can be implemented with no major new legislation requirements.

This alternative does not provide a planning hierarchy between local cities and the national government. The major philosophy behind the creation of a hierarchy of planning and management responsibility (national/regional/local) is to free the cities from direct reliance on the national government for all planning decisions. It was for this reason that alternatives 1 and 2 incorporated regional agencies into the resources management framework. The regional element is omitted in this alternative.

This alternative is more fragmented than the previous alternatives, and ultimately requires duplication of administrative and technical skills in each municipality. Because of the size of the municipal departments, the emphasis will be only on provision of services. This will preclude the use of planning and more comprehensive engineering studies that could be justified for larger regional agencies.

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Table 10-3

Municipal Departments Alternative

Institutional Arrangement	Municipal departments within each community to provide services.
Jurisdiction	Localized urban centers where the National Planning Council has identified the need for, and constructed community facilities.
Program Elements	Individual departments (as needed) for: water supply, wastewater and stormwater, and solid waste.
Responsibilities	1. Operation and maintenance of facilities. 2. Administration. 3. Monitoring, surveillance, and enforcement.
Evaluation	
Advantages	1. Utilizes existing departments. 2. Familiar to the public which will be serviced. 3. Demonstrated feasibility and requires no new laws to implement.
Disadvantages	1. Inefficient approach, requires duplication of skills in departments and between communities. 2. Fragmented management, difficult to coordinate internally. 3. Cannot coordinate with national policy and resources management programs. 4. Cannot provide adequate planning. 5. Not experienced in financing projects. 6. Service area too small to generate revenues for highly capital-intensive projects. 7. Monitoring and surveillance, and enforcement may not receive adequate attention because of budget limitations. 8. Quality of service dependent on community resources.

The municipal departments alternative, in contrast to the regional approaches, has a smaller financial base upon which the municipal services departments can rely for revenues. Potentially, a regional authority will be able to serve a larger number of customers since their service area is limited to the defined City limits.

10.5.4 Recommended Implementation Plan

Each of the institutional alternatives described can be used to implement the proposed plans for Irbid. Each has certain advantages and disadvantages that need to be further considered in selecting a preferred approach.

Table 10-4 compares the alternatives and evaluates the functions of each with respect to their relative capabilities. The analysis is subjective and relies on the proposed principles and criteria presented in this chapter as the basis for achieving project implementation, in a manner that is consistent with national planning as well as satisfaction of local needs. This analysis also relies on the demonstrated capabilities of existing institutions, both at the local Irbid-level (municipal departments), and at the regional level (JVA, AWSA, IURPG, and Water Councils), and the potential for regional departments that would be created under the MMRA.

With few exceptions, regional alternatives 1 and 2 are more desirable than the local municipal departments approach. This advantage comes from the improved ability to more efficiently use higher skills to address the problems in a large region, to coordinate with national policies, and to benefit at the same time from "economies of scale."

Although not specified directly as an evaluation criteria, but indirectly through consideration of local responsiveness, powerful regional agencies can be a problem if they become self-serving and ignore their responsibilities to the public they service.

The regional planning/district authorities alternative is selected over the regional authority alternative in part because of the concern that a large regional authority would possess too much power tending to make the authority nonresponsive to local needs. Despite the advantages identified for the regional authority in Table 10-4, this is a major flaw.

There are many reasons why the regional planning/district authorities option is the best institutional arrangement. The regional planning agency, water council, or regional department provides the necessary regional institution to provide separation between the national government and local municipalities in the region. This regional agency can administer the nation's policy on resources utilization, and guide the development of the region. It also will have the ability to assist in financing projects.

Table 10-4

Capabilities Comparison of Institutional Alternatives

Capability To: / Institutional Alternative	Implement Facilities Plan							Coordinate National Policy and Plans			Address Local and Regional Objectives	
	Admin.	Finance	O&M	Planning	Monitor and Surveillance	Enforcement	Training	Policy	Plans and Allocation	Funding	Responsive	Affordable
1. Regional Authority	+	+	+	+	+	+	+	+	+	+	0	+
2. Regional Planning Municipal Authorities	+	0	+	+	+	0	0	+	+	0	+	+
3. Municipal Departments	0	-	0	-	0	0	-	-	-	-	+	0

Implementation Capability Key:

+ Commendatory
0 Adequate
- Marginal

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In addition, the IURPG exists, and could assume the role of this regional planning agency, or a WSC regional water council or regional department can be created.

The district authorities are capable of local economies of scales, can improve efficiency, and can be highly coordinated municipal services agencies. In addition, they provide a dispersion of power to the district.

This combination of regional agency and district authorities can serve the implementation needs of the proposed Irbid facility plans. Because of the two-tier nature of the proposed institutional arrangement, it is possible to structure the Irbid district authority immediately to provide the necessary implementation needs and later create the regional planning agency.

10.6 RECOMMENDED IMPLEMENTATION PLAN

Assuming that the regional planning/district authority alternative institutional arrangement is selected, policy and program elements for the proposed Irbid facilities can be developed. This section identifies the required basic:

1. Policy needs.
2. Detailed institutional arrangement.
3. Plan development.

10.6.1 Policy Needs

Water resources in Jordan are limited by light seasonal annual rainfall. The average annual precipitation in the Irbid area is only about 400 mm per year, and the majority of the annual precipitation comes during the winter months (October-March).

A national water policy is being formulated. As described in subsection 10.4.1, the functions of a National Water Board will include:

1. Basic national water policy.
2. Water supply allocations to regions.

The basic national water policy will address issues of water pricing, equity, subsidies, and minimum subsistence levels of water that would be available and affordable to low income households, and water conservation.

The Water Board will provide the water to each region that will permit planned development, with respect to national economic development objectives. As a result of these objectives, policies and decisions concerning water allocation water projects will be defined in each region.

Water policy at the local level is also important. It will ensure that water resources are used effectively and equitably. Local water policies to be considered include:

1. Recognize the health aspects of a good water supply and distribution system.

2. Provide the required minimum per capita water requirements to all residents.

3. Provide water affordable to low income users.

4. Provide a water connection to every house.

5. Prevent illegal connections.

6. Meter all water use accurately.

7. Promote water conservation.

8. Detect leaks and provide prompt repair service.

9. Respond to public needs.

Policies that ensure the financial viability of the agency, encourage the efficient use of the constructed facilities, and are sympathetic to the public's need for low cost connection to the systems are important. Ordinances can be prepared that will:

1. Permit water service charges as soon as connection is possible, even for vacant lots.

2. Provide a period of time (i.e., six months) to voluntarily connect a dwelling or establishment to water or wastewater systems. Noncompliance would lead to installation by the municipality, and the connection cost would be secured by special liens against the property.

3. Permit an installment plan for defraying the private household connection costs.

Other policies influence the use of water resources and the overall effectiveness of the proposed water and wastewater systems. Water policy can be implemented through other local agencies and departments that can influence water use. Land use and tax policy can be prepared that will provide incentives to connect to the water (and wastewater) systems as soon as possible. Ordinances and codes can be prepared that will:

1. Change land use and zoning to more effectively use these systems.

2. Encourage use of water conserving equipment (i.e., building codes could specify the need to use water efficient toilets and shower heads in new construction).

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10.6.2 Detailed Institutional Arrangements

Structuring an Irbid district authority, as previously described in institutional arrangement alternative 2, requires careful planning to avoid many problems that have been observed in existing regional and local agencies. The proposed district authority could include some of the ideas discussed in the following subsections.

10.6.2.1 Organization Structure and Staffing.

Figure 10-5 presents an organization that utilizes personnel effectively in providing municipal services for Irbid. This proposed district authority has three departments which undertake the major responsibilities of the authority.

Table 10-5 presents an organizational table identifying the personnel/staffing requirements of the authority for the immediate future.

Requirements are specified assuming an appropriate system of compensation and remuneration s developed to minimize rapid turnover of personnel, obviating the need for duplicate staffing.

Total suggested staff requirements are approximately 300. The operations department is the largest with 254 personnel. More than half (135) are in the solid waste management section, reflecting the need for collectors and sweepers. The wastewater section has 70 staff members, and the water supply section has 49.

A key factor in developing this authority, as a stable, responsive agency, is the incentive/remuneration system employed. Unless adequate salaries are paid to qualified administrative and technical staff, the high turnover in personnel, which is presently adversely affecting other similar agencies in Jordan, will become a serious problem in the Irbid district authority. As an example, normal staffing for AWSA's wastewater treatment plant includes a complete backup staff to replace personnel who leave frequently. The Water Supply Corporation (WSC) staff members generally have less than one year of service with the Corporation.

Frequent turnover in personnel leads to serious problems in efficiency, morale, and overall effectiveness of the proposed facility development program. It is essential that qualified personnel be attracted to the municipal authority, and be sufficiently rewarded to remain as permanent staff.

Table 10-5

District Authority
Personnel Table of Organization

	Staff Requirements
1. Office of Director	
1.1 Director	1
Chief Engineer	1
Technical Assistants	2
Secretaries	2
Driver	1
2. Operations Department	
2.1 a. Water Supply Section Head	1
Secretary	1
Driver	1
b. System Operations Manager	1
Secretary	1
System Operators	3
Laborers	2
Drivers	2
c. Maintenance Section Manager	1
Secretary	1
Records Clerk	1
Pump Repair Technician	1
Valve Repair Technician	1
Emergency Service Foreman	1
Laborers	2
Drivers	2
d. Meter Section Manager	1
Records/Scheduling Clerk	1
Meter Readers	20
Meter Repairmen	4
Driver	1

Table 10-5
(Continued)

		Staff Requirements
2.2	a. Wastewater and Stormwater Section Head	1
	Secretary	1
	Driver	1
	b. Collection Systems Maintenance Manager	1
	Secretary	1
	Records Clerk	1
	Maintenance Operators	4
	Helpers	8
	Emergency Maintenance Foreman	1
	Pump Station Repair Technician	1
	Drivers	4
	c. Wastewater Treatment Plant Manager	1
	Secretary	1
	Senior Operators -- 1/Shift	4
	Operators -- 2/Shift	8
	Helpers -- 3/Shift	12
	Chemist	1
	Laboratory Technician	1
	Maintenance Foremen	2
	Records Clerks	2
	Plumbing Technicians	2
	Electrical Technicians	2
	Helpers	4
	Laborers	4
	Watchmen	2
	Drivers	4
2.3	a. Solid Waste Disposal Section Head	1
	Secretary	1
	Driver	1

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Table 10-5
(Continued)

	Staff Requirements
b. Solid Waste Collections Manager	1
Records Clerks	2
Maintenance Operators	8
Operators/Collectors	10
Helpers/Street Cleaners	100
Drivers	7
Watchmen	4
3. Engineering and Planning Department	
3.1 a. Engineering Section Head	1
Secretary	1
Driver	1
b. Engineers	2
Draftsmen	2
Secretary	1
Records Clerk	1
Driver	1
c. Planner/Policy Coordinators	2
4. Administrative Department	
4.1 a. Accounting Section Manager	1
Secretaries	3
Drivers	2
File Clerks/Billing Machine Operators	4
Accountants	2
Purchasing Clerk	1
b. Financing Supervisor	1
Secretary	1
Driver	1
c. Legal Advisor	1
Secretary	1

Table 10-5
(Continued)

	Staff Requirements
d. Motor Pool and Dispatch	
Foreman	1
Dispatcher	1
Master Mechanic	1
Mechanics	2
Helpers/Drivers	2

10.6.3 Plan Development

A construction operations plan as well as an investment plan for the proposed Phase 1 facilities have been developed based on:

1. Initial construction contract tendering and initial construction in 1980.

2. Completion of all of the major construction contracts by the end of 1982.

The operations plan is presented in Figure 10-7. The investment plan is presented in constant 1979 prices in Table 9-2, and in prices escalated for inflation projected over the project period in Table 9-3.

Contractors in Jordan are certified to construct various types of work, and are graded using a class system. General contractors handle projects such as roads, bridges, airports, harbors, irrigation systems, railroads, buildings, water supply, sewerage, electrical, mechanical works, etc. There is a second contractor classification for highway and bridge contractors. There are several grades within each contractor classification. The maximum value of each contract that may be awarded, as well as the maximum value of projects under construction at a given time by one contractor, are determined by the contractor's classification, and are as follows:

Contractor Classification	Maximum Value Each Contract (JD)	Maximum Value Total Projects Under Construction (JD)
General 1st Class	2,000,000	20,000,000
General 2nd Class	1,000,000	10,000,000
Highway 1st Class	1,000,000	10,000,000
Highway 2nd Class	500,000	2,000,000
Highway 3rd Class	100,000	1,000,000
Highway 4th Class	50,000	300,000

The scope and size of the Irbid project indicates that only contractors with the qualifications listed for General 1st and 2nd Class, and Highway 1st and 2nd Class should be used. Contract packages can be developed to meet this objective and create individual contracts of sizes that are attractive to the desired class of contractor.

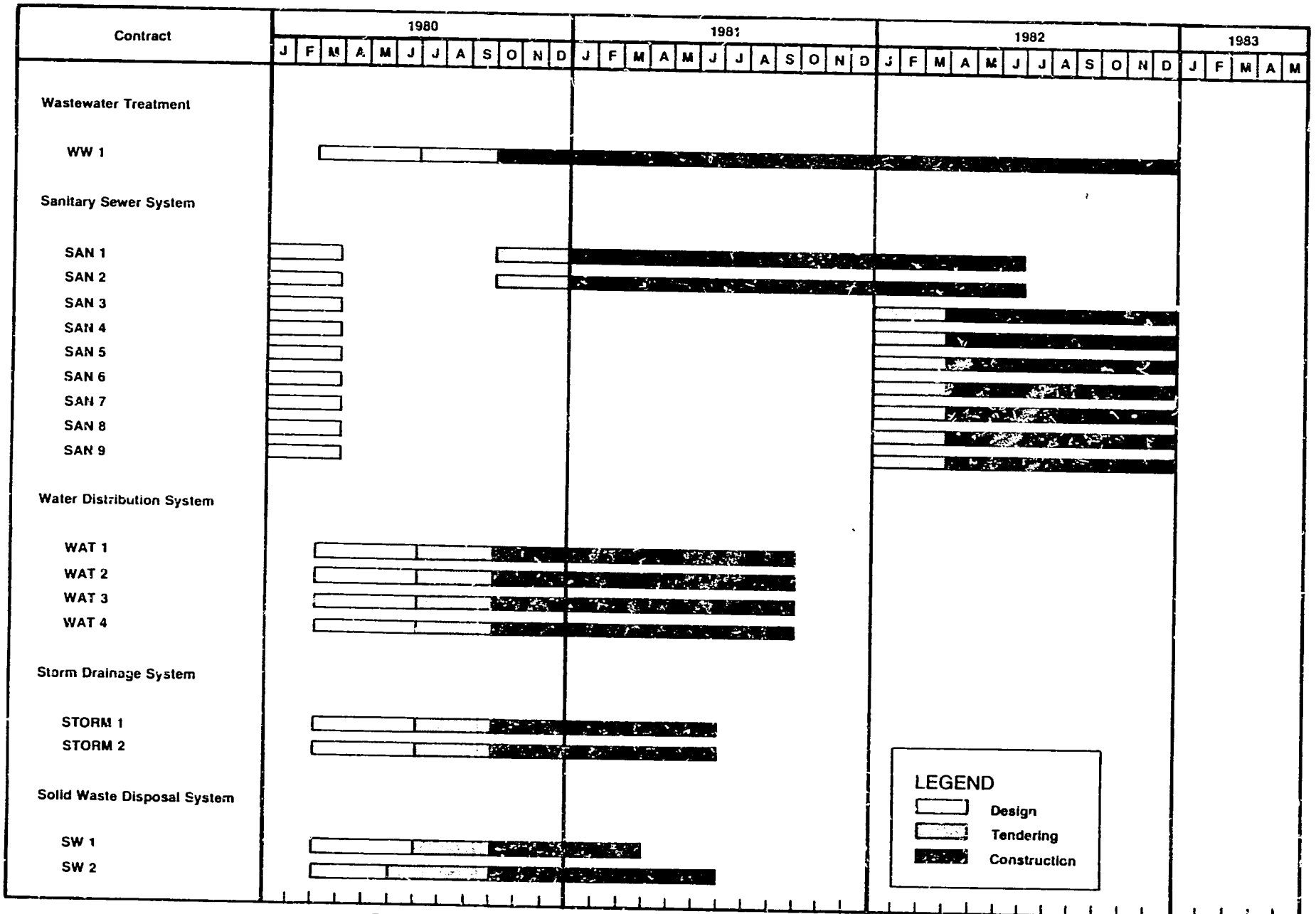

FIGURE 10-7 CONSTRUCTION OPERATIONS PLAN

IRBID WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT

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The wastewater treatment and sanitary sewer system contracts are developed so that the treatment and interceptor contracts are of sufficient size to require the qualifications of General 1st Class contractors.

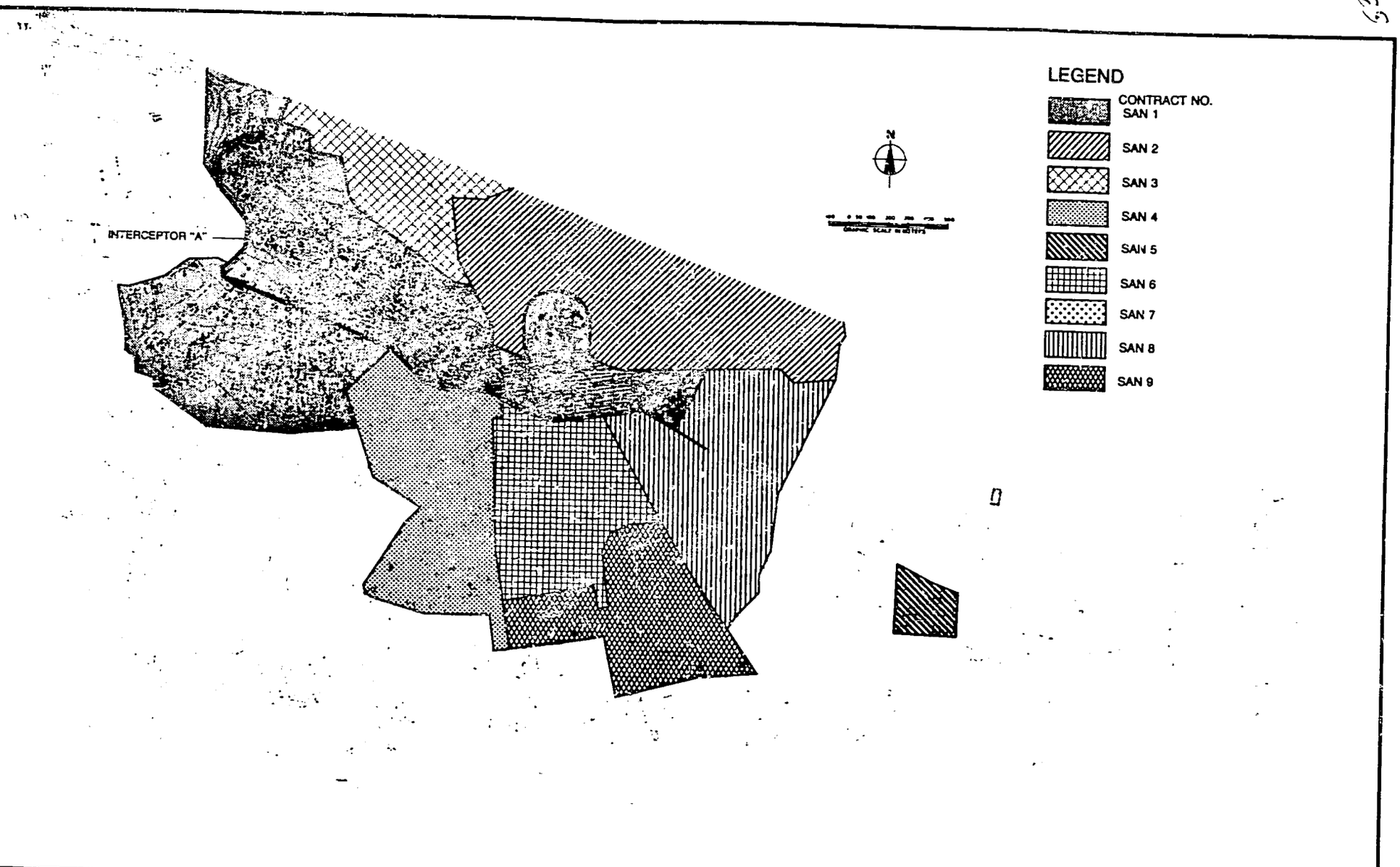
The water distribution system, storm drainage, and solid waste disposal system contracts are not interdependent, that is, water distribution facilities improvements can be constructed independent of storm drainage, solid waste, or sewerage facilities. In addition, these contracts can be easily completed within the selected construction period.

Construction of the various sewerage facilities is interdependent. This interdependence is illustrated in Figure 10-7. From this figure it can be seen that construction of the wastewater treatment plant is critical to completing the proposed facilities within the scheduled time frame. This contract requires the longest construction period, and the plant must be in operation before sewage flows are accepted in the sanitary sewers. The interceptor sewer contracts, SAN 1 and SAN 2, are next in importance. These sewers transport wastewater from the trunk and lateral sewers to the treatment plant. They should be in place prior to constructing trunk and lateral sewers.

Both interceptor contracts SAN 1 and SAN 2 include trunk and lateral sewers serving the less affluent areas of the City. These are the areas identified as having existing public health problems. If construction funds are limited, one or both of these contracts, together with the treatment facilities contract, will provide a limited, workable sewerage system.

The remaining sanitary sewer contracts (SAN 3 through SAN 9) are sized to appeal to smaller contractors. If financing is available for the entire project, all of the sanitary sewer contracts can be awarded and constructed within a two and one-half year period. If partial financing is available, the contracts could be awarded over a longer period of time.

The areas served by the various sanitary sewer system contracts are identified on Figure 10-8a and b.



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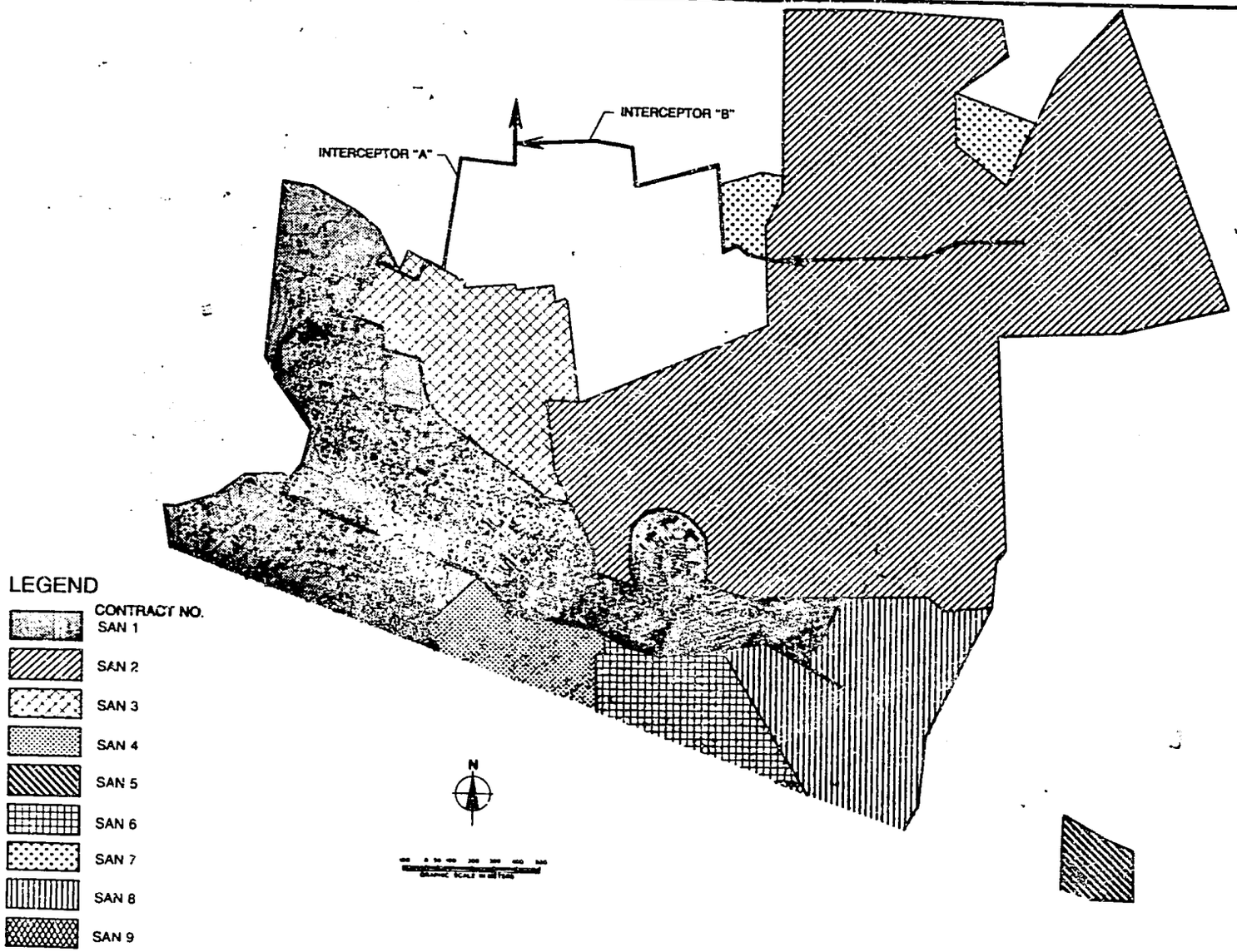
SANITARY SEWER
CONSTRUCTION CONTRACTS

SHEET NO.
FIGURE 10-8a

DATE: SEPT. 1979

BY: Costello

CHKD: Dzadzy



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SANITARY SEWER
CONSTRUCTION CONTRACTS

SHEET NO.
FIGURE 10-8b

DATE: SEPT. 1979
BY: Coriello
CHKD: Dradzy

10.6.4 Recommended Training Program

Construction of the water supply and wastewater facilities recommended in this report will create the need for trained operators and technicians to operate and maintain the system. The position titles and numbers of personnel needed for this purpose are listed in Table 10-5.

At present, there are a few trained operators employed at the Ain Ghazal Sewage Treatment Plant run by the Amman Water and Sewer Authority (AWSA). They are the only trained operators in Jordan. It is not reasonable to assume any of them would be available to run the Irbid facility.

Irbid has an existing Water Department as described in Chapters 9 and 10. These personnel have a sufficient level of competency to run a water supply system that does not involve a water treatment plant. Little, if any, training is needed in the water supply department, except for some management reorientation commensurate with the recommended reorganization. Therefore, the training program proposed in this section is directed primarily toward the wastewater training needs of the project.

The recommended program is divided into two major phases:

1. Preparation for training.
2. Training program implementation.

10.6.4.1 Preparation for Training.

The new wastewater facilities planned for Irbid will require the services of trained treatment plant operators and maintenance personnel. To avoid the need to recruit overseas personnel, a training program should be developed. It will qualify personnel in the following categories:

1. Supervisory Training -- Plant managers, shift foremen, maintenance supervisors, and laboratory managers.

2. Operator Training -- Treatment plant operators, plant maintenance personnel, distribution system/collection system maintenance personnel, laboratory technicians, and other skilled labor categories.

Training of these personnel is outlined as follows:

1.1 Identify staff requirements
1.2 Determine availability of required skilled personnel
1.3 Identify the magnitude of training to be accomplished

1.4 Obtain available training aids (manuals, course outlines, training aids, charts, etc.)
1.5 Determine best training approaches available for use:
-Use of overseas training institutions to which personnel would be sent
-Use of consulting services brought to Irbid
1.6 Identify schedule requirements

10.6.4.2 Training Program Implementation.

The work outlined in the following training program framework will require identification, selection, and employment of a qualified overseas engineering firm with demonstrated experience and qualifications in the field of operator training. It is recommended that the selection procedure be implemented as soon as possible to ensure early selection of a qualified firm capable of providing the necessary services throughout the entire program. The following outline suggests various aspects of the training program:

2.1 Overseas Training

2.1.1 Select five trainees (Civil engineers: 1-5 years experience, BSCE degree).

2.1.2 Select U.S. training school.

2.1.3 Send five trainees for 26 weeks' training program.

- 14 weeks school
- 12 weeks on-the-job-training at U.S. wastewater treatment plant.

2.1.4 Select one trainee for plant manager.

2.1.5 Consultant selects five sewerage districts in the U.S. that are similar to Irbid, and arranges management visit program.

2.1.6 Manager trainee goes on five-week management fellowship.

2.1.7 Out-briefing program for both groups by consultant.

2.2 In-Country Training

2.2.1 Consultant provides two senior operator training specialists for 18-month residency to start up plant and train local personnel.

2.2.2 Consultant trains local personnel for first six months.

2.2.3 Consultant is assisted by five trainees for last 12 months.

2.2.4 Consultant leaves at end of 18 months.

2.3 Consultant Training Services

2.3.1 Coordination of technical representative services.

2.3.2 Preparation of operation and maintenance (O/M) manual.

2.3.3 Preparation of parts procurement and parts management program.

2.3.4 Formal classroom training five hours per week per prepared lesson plans.

2.3.5 Ongoing 18 months on-the-job training program.

Qualified, adequately-compensated personnel will be the key to a successful municipal water supply and wastewater disposal program in Irbid.

10.6.4.3 Project Implementation Recommendations.

Many recommendations have been offered in this report that are essential to the successful implementation of the proposed facility plans. These recommendations are listed here, and represent a critical path for getting the job done. Recommendations are listed in the following categories:

- Institutional development needs.
- Policy development requirements.

1. Institutional Development Needs.

   a. Prepare necessary legislation to create an Irbid district authority.

   b. Prepare ordinances addressing connection to water and sewer systems.

      - Require connection to systems.
      - Permit installment payments of connection costs.

   c. Initiate training program.

   d. Select and train staff.

   e. Develop appropriate remuneration/incentives program.

   f. Coordinate program with national/regional institutional program.

2. Policy Development Requirements.

   a. Adopt philosophy of self-sustaining financing where full costs (less initial grants) are supported by use charges.

   b. Adopt policy of efficiency in institutional operations.

   c. Consider municipal pricing schedules to achieve basic water resources objectives and specific needs in Irbid:

      - Continued use of multipart pricing for water and sewerage.

      - Marginal or full-cost pricing for water usage.

      - Affordable, subsistence level of water to low income families.

      - Emergency pricing schedule to conserve water during water shortage and provide revenue to increase available supplies.

      - Enforce monthly billing of resources.

d. Promote program of conservation of water to reflect the scarcity of the resource.

   - Implement policy to restrict unnecessary use and waste (plumbing codes, etc.)

e. Develop policies that encourage in-filling of urban development to achieve efficient use of facilities and provide sufficient customers to enable authority to operate in a stable manner.

f. Adopt full-cost pricing policy for solid waste collection and disposal.

g. Modify property tax to include rate increase to finance stormwater facilities.

APPENDIX A

IRBID WASTEWATER TREATMENT FACILITIES
RECOMMENDED ALTERNATIVE
EXTENDED AERATION ACTIVATED SLUDGE

LIST OF MAJOR EQUIPMENT

	1990	2000
Bar Rack		
Number of units	1	1
Type	Manual	
Size, overall	1.8-m wide x 2.4-m high	
Bar size and opening	9.5-mm bars at 85-mm centers	
Construction	Steel	
Grit Chambers		
Number of units	2	3
Type	Velocity controlled-flow proportional weir	
Size, each	1.5-m wide x 1.4-m high x 21-m long	
Grit removal		
Number of units	One per chamber	
Type	Mechanical bucket lift	
Ancillary equipment		
Belt conveyor	One unit -- 0.7-m wide x 5-m long, 7-m per second	
Grit storage	One steel container -- 10 cu meters	

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	1990	2000
Screens		
Number of units	2	3
Type	Mechanical catenary	
Size, each	1.5-m wide x 3.0-m high	
Bar size and opening	6.3-mm bars at 25-mm centers	
Construction	Carbon steel	
Ancillary equipment		
Conveyor	One unit 0.7-m wide x 5-m long, 7-m per second	
Screening storage	One steel container -- 5 cu meters	
Influent Flow Measurements		
Number of units	1	1
Type	Parshall flume with sonic level element	
Size	1.83-m throat width	
Construction	Fiberglass reinforced plastic liner	
Aeration Basins		
Number of units	24	36
Size, each	1,027 cu meters -- 16.55-m x 16.55-m x 3.75-m sidewater depth	
Mixed liquor concentration		
MLSS	6,835	
MLVSS	4,272	
Dissolved oxygen uptake	123.15 mg per liter per hr	

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	1990	2000
Aerators		
Number	24	36
Type	Low speed surface turbine	
Standard oxygen transfer rate	1.95 kg O_2 per kwh (minimum)	
Drive	Two speed TEFC motor	
Control	Local, manual	
Final Clarifiers		
Number of units	3	4
Type	Circular with rapid sludge withdrawal	
Size	33.5-m diameter with 4.3-m side-water depth	
Ancillary equipment	Tangential scum skimmer with concentration capability	
Return Sludge Pumps		
Number of units	3	4
Type	Centrifugal, nonclog, variable speed	
Capacity	130 liters per second at 5-m TDH	
Control	Automatic, magnetic meter	
Waste Sludge Pumps		
Number of units	2	3
Type	Centrifugal, nonclog	
Capacity	17.5 liters per second at 5-m TDH	
Control	Timer, magnetic meter flow recorder	

	1990	2000
Effluent Flow Measurement		
Number of units	1	1
Type	Parshall flume with sonic level element	
Size	1.83-m throat width	
Construction	Fiberglass reinforced plastic liner	
Chlorinators		
Number of units	2	3
Type	Gaseous	
Capacity, each	500 kg per day	
Chlorine Contactor		
Number of units	2	2
Volume, each	511 cu meters	
Dimensions, each	5 channels -- 1.5-m wide x 17-m long x 4-m sidewater depth	
Construction	Concrete	
Reaeration		
Number of units	1	1
Type	Step/pool cascade	
Sludge Holding Tank		
Number of units	4	6
Size, each	1,027 cu meters -- 16.55 m x 16.55 m x 3.5-m sidewater depth	

	1990	2000
Aerators		
Number	4	6
Type	Low speed surface turbine	
Size, each	14.92 kw	
Drive	Single speed TEFC motor	

Sludge Dewatering

Design basis		
Sludge production--1.5% solids	1,000 cu meters	1,500 cu meters
Sludge cake--solids concentration	16 to 20 percent	
Sludge cake volume	80 cu meters per day	120 cu meters per day
Operation--hrs per week	154	
Number of units	2	3
Type	Belt filter press	

Ancillary equipment includes: control panels; sludge conditioners; polymer storage, feed, and controls; filter wash pumps; and utility water strainer.

Septage Handling

Number of units	1	1
Type	Circular gravity thickener	
Dimensions	409 cu meters -- 12.2-m diameter with 3.5-m sidewater depth	
Pumps		
Number of units	2	2
Type	Centrifugal nonclog	
Capacity	6.7 liters per second at 5-m TDH	
Control	Timers	

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	1990	2000
Utility Water System		
Type	Pumps with hydropneumatic receiver	
Pumps		
Number	6	6
Type	Submersible, centrifugal	
Capacity, each	12 liters per second at 18.3-m TDH	

Operations Buildings

Size 300 sq meters

Includes: office, control room, laboratory, motor control center, locker room, lavatory, and maintenance areas.

Sludge Dewatering Building

Size 300 sq meters

Includes: sludge conditioning and dewatering, chlorine storage and feed facilities.

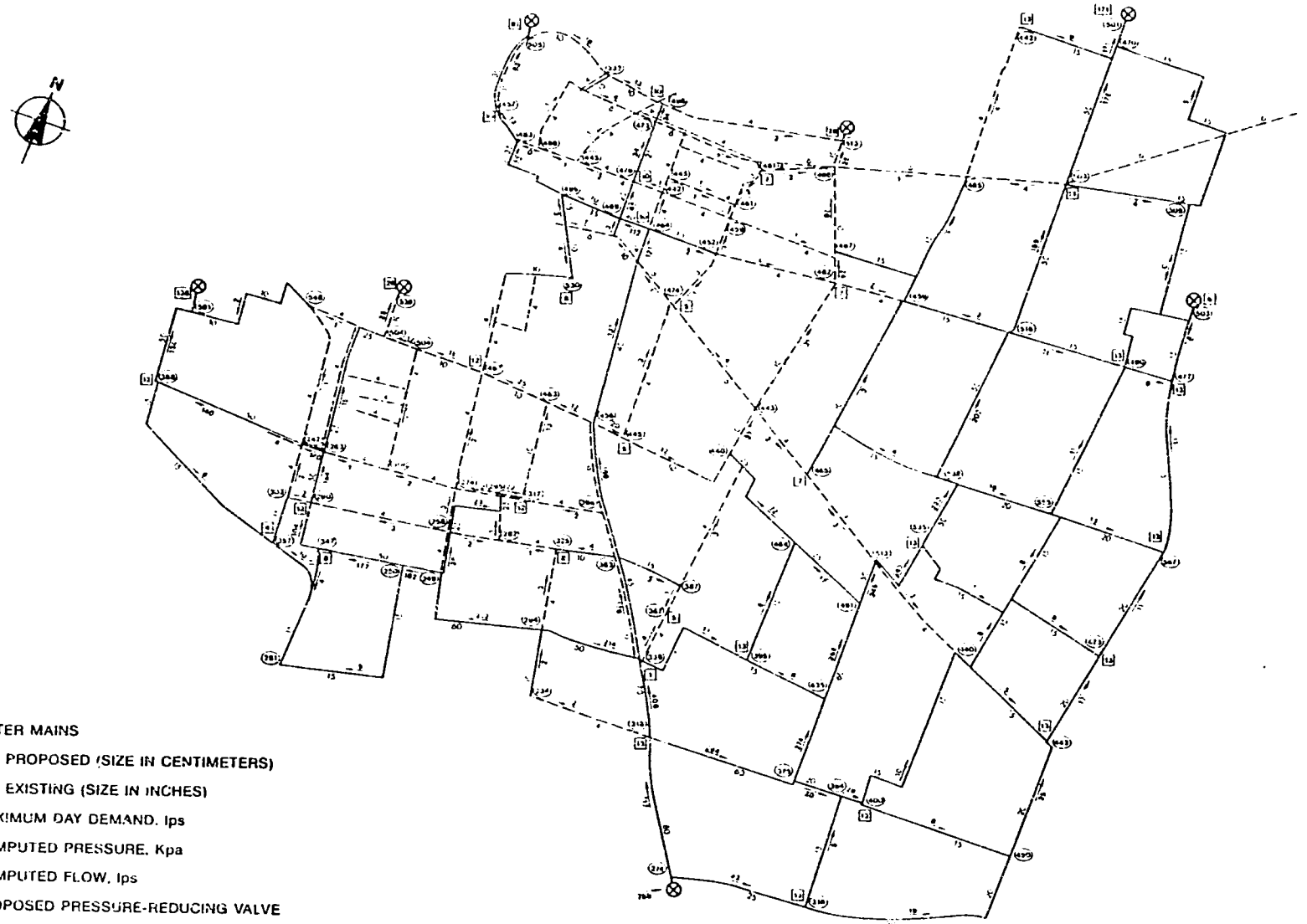
Sludge Pump Vault

Size 150 sq meters

Includes: waste sludge and return sludge pumps.

Emergency Generator

Capacity 1,800 kw



LEGEND

WATER MAINS

PROPOSED (SIZE IN CENTIMETERS)

EXISTING (SIZE IN INCHES)

MAXIMUM DAY DEMAND, lps

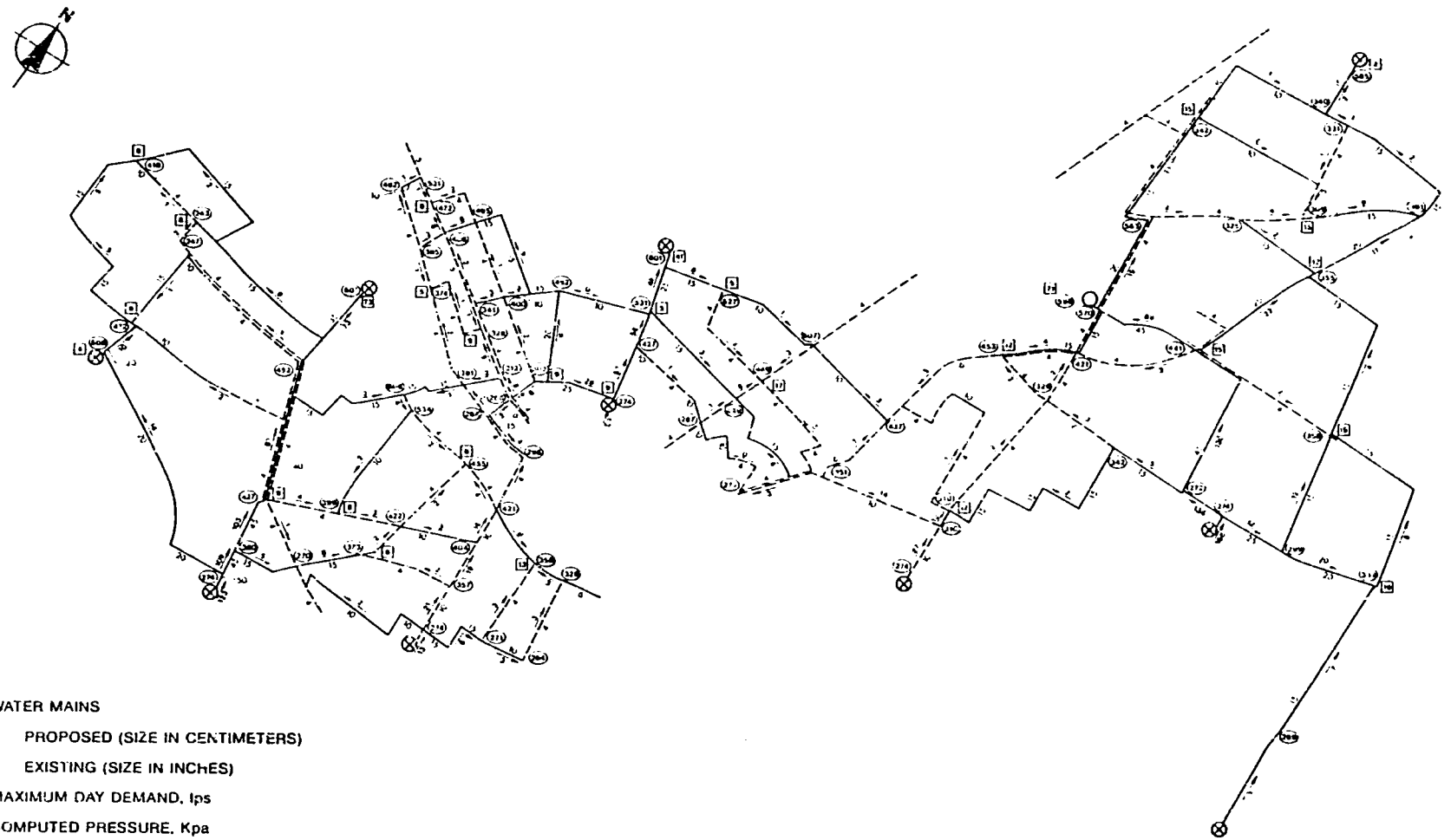
COMPUTED PRESSURE, Kpa

COMPUTED FLOW, lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS MASTER PLAN — MAXIMUM DAY DEMAND ZONE 2	SHEET NO. FIGURE B-1 DATE: SEPT. 1979 BY: CHKD:

550



LEGEND

WATER MAINS

15 PROPOSED (SIZE IN CENTIMETERS)

4 EXISTING (SIZE IN INCHES)

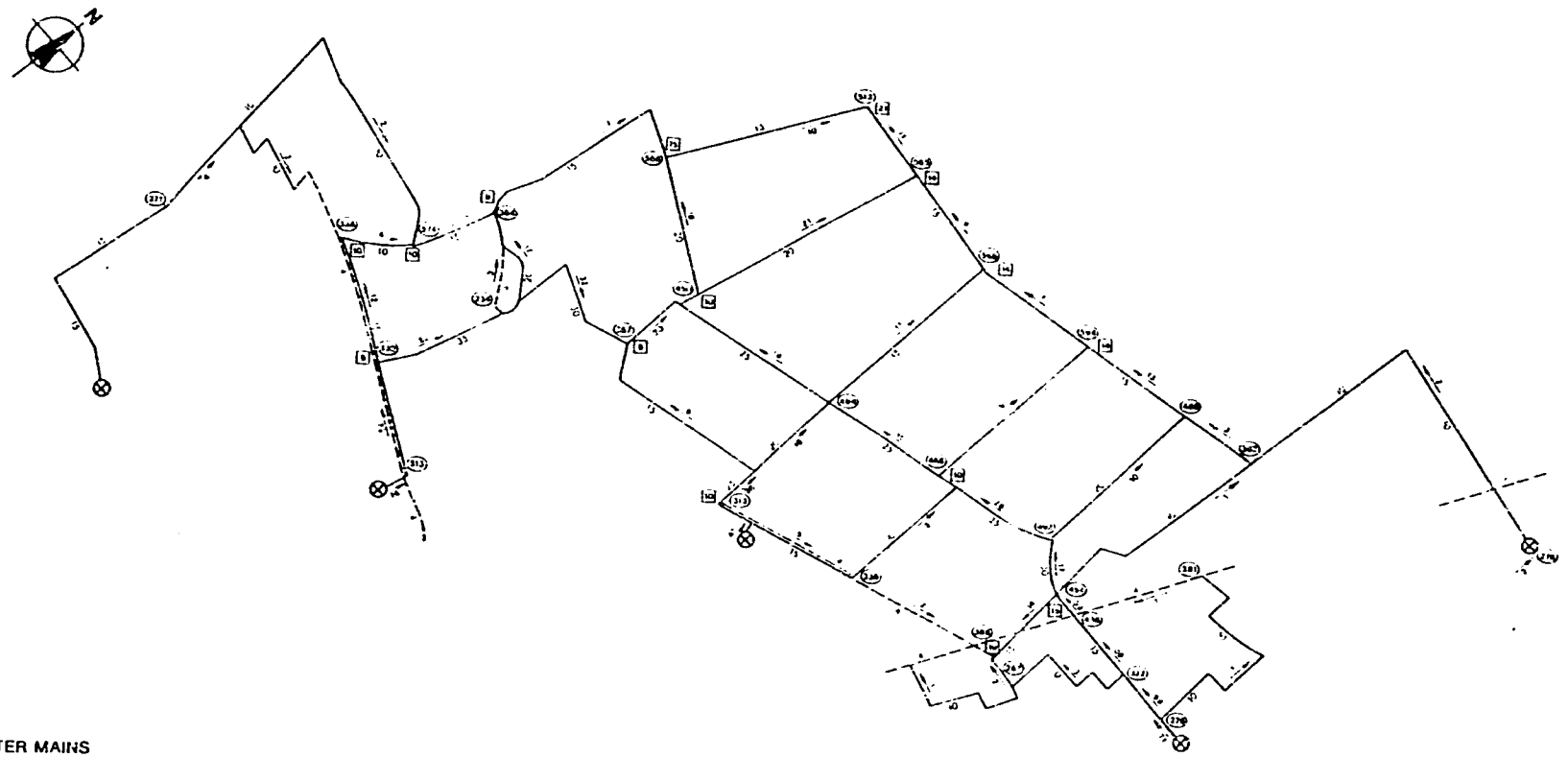
8 MAXIMUM DAY DEMAND, lps

601 COMPUTED PRESSURE, Kpa

1 COMPUTED FLOW, lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS MASTER PLAN — MAXIMUM DAY DEMAND ZONE 3	SHEET NO. FIGURE B-2 DATE: SEPT. 1979 BY: CHKD:



LEGEND

WATER MAINS

PROPOSED (SIZE IN CENTIMETERS)

EXISTING (SIZE IN INCHES)

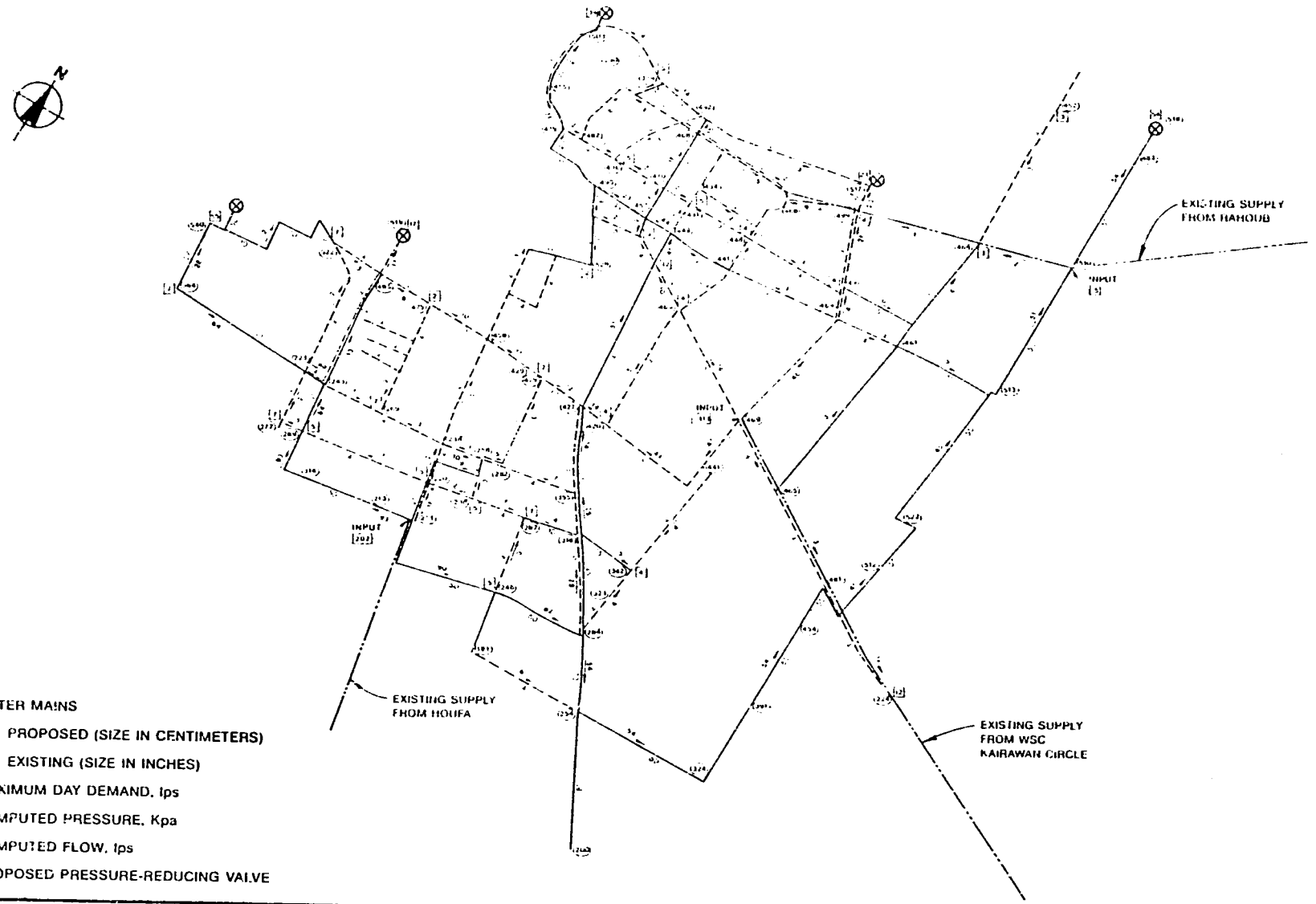
MAXIMUM DAY DEMAND, lps

COMPUTED PRESSURE, Kpa

COMPUTED FLOW, lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS MASTER PLAN – MAXIMUM DAY DEMAND ZONE 4	SHEET NO. FIGURE B-3 DATE: SEPT. 1979 BY: CHKD:



LEGEND

WATER MAINS

PROPOSED (SIZE IN CENTIMETERS)

EXISTING (SIZE IN INCHES)

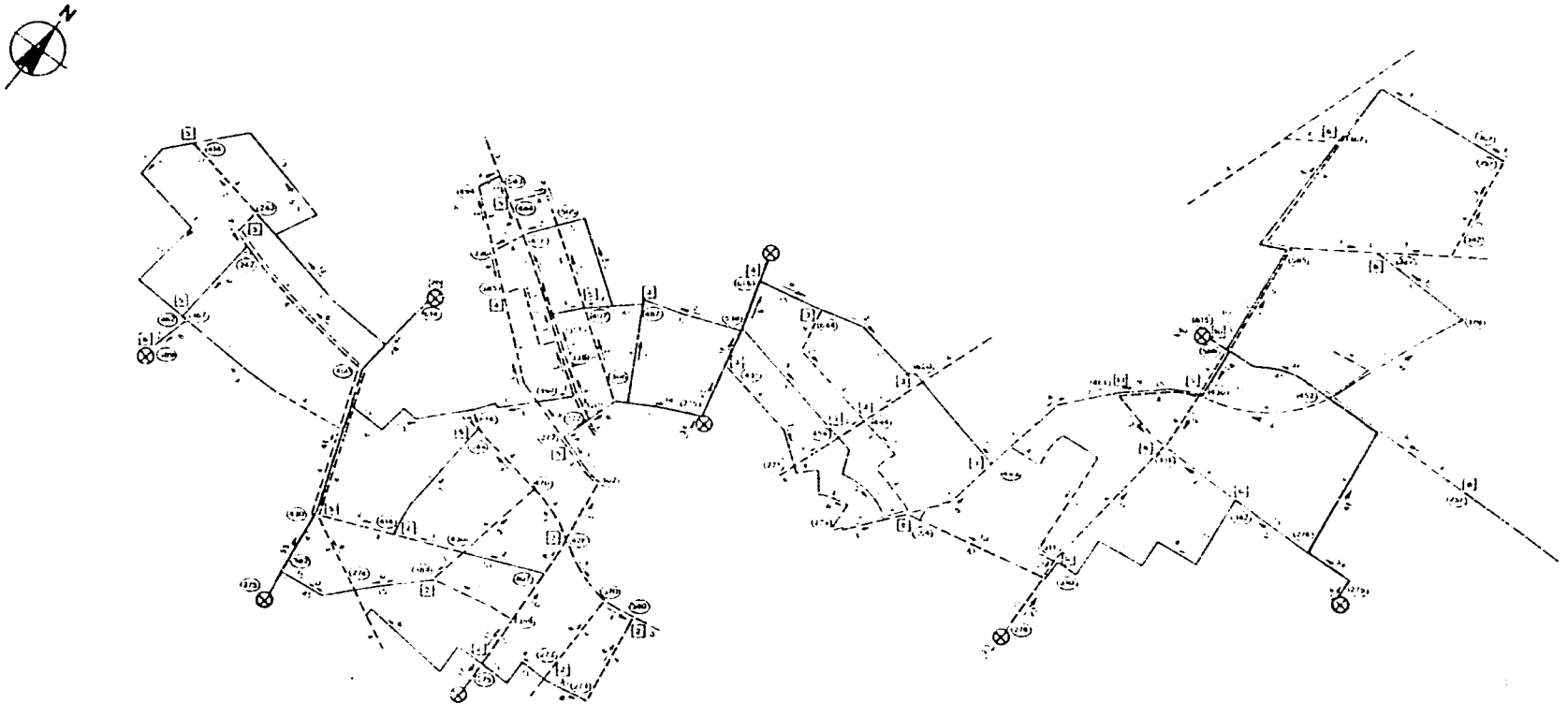
MAXIMUM DAY DEMAND, lps

COMPUTED PRESSURE, Kpa

COMPUTED FLOW, lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS PHASE 1 DEVELOPMENT — EXISTING SOURCES ZONE 2	SHEET NO. FIGURE B-4 DATE: BY: CHKD:



LEGEND

WATER MAINS

PROPOSED (SIZE IN CENTIMETERS)

EXISTING (SIZE IN INCHES)

MAXIMUM DAY DEMAND, lps

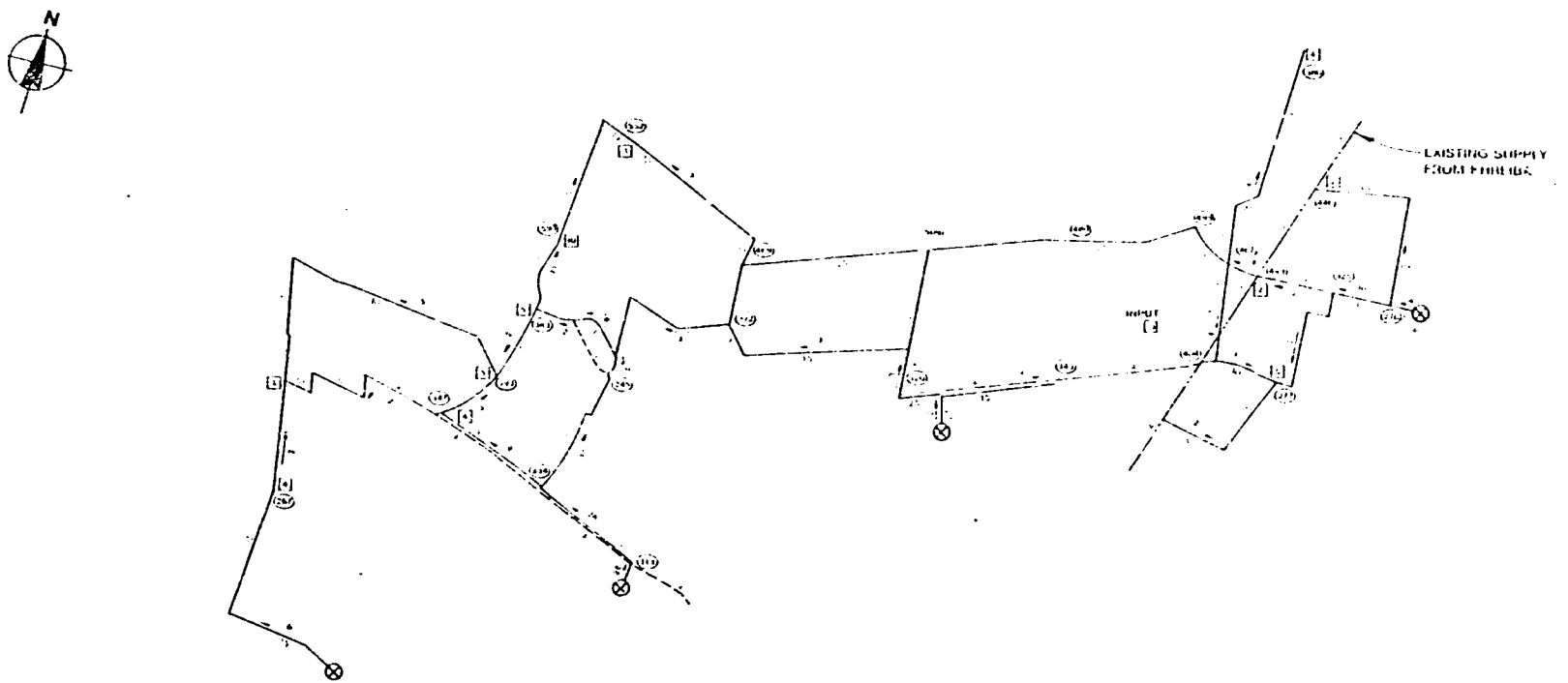
COMPUTED PRESSURE, Kpa

COMPUTED FLOW lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS MRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS PHASE 1 DEVELOPMENT — EXISTING SOURCES ZONE 3	SHEET NO. FIGURE B-5 DATE: BY: CHKD:

154



LEGEND

WATER MAINS

PROPOSED (SIZE IN CENTIMETERS)

EXISTING (SIZE IN INCHES)

MAXIMUM DAY DEMAND, lps

COMPUTED PRESSURE, Kpa

COMPUTED FLOW, lps

PROPOSED PRESSURE-REDUCING VALVE

WESTON INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC., SIGMA CONSULTING ENGINEERS SIRM CONSULTING ENGINEERS CO., LTD	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT	DISTRIBUTION SYSTEM ANALYSIS PHASE 1 DEVELOPMENT — EXISTING SOURCES ZONE 4	SHEET NO. FIGURE B-6 DATE: BY: CHKD:

APPENDIX C

SAMPLE SEWER USE ORDINANCE
CITY OF IRBID

ARTICLE I

GENERAL PROVISIONS

SECTION 101 — Title

This ordinance shall be known as the Sewer Code of The City of Irbid.

SECTION 102 — Definitions

Unless the context specifically and clearly indicates otherwise, the meaning of terms used in this code shall be as follows:

(1) "Authority" shall mean Irbid Municipal Authority.

(2) "BOD" (Biochemical Oxygen Demand) shall mean the quantity of oxygen, expressed in milligrams per liter (mg/L), utilized in the biochemical oxidation of organic matter under standard laboratory procedure for five (5) days at twenty (20) degrees Centigrade. The standard laboratory procedure shall be that found in the latest edition of "Standard Methods for the Examination of Water and Sewage" published by the American Public Health Association.

(3) "Building Sewer" shall mean the extension from the sewage drainage system of any structure to the service lateral of a collection sewer.

(4) "Capped Sewer" shall mean a complete sanitary sewage system installed on any improved property for future connection to the collection sewer system.

(5) "City" shall mean the City of Irbid, Hashemite Kingdom of Jordan.

(6) "Collection Sewer" shall mean the City's sanitary sewers located under highways, roads, streets, and rights-of-way with branch service laterals that collect and convey sanitary sewage or industrial wastes, or a combination of both, and into which storm, surface, and groundwaters or unpolluted industrial wastes are not intentionally admitted.

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(7) "Chlorine Requirement" shall mean the amount of chlorine, in parts per million by weight, which must be added to produce a specific residual chlorine content, or to meet the requirements of some other objective, in accordance with procedures set forth in "Standard Methods."

(8) "Connection Unit" shall mean each individual building or house whether constructed as a detached unit or as one of a pair or row which is designed or adaptable to separate ownership for use as a family dwelling unit or for commercial or industrial purposes. A school, factory, apartment house, office building, or other multiple unit structure whose individual apartments or units are connected to a common internal sewage system and which are not commonly subject to separate ownership shall be considered as one connection unit.

(9) "Garbage" shall mean solid wastes resulting from preparation, cooking, and dispensing of food, and from handling, storage, and sale of food products and produce.

(10) "Ground Garbage" shall mean the residue from the preparation, cooking, and dispensing of food that has been shredded to such degree that all particles will be carried freely in suspension under the flow conditions normally prevailing in public sewers, with no particle greater than one-half inch (1/2") in any dimension.

(11) "Improved Property" shall mean any property within the sewered area upon which there is erected a structure intended for continuous or periodic habitation, occupancy, or use by human beings or animals, and from which structure sanitary sewage and/or industrial wastes shall be or may be discharged. The property may or may not have public water or private water.

(12) "Industrial Wastes" shall mean any solid, liquid, or gaseous substance discharges, permitted to flow or escaping in the course of any industrial, manufacturing, trade, or business process, or in the course of the development, recovery of processing of natural resources, as distinct from sanitary sewage.

(13) "May" is permissible.

(14) "Owner" shall mean any person vested with ownership, legal or equitable sole or partial, of any property located in the sewered area.

(15) "Milligrams Per Liter (mg/L)" shall mean a weight-to-volume ratio.

(16) "Person" shall mean any individual, partnership, company, association, society, corporation, or other group or entity.

(17) "pH" shall mean the logarithm (base 10) of the reciprocal of the weight of hydrogen ions, expressed in grams per liter of solution, and indicates the degree of acidity or alkalinity of a substance.

(18) "Sanitary Sewage" shall mean normal water-carried household and toilet wastes from any improved property.

(19) "Sanitary Sewer" shall mean a sewer that conveys sewage or industrial wastes, or a combination of both, and into which storm, surface, and groundwaters or unpolluted industrial wastes are not intentionally admitted.

(20) "Service Lateral" means that part of the sewer system from the collection sewer to the curb line or right-of-way line.

(21) "Wastewater Treatment Plant" shall mean the Irbid Treatment Plant and facilities operated for such purpose by the Irbid Municipal Authority to which the sewer system is to be connected.

(22) "Sewer" shall mean any pipe or conduit constituting a part of the sanitary sewer system used or usable for sewage collection purposes, and to which ground-, surface- and stormwater is not intentionally admitted.

(23) "Sewer System" shall mean all facilities, as of any particular time, for collecting, pumping, treating, and disposing of sanitary sewage and industrial wastes, situated in the sewered area, and owned and/or operated by the Authority.

(24) "Sewered Area" shall mean that portion of the City of Irbid in which there shall be constructed a sewage collection system of the Authority in accordance with the plans of the Authority as from time-to-time constructed and extended.

(25) "Shall" is mandatory.

(26) "Sludge" shall mean any discharge of water, sewage, or industrial waste which, in concentration of any given constituent or in quantity of flow, exceeds for any period of longer duration than 15 minutes, more than 5 times its average hourly concentration or flow.

(27) "Standard Methods" shall mean the examination and analytical procedures set forth in the most recent edition of "Standard Methods for the Examination of Water, Sewage, and Industrial

Wastes," published jointly by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation.

(28) "Storm Sewer" shall mean a sewer that carries storm, surface-, and groundwater drainage, but excludes sewage and industrial wastes.

(29) "Street" shall mean and include any street, highway, road, lane, court, alley, and public square.

(30) "Suspended Solids" shall mean solids that either float on the surface of or are in suspension in water, sewage, or other liquids, and which are removable by laboratory filtration. The standard laboratory procedure shall be that found in the latest edition of "Standard Methods."

(31) "Toxic Substance" shall mean any poisonous substance, including copper, cyanide, and chromium ions.

(32) "Unpolluted Water or Liquids" shall mean any water or liquid containing none of the following: free or emulsified grease or oil; acids or alkalis, substances that may impart taste-and-odor or color characteristics; toxic or poisonous substances in suspension, colloidal state, or solution; odorous or otherwise obnoxious gases. It shall contain not more than 1,000 parts per million by weight of dissolved solids, and not more than 5 parts per million each of suspended solids or biochemical-oxygen-demand. Analytical determinations shall be made in accordance with procedures set forth in "Standard Methods."

SECTION 103 Unsanitary Deposits

It shall be unlawful for any person to place, deposit, or permit to be deposited in any unsanitary manner upon public or private property within the City of Irbid, or in any area under the jurisdiction of said City, any human or animal excrement, garbage, or other objectionable waste.

SECTION 104 Discharges to Natural Outlets

It shall be unlawful to discharge to any wadi, stream, or other area which may continuously or from time-to-time carry a natural flow of surface or subsurface water within the City of Irbid, or in any area under the jurisdiction of said City, any sanitary sewage, industrial wastes, or other polluted waters, except where suitable treatment has been provided in accordance with subsequent provisions of this code and any applicable laws relating to sewage and industrial waste.

SECTION 105 Duty to Connect to Public Sewer

(a) Notice

(1) Whenever any sewer constituting a branch or extension of the City sanitary sewer system has been completed and is ready for public use, it shall be the duty of the Authority to cause a printed or written notice of the completion of such sewer, together with a copy of the Code, to be served in the manner hereinafter provided on the owner as defined in Section 105(b)(3).

(2) If the Authority shall so elect, notice of such completion may also be advertised in one newspaper circulated in the City.

(3) Such notice in each instance shall state that it is the duty of such owners to cause buildings erected on their premises requiring sewage drainage to be connected therewith at their own expense, and subject to the payment of the annual sewer rental for the use of the same, and subject to the payment of the tapping fee required by Section 308.

(b) Duty to Connect

(1) It shall be the duty of every owner as defined in subparagraph (3) hereof of existing premises to cause each old or new building erected thereon requiring sewage drainage to be separately connected to the City sewer within sixty (60) days from the time of the receipt of the aforesaid notice.

(2) If a new building is erected on any premises, the duty to connect shall arise upon completion of said building, and must be completed within sixty (60) days of said completion.

(3) Owner for the purpose of Section 105 shall mean the owner or owners of any type of building or structure which contains sewage facilities where some point of the structure is within 50 meters of a City collection sewer.

(4) Special exceptions to this requirement may be granted by the Authority upon the showing of unusual hardship or circumstance.

(5) If at any time the Authority shall deem it necessary for the public health to require that any building erected on premises abutting on, adjoining, or adjacent to any City sewer, wheresoever any such building may be located on such premises, shall be connected with such sewer, it shall cause to be served upon the owner or owners of any such building, in the manner hereafter provided, a copy of this Code and a printed or written notice directing that the necessary connections be made within sixty (60) days from the date of its service.

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(c) Failure to Connect

If any owner of premises situated along the line of a City sewer shall fail to heed the notice, the Authority shall cause the necessary connections to be made, and, upon completion of the work for the same, shall render a bill covering the cost of said work to the owner of such premises. All such bills shall contain a notice that, if bills be not paid within sixty (60) days after date thereof, the same shall be collected in the manner provided by law.

(d) Obtaining Permit to Connect

(1) No person shall uncover, connect with, make any opening into or use, alter or disturb, in any manner, any sewer or sewer system without first obtaining written permission from the Authority. Such permission will be issued to owners required to connect to a City collection sewer by this Code. The improved property owner shall apply to the Authority for the required permit, stating his desire and intention to connect to the sewer system, and noting the type of existing facilities to be abandoned. At least forty-eight (48) hours notice prior to the connection shall be given the Authority so arrangements can be made to inspect and test the connection works. (See also Sections 302, 304, and 309, 310, and 409.)

(2) Before commencing any phase of the construction for building sewer connection, the plumbing contractor shall locate and expose the existing wye or stub provided to connect to the City sewer. No cap, stopper, or plug shall be removed or punctured until permission has been granted by an authorized Municipal Authority engineer. If no connection is provided, the contractor shall locate and expose the City sewer main at the point where the connection is to be made.

A 6-mm per meter gradient is required from point of entry at the building to sewer main. A check shall be made to verify that there is a 6-mm per meter gradient by obtaining the differential elevation using approved methods. If the elevations are such that the connection cannot be made at 6-mm per meter gradient, he shall contact the Municipal Authority engineer for permission to install the line at a minimum grade of 3 mm per meter. Under no circumstances shall the trench between connections be excavated before it is ascertained that the minimum can be obtained.

SECTION 106 Violations--Liability to Authority for Costs

Any person violating any of the provisions of this Code shall become liable to the Authority for any expense, loss, or damage occasioned to the Authority by reason of such violation.

SECTION 107 Change of Ownership -- Notice of

Each property owner shall give the Authority written notice of any change of ownership of any improved property.

SECTION 108 Vacating Possession -- Notice of

When the premises are vacated, the owner of improved property shall give written notice to the Authority, and the owner shall be responsible for all sewer charges and fees until such notice is given.

SECTION 109 Authority's Right to Refuse Service on Notice of Violations

If any person shall fail or refuse, upon receipt of written notice of the Authority, to remedy any unsatisfactory conditions or violations of this Code within sixty (60) days of receipt of such notice, the Authority may refuse to permit such person to discharge sanitary sewage and industrial wastes into the sewer system until such unsatisfactory condition shall have been remedied to the satisfaction of the Authority.

SECTION 110 Authority's Right to Refuse Service Where Harmful Discharges

In order to prevent discharge into the sewer system of wastes, the discharge of which is in violation of the provisions of this Code or which may be deemed by the Authority to be harmful to the sewer system or to have a deleterious effect on wastewater treatment process, or to have a deleterious effect on the public health, welfare, or safety, the Authority shall refuse to any person the privilege of connection of any improved property to a sewer, or to compel discontinuance of use of a sewer by any person, or to compel the pretreatment of industrial and harmful wastes.

SECTION 111 Authority Not Liable

(a) The Authority shall not be liable for any damages, expenses, costs, or other injury resulting from leaks, stoppages, or defective plumbing, or from any other cause occurring to any premises or within any house or building.

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(b) The Authority shall not be liable for damages, expenses, costs, or other injury caused by the breakage or stoppage of, or any damage or expense to, any lateral or house connection when the cause thereof is found to be in the lateral or house connection.

(c) The Authority shall not be liable for any breaking, stoppage, or any damage or expense to any service laterial or building sewer where the cause thereof is found to be in the building sewer.

(d) The Authority shall not be liable for any costs, damages, expenses, or other injury caused or occasioned by or in connection with a deficiency or failure of service when occasioned by an emergency, required repairs, or failure from any cause beyond control.

SECTION 112 Conditions of Service

The Authority will furnish sewage service only in accordance with the prevailing, and as hereafter revised, Rates, Rules and Regulations of the Authority, which Rates, Rules and Regulations are made a part of every application, permit, and contract entered into between the property owner or customer and the Authority.

ARTICLE II

BUILDING SEWERS AND SERVICE LATERALS

SECTION 201 Size of Pipe

Unless a larger size is required in pursuance of this Code, no building sewer shall be less than 150 mm in diameter.

SECTION 202 Types of Pipes

All building sewers and service laterals shall be constructed by use of one of the following types of pipe:

(a) Asbestos cement building sewer pipe at least 150 mm in internal diameter and conforming to "Asbestos-Cement Non-Pressure Sewer Pipe," ASTM C428-69a, Type 11, and "Asbestos-Cement Non-Pressure Small Diameter Sewer Pipe," ASTM 644-69, Type 11, latest revision.

(b) Service weight (SW) cast iron soil pipe at least 150 mm in internal diameter conforming to "Cast Iron Soil Pipe and Fitting," ASTM A 74-69, latest revision.

(c) Jointing materials for the various types of pipe shall be as follows:

(1) Asbestos cement pipe shall have joints consisting of two rubber rings, and an asbestos cement sleeve. Rubber rings shall conform to the requirements of "Rubber Rings for Asbestos-Cement Pipe," ASTM D 1869-66, latest revision.

(2) Cast iron pipe shall have push-on joints consisting of rubber gaskets conforming to the requirements of "Rubber Gaskets for Cast Iron Soil Pipe," ASTM 564-74.

SECTION 203 Beddings

Uniform bedding shall be provided along the entire length of a building sewer, and all joints of a building sewer shall be watertight and rust-proof. No cement mortar joints shall be used.

Trenches (both earth and rock trenches): "First class bedding" shall be provided as a foundation for all pipe. The bedding material shall consist of crushed stone. The crushed stone shall be placed on the bottom of the trench to a minimum depth of 100 mm and along the sides of the pipe to a depth of one-half the pipe diameter.

Concrete joints shall be used when tying new pipe to existing pipe.

SECTION 2049 Method of Transfer to Authority System

Where a building or buildings on an improved property, at the time of securing a permit under Section 105 to connect to a sewer, shall be served by its own sewage disposal system, device, or other form of private sewage disposal, and where such building or buildings are required, pursuant to this Code, to be connected to a collection sewer, the existing house sewer or building sewer shall be broken on the structure side of such existing sewage disposal system or device, and an attachment shall be made, with proper fittings, to continue such house or building sewer line, as a building sewer undiminished in inside diameter, but not less than 150 mm, to the service lateral.

SECTION 205 Building Sewers -- Common Trench -- Adjoining Property

A building sewer which serves one improved property may occupy the same trench as a building sewer to serve the next adjoining improved property, and provided that such joint occupancy is by mutual agreement of the owners concerned.

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SECTION 206 All Pipes, Connections, and Work Must Fit Its Purpose

It shall be the duty of every person constructing or owning any building sewer, housing drain, soil pipe, waste pipe, vent pipe, plumbing fixture, or any other passage or connection between a sewer and any grounds, buildings, erections, and in like manner it shall be the duty of the owners of all grounds, buildings, erections, and all parties interested therein or thereof, to cause and require that such building sewer, house drain, soil pipe, waste pipe, vent pipe, plumbing fixture, and every other passage or connection shall be adequate for its purpose, and at all times allow to pass freely all material that enters or should enter the same.

SECTION 207 Changes in Connections, etc. -- Notice and Approval

In order to change, alter or modify any building sewer, house drain, service lateral, vent pipe, waste pipe, soil pipe, plumbing fixture, or any other sewer passage or connection, written notice of such must be served on the Authority which must give its written approval before any changes, alterations, or modifications shall be made.

SECTION 208 Fittings

Fittings in a building sewer shall conform to the type of pipe used in construction of such sewer.

SECTION 209 Building Sewers -- Directional Changes

Change in direction in a building sewer must be made by use of "Y" branches, or of 1/4, 1/6, 1/8 or 1/16 bends, or 60-cm by 60-cm manholes.

SECTION 210 Types of Fittings Not Permissible

Fittings or connections in a building sewer which have an enlargement, chamber, or recess with a ledge, shoulder reduction of pipe area that shall offer any obstruction to flow shall not be allowed.

SECTION 211 Cleanouts Required

Cleanouts shall be provided in each building sewer at maximum intervals of 20 meters and each change of direction greater than 45 degrees to permit rodding with an auger or tape. Cleanouts shall be constructed by using a "Y" fitting in the run of pipe with a 45-degree bend and riser to the ground surface. The cast iron riser pipes shall be provided with brass screw plugs. Risers shall be at a level equal to the finished grade level; 60-cm by 60-cm manholes shall be considered cleanouts.

Refer to the Typical Building Sewer Sheet, Drawing Number C-1.

SECTION 212 Interceptor Traps Required -- Type

A building sewer shall be provided with a horizontal single vented trap, known as an interceptor trap, of not less than 150-mm inside diameter. The trap shall be provided with a cast iron mushroom vent. The trap shall be cast iron. All materials shall comply with Section 202.

The vented trap shall be constructed at the lower end of the building sewer. The 3-meter dimension shown on the sketch is approximate and may be revised according to conditions encountered in the field. Where the distance from the main sewer to the building is less than 20 meters, the vented trap may be used as the cleanout in lieu of the cleanout located approximately 3 meters from the building as shown on Drawing C-1.

SECTION 213 Interceptor Traps -- Location

The interceptor trap described under Section 212 shall be located at a point to be determined and approved by the Authority, and in accordance with rules and regulations applicable thereto as adopted by Authority. Such trap and its vent shall be on the property side of the curb line or right-of-way line.

SECTION 214 Special Conditions

Wherever in the opinion of the Authority the trenching conditions require either a specific type of pipe, jointing material, or encasement in concrete, such materials as it may direct shall be installed to protect the property owner and/or the City for special conditions as follows:

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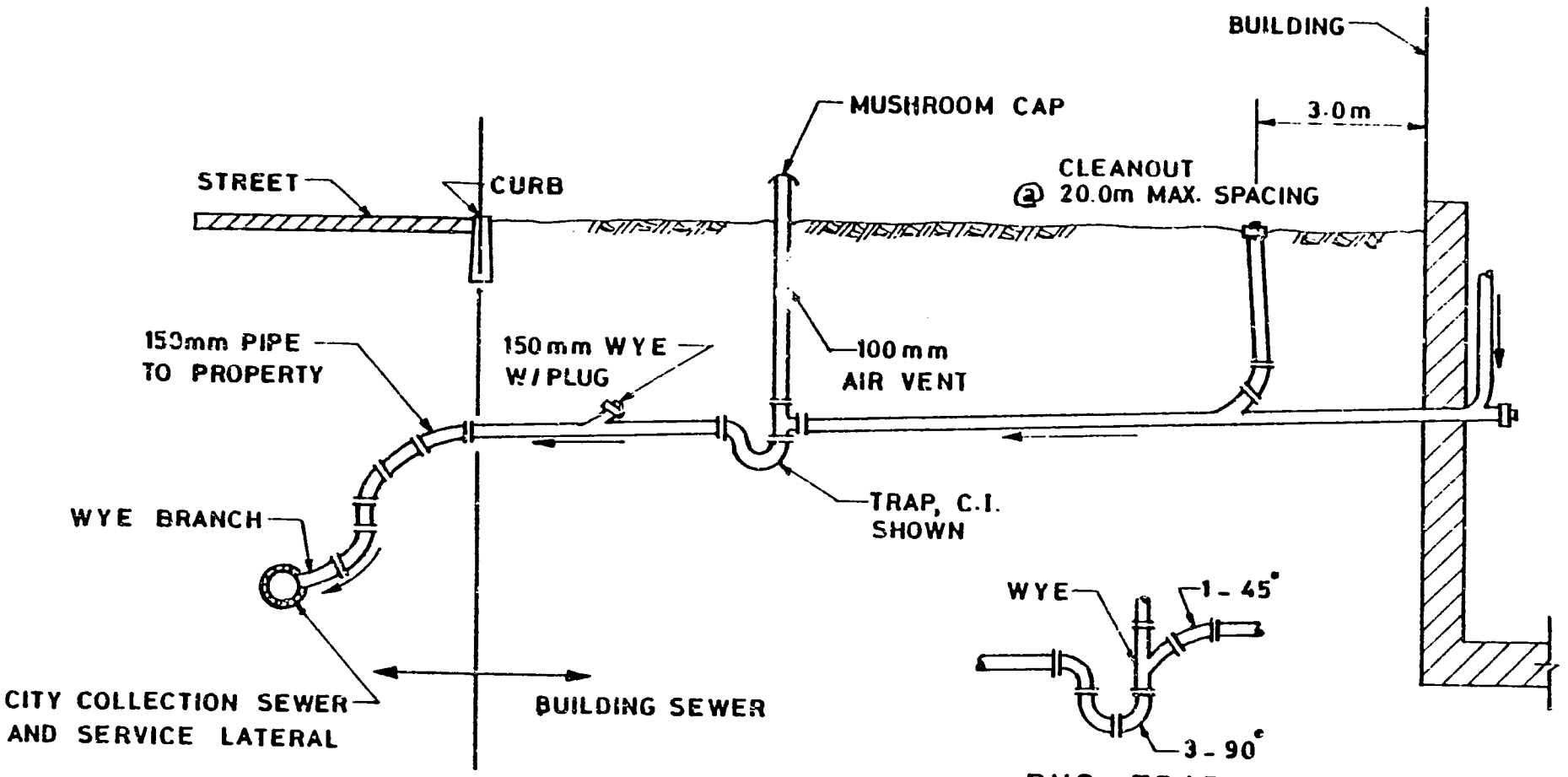

NOTE:

BUILDING SEWERS CONSTRUCTED PRIOR TO THE CITY SEWER SYSTEM BEING ACTIVATED, SHALL BE CAPPED AT A POINT OUTSIDE THE BUILDING WALL.

WESTON-INTERNATIONAL, INC. IN ASSOCIATION WITH STANLEY CONSULTANTS, INC. SIGMA CONSULTING ENGINEERS	IRBID WATER SUPPLY, SEWERAGE, STORM DRAINAGE & SOLID WASTE	TYPICAL BUILDING SEWER SHEET	FIGURE C-1 DATE BY F. R.

(a) Where the trench is less than 1.2-meters deep in a traveled roadway, special bedding, consisting of crushed stone or concrete cradle, as directed by the City shall be used.

(b) Service laterals and building sewer for all service stations, garages, or other establishments storing, using, or dispensing gasoline, kerosene, benzine, naphtha, fuel oil, or other flammable or explosive liquid, solid, or gas, or similar solvents shall be constructed of cast iron pipe with leaded joints.

(c) Where lines are laid in fill or within 0.5 meter of potable water lines, cast iron soil pipe with caulked and lead gasket joints shall be used.

(d) Where water, excessive amounts of wet backfill, or marshy ground exists the use of cast iron pipe will be required.

(e) Where foundation conditions are poor the building sewer shall be laid on a base of crushed stone at least 15 centimeters in depth.

(f) Backfilling of pipe trenches on City roads and rights-of-way shall be made with loose earth, free of rock and stones, and carefully tamped about and over the pipe in a 15-centimeter layer for a depth of 60 centimeters above the pipe, when coarser materials may be backfilled, and the trench brought to its original condition.

SECTION 215 Building Sewer -- Required Slope and Grading

The slope or grade of a building sewer shall be no less than 6-mm per meter of length, and shall be sloped downward in the direction of flow. If elevations are such that the connection cannot be made at 6-mm per meter, the Municipal Authority may grant permission to install the line at some gradient less than 6 mm per meter, but in no case less than 3 mm per meter.

SECTION 216 Building Sewers -- Testing, Approval, Observation

(a) The Authority shall observe all testing of a building sewer. All equipment and material required for testing shall be furnished by the owner of the improved property to be connected to a sewer.

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(b) In the event a building sewer is not approved by the Authority, further test or tests shall be made following completion of necessary corrections.

SECTION 217 Building Sewers -- Approval Needed Before Covering

No building sewer shall be covered until it has been inspected, tested as provided in Section 216, and approved. If any part of a building sewer is covered before being inspected, tested, and accepted, it shall be uncovered for inspection and testing at the cost and expense of the owner of the improved property.

SECTION 218 Building Sewers -- Safe and Sanitary Operation

Every building sewer on any improved property shall be maintained in a sanitary and safe operating condition by the owner.

SECTION 219 Building Sewers -- Excavation, Safety, Street Restoration -- Cost of

Every excavation for a building sewer or service lateral shall be guarded adequately with barricades and lights to protect all persons from damage and injury. Streets, sidewalks, and other public property disturbed in the course of installation of a building sewer or service lateral shall be restored, at the cost and expense of the owner of the improved property being connected, in a manner satisfactory to the City.

SECTION 220 Restoration of Excavations -- Permits and Standards

Whenever the surface of any public street, sidewalk, or cartway is disturbed by construction of the service laterals, the surfacing material must be restored in kind and maintained to the satisfaction of the Authority and City. Any and all construction in a public street of the City shall be in compliance with the ordinances of the City. All permits shall be obtained before construction is commenced.

SECTION 221 Supervision by Authority -- Construction, Covering, Backfill

The construction of service laterals and building sewers shall at all times, be subject to supervision and inspection by the Authority or its

representative and shall conform to the Authority specifications. The service laterals and building sewer shall not be covered until permitted by the Authority, and all backfilling of trenches shall be under their supervision and shall be compacted according to Section 214.

SECTION 222 Sewers Through Private Land Subject to Code

Connections with sewers where same are run through private property shall in all respects be governed by this Code.

SECTION 223 Use of Old Building Sewers

Old building sewers may be used in connection with new buildings only when they are found, on examination and test by the Authority, to meet all requirements of this Code.

SECTION 224 Building Sewers -- Positioning

No building sewer shall be laid parallel to or within one (1) meter of any bearing wall, which might thereby be weakened.

SECTION 225 Building Sewers -- Use of Power Other Than Gravity

In all buildings in which any building drain is too low to permit gravity flow to the collection sewer, sanitary sewage carried by such drain shall be lifted by artificial means approved by the Authority and discharged to the building sewer.

SECTION 226 Open Trench Work Required

All excavations required for the installation of a building sewer shall be open trench work unless otherwise approved by the Authority in writing.

SECTION 227 Building Demolition -- Severance From Sewer

In the event of the demolition of any building, the owner of the building shall be responsible for plugging the existing building sanitary sewer connection at the property line. Any reuse of such connection shall require a building sewer connection permit and connection fee.

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SECTION 228 Service Laterals -- Approval, Supervision of Construction

No service lateral shall be constructed, laid, and connected except in a manner and type approved by the Authority which shall supervise and control the construction of the same.

ARTICLE III

CONNECTIONS OF BUILDING SEWERS

SECTION 301 Separate Connections Required For Each Unit

Each connection unit on each improved property shall be connected to a service lateral through a building sewer. Special written permission must be obtained from the Authority to group more than one connection unit on one building sewer.

SECTION 302 All Costs Borne by Owner -- Indemnity of City

All costs and expenses of construction of a building sewer and all costs and expenses of connection of a building sewer to the collection sewer or service lateral shall be borne by the owner of the improved property to be connected; and such owner shall indemnify and save harmless this City and Authority from all loss or damage that may be occasioned, directly or indirectly, as a result of construction of a building sewer, or of connection of a building sewer to the sewer lateral and/or collection sewer.

SECTION 303 Materials to be Used

Materials for a building sewer, jointing materials, and methods of installation shall be in accordance with requirements of this Code, and shall be subject to approval of this Authority.

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SECTION 304 — Permissible Types and Places of Joints and Connections -- Approval and Supervision of Authority

(a) A building sewer shall be connected to a collection sewer at the service lateral, or at the place where the wye (Y) in the collection sewer is located. No person shall make a connection directly to or tamper with a collection sewer in any manner, except as herein provided.

(b) All work of making connections to any of the City sewers shall be done under the personal supervision of an authorized representative of the Authority and shall conform to the following requirements:

(1) The location of existing service wye (Y) or house laterals will be secured by the property owner from the Authority records before construction is undertaken so that the house sewer may be properly located. If the existing service wye or service lateral location is not suitable for building sewer connecting alignment, or a service wye or service lateral does not exist, the connection to the collection system shall be made with an approved saddle fitting properly installed and encased in a minimum of 150 mm of concrete on all sides of fitting. All associated costs shall be paid by the property owner.

(2) Connections to the collection sewer where no branch or wye (Y) fitting has been previously provided shall be made with an approved saddle-type fitting properly installed and encased in an envelope of concrete extending completely around the barrel of the collection sewer pipe, and a minimum of 150 mm either side of the fitting, the cost thereof shall be paid by the property owner.

(3) All joints shall be sealed and made watertight, and shall be made smooth and clean inside, with all sewers in proper alignment and of proper grade, so as to provide free flow of sewage matter without any obstructions, and to be made in accordance with the Authority specifications for its sanitary sewers. All work pertaining to the connection with the Authority's sewers shall be, financially and otherwise, the responsibility of the owner of the property with which connection is made, subject to the right of supervision hereby reserved by the Authority.

SECTION 305 — Sizes of Connection Pipes -- Variance

Connections to the service laterals shall be made of the same pipe diameter (size), properly joined. When the building sewer is made with a pipe of larger diameter than the existing service lateral, the building sewer shall be extended to the collection sewer and connected with a saddle fitting.

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SECTION 306

All connections shall be made pursuant to Sections 210, 225, and the other provisions of this Code.

SECTION 307 Connection Fees

There will be charged and imposed upon the owner of each connection unit a connection fee as set forth in the appropriate resolutions adopted by the Authority from time to time. Such connection fee shall be due and payable to the Authority at the time the connection is made by the owners required to connect to the sewer by Authority ordinance. If the owner fails to connect in the allotted time covered by the ordinance, then the connection fee shall be due and payable sixty (60) days, including the allotted time under the ordinance, after written notice to connect is given to the owner by the Authority. Owners not required to connect, but who desire to do so, shall pay the connection fee at the time of permit application approval.

SECTION 308 Authorized Plumbers -- Permit, Insurance Required

Any individual desiring to do plumbing installation or other plumbing work upon the building sewer and its connection with the service lateral connected with any improved property which is connected to or which is to be connected to a sewer, shall obtain from the Authority a permit authorizing such individual to engage in such plumbing work. Such permits shall be issued on a calendar year basis. A fee of ten (10.000 JD) Jordan dinars shall be charged for issuance of each permit. Such permits shall be issued to such individuals who have demonstrated to the satisfaction of the Authority that they are qualified and capable of performing plumbing work in accordance with good plumbing practice, and shall be revocable by this Authority for negligent or willfull failure to comply with rules and regulations of the Authority.

Such permits shall be reissued from calendar year to calendar year by appropriate endorsement of this Authority or by issuance of a new permit, at the discretion of this Authority upon payment of the required fee. Owners, their agents, employees, or independent contractors may do trench preparation work independently of the plumbing work involved upon receipt of a permit from the Authority and subject to compliance with its regulations and inspection requirements.

The City shall be responsible for administering the permits for the licensing of plumbers and collection of all fees.

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SECTION 309 Permit Required

Any improved property upon which plumbing work is performed by an individual not possessing a permit as required under Section 308 will not be approved for connection to a sewer.

ARTICLE IV

PRIVATE SANITARY SEWAGE DISPOSAL

SECTION 401 In General -- Private Sewage Disposal is Prohibited

Except as hereinafter provided, it shall be unlawful to construct or maintain any privy, privy vault, septic tank, cesspool, or other facility intended or used for the disposal of sewage

SECTION 402 Where Public Sewer Unavailable

Where a public sanitary sewer is not available under the provisions of this Code, the building sewer shall be connected to a private sewage disposal system complying with the provisions of this Article.

SECTION 403 Permit Required

Before commencement of construction of a private sewage disposal system, the owner or his agent shall first obtain a written permit from the City.

SECTION 404 Permissible Private Sewage Disposal Types, Location, Discharge

(a) The type, capacities, location, and layout of a private sewage disposal system shall comply with all regulations and ordinances of the Authority.

(b) If a cesspool is hereinafter constructed on or near a property line, the same shall be backfilled and the system moved to a proper location to comply with Authority regulations.

(c) No septic tank or cesspool shall be permitted to discharge into any public sewer or natural outlet.

SECTION 405 Private Sewage System -- Safe and Sanitary Maintenance

The owner of premises utilizing private sewage disposal facilities shall operate and maintain the same in a safe and sanitary manner at all times, at no expense to the Authority.

SECTION 406 Facilities Must Be Noted -- Required Under Section 105

Pursuant to Section 105, an application for a permit to connect to a public sanitary sewer must state the type and location of all existing private sewage disposal facilities.

SECTION 407 When Public Sewer Becomes Available

At such time as a public sanitary sewer becomes available for use, as set out in this Code, a direct connection shall be made to the public sanitary sewer in compliance with this Code, and any cesspools, septic tanks, and similar private sewage disposal facilities shall be pumped out of all sewage. Metal tanks shall be collapsed and filled with earth. Concrete tanks are recommended to be filled, but it is not mandatory.

SECTION 408 Private Sewage System -- Abandonment, Fill, Permits

(a) All abandoned cesspools, septic tanks, privy vaults, seepage pits, or similar sanitary waste receptacles shall be pumped out and dirt-filled within sixty (60) days after abandonment, under the direction of the Authority. Metal tanks shall be collapsed and filled with earth. Concrete tanks are recommended to be filled, but it is not mandatory.

(b) An Authority permit shall be required prior to the abandonment of existing facilities.

(c) Where a plumber, contractor, employee, or any other agent or independent contractor of the owner of the property is delegated and assumes the responsibility for all service lateral and building sewer

work to be performed, the permit shall require the pumping and filling of the abandoned private sewage disposal facility shall be performed by the aforementioned person or persons.

(d) Where the particular property owner assumes the responsibility of pumping and filling the facilities to be abandoned, he shall be required to secure a permit from the Authority for this work.

SECTION 409 Violations -- Public Nuisance and Remedy

The maintenance of a private sewage disposal facility in violation of the provisions of the ordinance is deemed to be a public nuisance, and all rights and remedies are available to the Authority for the abatement of such a nuisance. Additionally, the person violating the provisions of this Article shall be liable for all costs incident to the said abatement.

ARTICLE V

PERMISSIBLE DISCHARGES

SECTION 501 Waters Not Permitted

(a) No roof drainage, cellar, surface-water, waste from hydrants or groundwater from underground drainage fields shall be admitted or be permitted to drain into the sewer system. The sewer system is intended to convey sanitary sewage and permitted wastes only.

(b) No person shall discharge or cause to discharge any stormwater, surface-water, groundwater, roof runoff, subsurface drainage, cooling water, or unpolluted industrial or unpolluted commercial process water into any sewer.

SECTION 502 Industrial Discharge

Except as otherwise provided in this Code, all industrial users shall comply with the requirements of Article VI.

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SECTION 503 Other Prohibited Wastes and Waters

Except as otherwise provided in these rules and regulations, no person shall discharge or cause to be discharged any of the following described wastes or waters into the sewer system:

(a) Any liquid or vapor having a temperature higher than sixty-five (65) degrees Centigrade.

(b) Any water or waste containing more than one hundred (100) ppm by weight of fats, oils, or greases.

(c) Any gasoline, benzine, naphtha, fuel oil, or other flammable or explosive liquid, solid or gas which, by reason of its nature or quality, may cause fire or explosion, or which, in any other way, may be injurious to persons or the sewer system or the wastewater treatment plant.

(d) Any noxious or malodorous gas or substance which, whether singly or by interaction with other wastes, shall be capable of creating a public nuisance or hazard to life or of preventing entry into any sewer or the wastewater treatment plant for maintenance and repair.

(e) Any ashes, cinders, sand, mud, straw, shavings, metal, glass, rags, bones, feathers, tar, plastic, wood, paunch manure, butchers offal, or any other solid or viscous substance which shall be capable of causing obstruction to the flow in any sewer or other interference with the proper operation of the sewer system or the wastewater treatment plant.

(f) Any water or waste having a pH lower than 5.0 or higher than 10.0, or having any corrosive property capable of causing damage or hazard to structures or equipment of the sewer system or the wastewater treatment plant or to personnel engaged in operation and maintenance thereof.

(g) Any water or waste containing any toxic substance in quantity sufficient to constitute a hazard to humans or animals, or to interfere with the biochemical processes of the wastewater treatment plant, or that will pass through the wastewater treatment plant in such condition so that it will interfere with legitimate downstream uses as determined by the appropriate authority.

(h) Any water or waste containing suspended solids of such character and quantity that unusual attention or expense shall be required to handle such water or waste at the wastewater treatment plant.

(i) Any toxic radioactive isotopes, except by special permission of City.

(j) Any drainage from building construction.

(k) Any garbage.

SECTION 504 — Gas Stations, Restaurants -- Traps and Interceptors

(a) Gas stations and garages are required to provide oil interceptors approved by the Authority, in the proper location, where the dangerous liquids are to be intercepted.

(b) Restaurants and commercial institutions and industrially-operated cafeterias are required by the Authority to provide grease interceptors.

(c) Grease, oil, and sand interceptors, and oil reclaimers shall be provided when, in the opinion of the Authority, they are necessary for the proper handling of liquid wastes, sand, and other harmful ingredients (hair traps shall be provided for all barber shops and beauty parlors), except that such interceptors shall not be required for private living quarters or dwelling units. All interceptors shall be of a type and capacity approved by the Authority, and shall be located as to be readily and easily accessible for cleaning and inspection.

SECTION 505 — Stormwater to Drain to Storm Sewers

Stormwater and all other unpolluted drainage shall be discharged to such sewers as are specifically designated as storm sewers, or to a natural outlet approved by the Authority.

SECTION 506 — Authority has Right to Waive Requirements

Nothing contained in this Article shall be construed as prohibiting any special agreement or arrangement between this Authority and any person whereby wastes of unusual strength or character may be admitted into the sewer system by this Authority, either before or after preliminary treatment.

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ARTICLE VI

INDUSTRIAL WASTES

SECTION 601 — Industry Required to Apply for Sewage Service

All industries shall make application to the City for sewage service. Industrial wastes may be discharged into the sewer system only with the written consent of and pursuant to written agreement with the City, provided that rules and regulations which may from time-to-time be adopted by the City and prescribed for the pretreatment of industrial wastes are fully complied with to the satisfaction of the City.

SECTION 602 — Permissible Industrial Wastes

Characteristics of industrial wastes to be acceptable for collection and/or treatment must not be in excess of the following:

(a) The 5-day, 20-degree Centigrade BOD (biochemical oxygen demand) shall not exceed 1,000 ppm on an average 24-hour composite sample.

(b) The suspended solids content shall not exceed 1,000 ppm on an average 24-hour composite sample.

(c) The total dissolved solids content shall not exceed 1,100 ppm on an average 24-hour composite sample.

(d) The pH shall not be less than 5.0 nor shall it exceed 10.0 or found to be excessively corrosive.

(e) The temperature shall not exceed 65°C.

(f) The color shall not be such as to require special treatment to render the effluent acceptable for discharge.

(g) The waste shall not contain heavy metals or other toxic substances in excess of the following concentrations:

Item	Concentration mg/L
Arsenic	0.05
Barium	1.0
Beryllium	0.5
Boron	0.75
Cadmium	0.005

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Item	Concentration mg/L
Chromium (hexavalent)	0.5
Chromium (trivalent)	5.0
Cobalt	0.2
Copper	0.2
Cyanides	0.05
Fluoride	1.7
Sulfide	0.0
Iodide	0.0
Iron	0.3
Lead	0.05
Lithium	5.0
Manganese	2.0
Mercury	0.002
Molybdenum	0.005
Nickel	0.05
Nitrate (as N)	10.0
Phenols	0.001
Selenium	0.01
Silver	0.05
Tin	1.0
Vanadium	10.0
Zinc	5.0

(h) The waste shall not contain grease and oil, inflammable material, nonbiodegradable material, or any oxygen scavenger, sufficient in quantity to be injurious to the treatment facilities, or interfere with any treatment processes, or to constitute a hazard to human or animal life.

(i) The waste shall not contain any other solid or viscous material capable of causing obstruction to the flow in the sewers or at the treatment facilities, or any material capable of causing interference with the proper operation of the treatment facilities.

(j) The waste shall not contain any material requiring unusual processing or expense at the treatment facilities.

Where required, in the opinion of the City's engineers, the user shall provide at his expense such preliminary treatment or handling as may be necessary to modify the objectionable characteristics or control the quantities and rates of discharge of such water or wastes as necessary.

Plans, specifications, and any other pertinent information relating to proposed preliminary treatment or handling facilities shall be submitted for review to the City and no construction of such facilities shall be commenced until a permit for the connection is obtained in writing from the City.

SECTION 603 Preliminary Treatment of Industrial Wastes

Whenever necessary, the owner of the improved property shall provide, at his expense, such preliminary treatment or handling to modify the objectionable characteristics or control the quantity and rates of discharge of such water or wastes. Wherever facilities for preliminary treatment and handling of industrial wastes shall have been provided by the owner of such improved property, such facilities continuously shall be maintained in satisfactory operating condition. The Authority shall sample, test, or otherwise examine the industrial waste as often as reasonably necessary to insure quality compliance, and to reduce the possibility of accidental discharges of wastes not conforming to Section 602. In lieu of constructing a treatment facility, the owner may elect to pay a surcharge as described in Section 609 and only upon approval of the City.

SECTION 604 Steps Necessary for Industrial User

The following procedure outlines the prerequisite to be fulfilled by the owner and special requirements of the Authority. Generally the following events must take place prior to use of the system:

1. Permit application form -- Ministry of Health, Pollution Control Department, and preliminary approval.

2. Prepare detailed plans and specifications.

3. Approve plans and specifications.

4. Enter into agreement with City.

5. Construction, inspection, and approval.

1. Preliminary Approval.

The initial approval is required by the Ministry of Health and the City in order that the City may provide whatever prior planning is necessary to include the user in the system. The applicant shall submit a permit application form to the Authority, City, and the Ministry of Health for review and approval. The application shall generally include:

(a) Define the wastewater characteristics, water sources, and quantities.

(b) Process descriptions of the manufacturing process and the pretreatment scheme proposed to meet the Authority requirements and other governmental regulatory agencies.

(c) Summary of design basis, major equipment sizes, raw materials, and product list.

(d) Effluent characteristics.

(e) Plot plan.

(f) Process flow diagrams.

2. Prepare Detailed Plans and Specifications.

(a) Detailed plans and specifications are to be prepared for approval.

(b) Sewer plans shall conform to all the specifications established by the City. In no case will lesser standards than exist in the present specifications or as outlined in these rules and regulations be adopted by the Authority.

(c) Standard specifications for the collection sewers may be obtained from the Authority. The cost of these specifications shall be borne by the owner.

Information relative to specifications for building sewers is available in Articles II and III of this Code.

The owner shall submit a specified number of the as-built plans to the City prior to final acceptance of wastes into the collection system.

3. Approval of Plans and Specifications.

At the owner's expense, the Authority, City engineer, and Ministry of Health will review plans and specifications submitted to the Authority.

4. Construction, Inspection, and Approval.

(a) Owner shall construct at his expense, all lines, pumping and pretreatment facilities and appurtenances for their connection to the collection system.

(b) All construction work associated with the Owner's connection to the Authority collection system within the corporate limits of the City shall be subject to inspection by the Authority and the City engineer. After a final inspection and approval of the construction work, the City will issue a connection permit which will allow the owner to connect

to the collection system. The connection permit in no way relieves the owner of the responsibility of meeting the effluent requirements in Section 602 or as approved in writing by the Authority and City engineer.

(c) Connection to the collection system does not relieve the owner of any obligation of making revisions to insure maintenance of approved effluent standards.

SECTION 605 Manholes Required -- Location

Any person who shall discharge industrial wastes into the sewer system, shall construct and thereafter properly maintain a suitable control manhole to facilitate observation, measurement, and sampling by the Authority. Any such control manhole shall be constructed at an accessible, safe, suitable location in accordance with plans approved by the Authority prior to commencement of construction.

SECTION 606 Sampling of Industrial Wastes

Industrial wastes being discharged into the sewer system shall be subject to periodic sampling, inspection, and determination of character and concentration. Such sampling, inspection, and determination shall be made as frequently as may be deemed necessary by the Authority. Wastewater sampling facilities shall be accessible to the Authority at all times. Representative samples for a full working day shall be obtained by taking periodic samples and compositing them in accordance with the flow at the time of sampling as required by the Authority.

SECTION 607 Duty to Analyze Samples

The Authority shall be responsible for analysis of samples of industrial wastes, provided such sample is taken by a representative of the Authority.

SECTION 608 Change in Industrial Wastes -- Notice

Any owner of an improved property who is discharging industrial wastes into the collection system and who contemplates a change in the method of operation which will alter the type of industrial wastes being discharged into the sewer system shall notify the Authority, in writing,

at least ten (10) days prior to consummation of such change. Any owner changing the type of industrial waste without proper notification will be subject to penalties and surcharges as provided in this Code.

SECTION 609 Right to Restrict Use

The Authority reserves the right to restrict or discontinue the owner's use of the sewer service if the owner fails to comply with the established effluent standards.

ARTICLE VII

MISCELLANEOUS

SECTION 701 Tampering With Sewage System -- Criminal Penalty

No unauthorized person shall maliciously, willfully, or negligently break, damage, destroy, uncover, deface, or tamper with any structure, appurtenance, or equipment which is part of the municipal sewage works.

Any person violating this provision shall be subject to immediate arrest.

SECTION 702 Right to Inspect -- Owner's Liability for Defects and Inspection Costs

(a) The Authority and other duly authorized employees of the City bearing proper credentials and identification shall be permitted at any time to enter upon all properties for the purposes of inspection, observation, measurement, sampling, testing, supervising, and any other functions relating to service rendered by the City through the sewer system in accordance with the provisions of this Code.

(b) All found defects shall be corrected at the owner's expense.

If defects are found as a result of an inspection, test, sample, measurement, or observation, the owner will indemnify the Authority for the cost of said inspection, observation, measurement, sample, test, or supervision.

SECTION 703 — Notice of Violations -- Time for Cure -- Criminal Penalty

Any person found to be violating any provision of this Code, except Section 701, shall be served by the City with written notice stating the nature of the violation and providing a reasonable time limit for the satisfactory correction thereof. The offender shall, within the period of time stated in such notice, permanently cease all violations.

SECTION 704 — Violators of Code Must Indemnify Authority

Any person violating any of the provisions of this ordinance shall become liable to the Authority for any expense, loss, or damage occasioned the Authority by reason of such violation.

SECTION 705 — Engineering Requirements

In order to maintain the same standards that exist in the sewage collection system and as set out in this Code, the Authority shall require any property owner applying for a sewer permit to have the collection system engineered in one of the following ways:

(a) The property owner may request that the Authority, through the City engineer, prepare plans and specifications, and inspect construction of the sewer system in accordance with approved plans and specifications, or of the sewer system in accordance with approved plans and specifications.

(b) The property owner may retain an engineer with experience in the design of sewer systems, waste treatment plants, and related appurtenances; said engineer to prepare plans and specifications in accordance with the City Sewer Code, and obtain approval from the Authority.

SECTION 706 — Saving Clause

The invalidity of any section, clause, sentence, or provision of this Code shall not affect the validity of any other part of this Code which can be given effect without such invalid part or parts.

SECTION 707 Time Code Becomes Law

This Code shall be in full force and effect from and after the date of its passage, approval, recording, and publication as provided by law.

SECTION 708 Notice -- Method of Service

Unless otherwise specifically provided, whenever notice is required by this Code to be served on any person and/or property owners, such service shall be made personally upon the owner, if he can be found in the City, or an adult person residing on the property affected, or in case personal service cannot be made upon the owner, or an adult person cannot be found residing on the property, said notice shall be tacked or posted conspicuously on the premises.

APPENDIX D

UTILITY PRICING APPROACHES AND POLICY CONSIDERATIONS

A major objective of the financial analysis is the determination of effective user charges and fees that will permit the stable operation of the proposed facilities in Irbid. This section introduces the issue of municipal utility pricing; identifies the resource allocation aspects of pricing, including prospects for water conservation and impacts of subsidies; and sets a foundation on which later recommendations regarding future rate structures and fees are based.

D.1 ISSUES OF MUNICIPAL UTILITY PRICING AND RESOURCES

No matter what basis is used to determine water rates and fees, the selected charges must perform one basic function, i.e., they should spread the cost of service to those benefited, approximately in proportion to the cost of providing the service, and with respect to the benefit received.

Of course, other objectives are possible and will be discussed later. Basically, the objective of a publicly-owned utility is to produce sufficient revenues to cover current expenses and outstanding debt, including interest and principal payments. If these commitments are met regularly, the utility can survive. When system expansion is necessary, bonds are issued or loans are secured, and the amortized debt becomes an addition to annual costs. These additional annual costs are paid by increasing service charges and fees. As a result, debt amortization is equivalent to depreciation.

The cash flow model analyses presented in Chapter 9 and Apperdix E basically reflect this philosophy. Charges and fees are set to cover costs of operation and debt repayment, and to provide an image of institutional stability. Institutional stability is reflected in user charges that are maintained at "constant" rates over periods of time. In this way future capital expenses do not necessarily imply need for instantaneous rate changes, because small surpluses are accumulated for capital improvements. Policy considerations can also be incorporated into a fee schedule. User charges can be set to bring about desired changes in water and land use that are consistent with national, regional, and local objectives.

D.2 RESOURCES ALLOCATION CONSIDERATIONS

In terms of theoretical economics, the pricing mechanisms of the free market system--perfect competition, provides an optimal efficient

allocation of resources. This is a result of the free entry of firms into a market. For many services, the market system works well; in other areas the market cannot serve the optimal results. With water supplies and other municipal services we are faced with the problem of how public policy can intervene to provide a more efficient resource allocation.

Provision of public services by authorities, utilities, or other natural monopoly arrangements is an example. Natural monopolies (authorities and utilities) are created by government because of the technical factors related to substantial returns to scale in production and distribution, which means that a single "firm" can produce more cheaply than several firms.

Generally, increasing returns to scale exist for any production process that requires substantial fixed costs before any output can be produced. This situation exists for water supply distribution, wastewater collection and treatment, and solid waste disposal.

Monopoly pricing is the theoretical inevitable outcome of an unregulated monopoly's attempt to maximize profits by equating marginal revenue (the revenue received from an additional unit of production) with marginal cost (the unit of cost associated with the produced unit). This excessive monopoly price leads to insufficient service at high prices and excessive profits for the producer. Some of the alternative pricing approaches presented here can remedy these problems and provide efficient resources utilization. Other approaches can be useful in implementing policy, e.g., peak-load pricing. Some approaches lead to over-use of resources and should be avoided, if possible, e.g., flat-rate pricing.

The alternatives considered include:

1. Marginal-cost pricing.
2. Full-cost pricing.
3. Peak-load pricing.
4. Multipart pricing.
5. Flat-rate or block-rate pricing.

D.2.1 Marginal-Cost Pricing

The theoretical economic literature on natural monopolies identifies marginal-cost pricing as an optimal regulatory pricing approach. In its simplest form, the price of user charge would be set equal to the marginal cost. In addition, the natural monopolist would be required to produce as many units of output as the members of society are willing to purchase at a reasonable cost (the marginal cost). In this manner, the economic efficiency criterion would be achieved, since marginal costs reflect the social opportunities foregone (the resources which are drawn away

from alternative uses). The equality of user charge with marginal cost ensures that consumers equate marginal benefits from this use of resources with the real alternatives foregone elsewhere. In the theoretical free market world of pure competition, the market mechanism would operate to ensure this equality.

The rationale of marginal-cost pricing is as follows: If the price of a resource is set equal to its marginal cost, a consumer will be encouraged to purchase the resource to the point where the benefit he receives from the marginal unit is equal to the price -- the marginal cost. This approach permits individuals who derive different levels of benefit from use of the resource to consume quantities consistent with their willingness to pay for the incremental unit of benefit.

Marginal cost or incremental cost is simply the addition to total cost involved in expanding production by one unit. It is the relevant cost involved in making decisions for efficient use of resources in production. A businessman, for example, would stop production if the incremental cost of providing an extra unit of output exceeded the marginal revenue, the increment of revenue, associated with the production of the extra unit.

There is no question that setting the user charge equal to marginal cost is a socially-appropriate pricing policy. For some types of public goods, however, where production is characterized by increasing returns to scale, which is the case for the natural monopolies, the utility will have insufficient revenue to cover its full cost. Paying the utility a subsidy which will compensate the loss would be required in this approach. For technical reasons, only if this subsidy is charged to the customers in the form of a lump sum tax will the marginal cost pricing approach provide the socially-desirable solution. In addition, this approach also requires periodic estimates of marginal costs (incremental costs) which are constantly changing and difficult to measure.

A recent World Bank staff working paper, No. 259, "Alternative Concepts of Marginal Cost for Public Utility Pricing: Problems of Application in the Water Supply Sector," May 1977, presents several methods for developing a marginal cost pricing approach. Based on the conclusions of the paper, that the "better" marginal cost pricing approaches are effective with projects where investments are spread out (capital divisibility), this approach was not used because the majority (86 percent) of the Irbid Phase 1 capital costs are scheduled in the first three years, and the approach is considered inappropriate.

D.2.2 Full-Cost Pricing

It is relatively simple to specify the theoretically-optimum marginal-cost pricing policy to finance a natural monopoly. However, the implementation of a specific system of charges and taxes which is consistent with this optimum policy requires knowledge concerning marginal cost variation over space (from place-to-place in the service area), over time (from one moment, day, week or month to another),

and information concerning the economically-efficient lump-sum tax subsidy which is necessary to recover full costs of the utility.

To remedy these problems, a full-cost pricing policy is a generally accepted theoretical/practical approach to pricing the products or services of a natural monopoly. In general terms, this is the method used to price the resources of services provided by public utilities. This standard regulatory policy requires the natural monopolist to produce as many units of output as the service customers are willing to purchase at the price which is determined by the intersection of the market demand curve and the monopolist's average cost curve. Full-cost pricing is the single summation of all costs associated with providing a service, divided by the total number of users.

Technically it can be shown that this standard regulatory approach is economically inefficient. This price is greater than the marginal cost, and society's welfare could be theoretically improved by lowering the user charge to the price required by the optimum marginal-cost pricing solution. Because of the implementation problems of optimum marginal-cost pricing, however, this approach may provide a socially-superior solution.

D.2.3 Peak-Load Pricing

Economic literature typically refers to peak-load pricing as an approach applicable to the electricity industry where consumption varies over the day and the seasons of the year, and capacity must meet the peak consumption. The problem in this case is accentuated by the fact that electricity cannot be stored. This peak-load pricing problem also characterizes other natural utilities including gas and water distribution, but not generally water supply, wastewater treatment, and solid waste disposal.

Although peak-load pricing is generally not useful for pricing municipal services that will be used in Irbid, the concept is presented here for two reasons. The method could be:

1. Applicable for pricing municipal services that are affected by seasonal use.

2. Useful in administering increased prices during periods of water shortage or water emergency.

In an area that has limited water resources, peak-load pricing and water surcharges should be considered as a part of the policy program for managing the resource. Peak-load pricing implies higher prices at peak periods.

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The failure to vary rates over time results in price discrimination, since the cost of producing for the peak is clearly greater than the cost of producing for other periods. The failure to charge higher rates in peak periods encourages the waste of resources which are used inefficiently to satisfy peak needs, and low peak prices that cause peak consumption to be even higher than it would be otherwise.

The general comments can be made concerning peak-load pricing:

1. Peak prices should be higher than off-peak prices to allocate the limited capacity efficiently, e.g., to those who are willing to pay for its true costs.

2. Peak prices should be higher than off-peak prices to defray the costs of providing additional capacity.

3. The relevant costs in determining both peak and off-peak prices are marginal costs.

The theoretical solution to a peak usage problem is to equate price with marginal costs. The problems of this approach (measurement of marginal costs and subsidies, financed through lump-sum taxes) were discussed previously. The practical approach requires application of full-cost pricing (equating price with average costs) on a seasonal basis. This approach will affect system usage and capacity requirements.

Water supply and wastewater treatment needs fluctuate to peak levels in much the same way as the demands for electricity. On a daily basis, each utility provides a maximum level of service in the morning and evening. On a seasonal basis, peaks in electricity usage are related to air-conditioning power requirements which are not distributed to the winter months. Water supply peaks occur during hot dry periods. Wastewater treatment peaks occur in recreation areas which experience dramatic changes in population over the year.

From a practical point, peak-load pricing would be impossible for a municipal utility, but a seasonal rate is possible and reasonable. Peak prices could be designed for the summer months. This would provide efficient resource use and equity.

During periods of drought and water emergency, stand-by water surcharges could be implemented to help manage the scarce resource and provide additional revenues to augment future water supplies.

D.2.4 Multipart Pricing

Consistent with the practical and equity pricing interests of peak-load pricing, and as an approach to bridge the gap between theoretical

objectives and practical application, a multipart pricing system would provide additional advantages. Consumers could be required to pay at least a two-part price in which the first part is independent of the quantity of output purchased and reflects the direct cost of providing any level of service. The second part would be directly dependent upon the quantity of output consumed, and reflect the marginal cost of supplying additional units.

In terms of a municipal wastewater service, the two-part costs would consist of:

1. A charge for connection to the municipal system reflecting the direct cost of providing this connection.

2. A unit service charge which reflects the marginal cost of service.

The first charge, for connection to the system, recognizes that the costs of installation and system use are not equal for all users of a system, and that areas requiring special pumps and construction, or areas designed to be protected from growth, should be charged for these expenses. The second charge, a service charge, is consistent with recovering the user's marginal cost of service, as described previously by the practical, full-cost pricing policy.

Multipart pricing provides planning information with respect to the desirability of producing the socially-desirable level of output. To the extent the two-part charge recovers the total direct cost of providing the service, the policy tests the willingness of the public to pay the true costs of expansion of services. The costs of developing and administering a multipart pricing policy, however, may be substantial thereby offsetting the efficiency advantages of the approach.

D.2.5 Flat-Rate or Block-Rate Pricing

Flat-rate pricing is frequently used for pricing unmetered utilities. Under a flat rate, a fixed sum of money is charged for services during a specific period of time, regardless of the actual quantity consumed. This technique is frequently used by utilities and authorities where the annual debt service costs and operation and maintenance costs are allocated equally for all users. In this case, flat-rate and full-cost pricing (discussed earlier) are identical. However, sometimes flat-rate prices are based on numbers of fixtures and other counted items in a house or commercial establishment. Under these conditions, flat-rate charges will not be consistent with uniform service charges. The approach is easily administered, however, there are two major objections:

1. A flat-rate pricing system leads to waste and careless use of services and over-design for unnecessary services.

2. Flat rates do not provide a fair and equitable method of distributing the cost of municipal services. Whenever there are wide differences in the quantity of service used, some customers are favored at the expense of others.

Block-rate pricing structures or declining-block rate pricing policies can compound the inefficiency problems evident in flat-rate approaches. Declining-block rate structures require that customers who use less resource per billing period must pay a higher price for an additional block of water, electricity, or wastewater treatment service than customers who use more. The system may result in subsidy transfers between resource user groups--residential, commercial and industrial customers, or between the poor and the rich. Also, declining prices encourage wasteful use of additional units of service.

Flat-rate and block-rate pricing of wastewater utilities' services possess none of the characteristics needed for an efficient pricing policy. They are entirely unrelated to marginal costs, and require frequent rate adjustments due to revenue erosion problems during periods of rising costs. Alternative pricing policies, however, require metering or other methods of service measurement to accurately estimate service usage by each utility customer.

D.3 WATER CONSERVATION

The greatest incentive for conservation of municipal services is provided by a user charge system based on measured consumption. The existing Irbid water distribution system is metered, and the consumption is priced at progressive rates possibly to encourage conservation. National policy also bases wastewater collection and treatment in part on metered water use.

Together these policies could encourage water conservation in Irbid, depending on the per unit costs.

Conservation measures will affect various users (e.g., income groups) in different ways. The degree to which metering and pricing strategies will affect water consumption and use of wastewater treatment facilities will depend on the influence of price and income elasticities. Price and income elasticities are, respectively, estimates of the influence of price and income changes on quantity of services demanded. For example, a price elasticity of infinity (perfectly elastic demand) means that at the prevailing price a firm can sell any quantity it wishes, but none at a slightly higher price.

The technical literature indicates that water reduction from metered use and appropriate pricing is relatively inelastic or insensitive

to price changes. A recent World Bank Research Publication, Patterns in Household Demand and Saving, 1977, presents price elasticities for total expenditures for food, clothing, and housing, three of the basic necessities of life, for low, middle, and high income groups. Although water elasticities are not included, they can be approximated by the elasticities presented for housing or the other necessities.

Water Use Price Elasticity by Income Group[1]

	Low Income	Middle Income	High Income
	(50-250)[3]	(250 - 500)[3]	(500 and over)[3]
Water use price elasticity[2]	-0.24	-0.50	-0.69

These elasticities are believed to be appropriate proxies for the elasticity of demand for water. They indicate that low-income users (typical of the majority of Irbid households) would reduce their consumption of water by 24 percent as a result of a 100 percent increase in price. This same price increase would affect middle and high-income groups by reducing water consumption by 50 percent and 69 percent, respectively.

These relationships also suggest that opportunities for reduction in water consumption are better for middle and high-income groups than for low-income users. This results from the fact that the low-income population uses water for basic subsistence purposes. As income increases, however, water is used for other purposes, and these uses can be more easily curtailed.

The low-income group is most representative of Irbid at this time. It is expected that Irbid will become more affluent in the future, and the middle-income group price elasticities (which are representative of some Irbid households now) could apply then.

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[1] 1970 summary of international patterns. Low-income group countries: Korea, Thailand, Taiwan. Middle-income group countries: Jamaica, South Africa, Greece, Ireland, Puerto Rico. High-income group: Italy, United Kingdom, Sweden, United States. Per capita income inflated to 1979 levels by 5 percent per year, compounded annually (JD).

[2] Housing price elasticity used as an approximation.

[3] Household income in JD per month.

Based on these elasticities, however, it is not likely that price adjustments will be an effective method for achieving reduction in quantities of water consumed by Irbid residential customers.

Probably the most effective application of pricing to achieve water conservation would involve nonresidential users who could attempt to avoid increasing costs. Commercial and industrial customers could avoid some of the costs of water use by installing water-conserving appliances. Building codes can also require the use of water-saving devices in new homes, restaurants, hotels, and other businesses that use water.

D.4 SUBSIDIES AND IMPACTS ON WATER USE

In general, subsidized public services introduce several potential problems. Subsidies may:

1. Encourage users to demand that a service be unduly expanded, extended, or improved in quality, especially where the circumstances are such that the consumers who benefit would not or possibly should not be called upon to bear the full burden of the added cost.

2. Encourage expenditures of funds for improvements that would otherwise be foregone if the operating agency were dependent on revenues available from charges it levies on its own responsibility.

3. Encourage inefficiency in administrative practices because of easy access to subsidies covering costs related to inefficiency.

4. Encourage an excessive proportion of administrative effort in trying to justify increases in the subsidy.

Each of these problems must be weighed against the avoidable inefficiency in terms of prices and outputs (the theoretical purpose for the subsidy was to price the service at the marginal cost), and the administrative level efficiency that would result from a self-sufficient (unsubsidized) operating agency. The loss of efficiency can be minimized to some extent by a partial subsidy. By limiting the subsidy and administering it firmly to constrain the operating agency from using pressure to modify the subsidy, efficiency can be maintained. As a result, much of the administrative disadvantages of the subsidy can be avoided.

D.5 SELECTION OF A RECOMMENDED PRICING STRATEGY

User charges should provide economic efficiency, be equitable, legally acceptable, and capable of being implemented. These criteria are summarized as follows:

1. Economic Efficiency -- User charges are consistent with the lowest attainable cost per unit of service provided.

2. Equity -- User charges are imposed on individuals and other customers with respect to the benefits received.

3. Legality -- User charges are in agreement with Kingdom policy.

4. Administrative Practicality -- User charges are capable of being implemented by a service authority, and recover the annual costs of debt service and operation and maintenance.

5. Policy Implementation -- From a water resource management perspective, it may also be useful to use the rate system to achieve policy objectives, i.e., water conservation.

Table D-1 presents each of the available user charge methods that could be implemented in Irbid. The most effective approach, a multipart pricing scheme is similar to that already in use for water supply and wastewater services throughout the Kingdom. If administered properly, such a system could achieve all of the objectives of a desirable pricing scheme. The existing policy for solid waste collection uses a flat-rate pricing approach that is also probably the best available. Although stormwater costs are not now repaid by the residents of Irbid, a future pricing approach would probably also rely on a flat-rate method applied through the municipal tax structure in which the cost of the system would be shared equally by the residents, based on the assumption that all residents share equally in the benefits.

D.6 EFFICIENT UTILIZATION OF MUNICIPAL SERVICES

The efficient use of municipal services can also be encouraged by managing the development of Irbid. Uncontrolled growth in any community is generally characterized by sprawl or scattered development. With respect to municipal services, this scattered development or sprawl imposes two related problems on service departments and the community:

1. It forces extension of service into new areas before other sections of the community have been fully developed.

2. It imposes higher user costs on the community because municipal services are under-utilized.

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Table D-1

User Charge Strategies for Municipal Services Pricing

Pricing Approach	Evaluation Criteria: Economic Efficiency	Equity	Legality	Administrative Practicality	Policy Implementation
1. Monopoly Pricing	-	-	-	-	-
2. Marginal-Cost Pricing	+	+	+	-	-
3. Full-Cost Pricing	0	0	x	0	-
4. Peak-Load Pricing	+	+	x	0	+
5. Multipart Pricing	+	+	+	0	+
6. Flat-Rate (or) Block-Rate Pricing	-	-	+	+	-

+ Good
0 Acceptable
- Poor
x Uncertain

Municipal services planning can help to avoid these problems. A major benefit of an effectively-used municipal facilities project will be lower costs to users, and a stable institutional arrangement that provides municipal services to meet the needs of the public.

Lower user charges to municipal service customers will result in the residents of Irbid having more income available for other needs.

In summary, the following recommendations are offered:

1. Rates charged must reflect marginal costs as closely as possible.

2. Rates must be as stable as possible.

3. Customers should have an understanding of the rate structure and its application to make rational decisions.

When the rate schedule reflects marginal costs, stability will be encouraged in the utility's financial arrangements. Both the customer and the utility will be better able to plan for the future, and to insure the most efficient use of the necessary resources.

Requirements of both the utility and the public are served by establishing a user charge system that is stable, reflects the user's costs of providing service, and is not unnecessarily complex. When the public is fully informed about rate schedules and believes that they are reasonably stable, or at least predictable in the future, they are motivated to change their habits concerning use of resources. For example, customers may choose appliances that are water saving in order to maximize the net benefit they receive from use of the water and wastewater systems where charges are a function of water consumption.

APPENDIX F

ANALYSIS OF ECONOMIC BENEFITS FROM PLANNED PROJECT DEVELOPMENT

This appendix presents an analysis of the economic improvement that may be attributed to the proposed project. The approach is to consider the influence of the project from a "with" and "without" project basis on socioeconomic conditions, and to estimate population, labor force, and other changes that may be attributed to the project. This appendix does not place dollar or dinar values on the improvements.

F.1 "WITHOUT PROJECT" CONDITIONS

The "without project" analysis of socioeconomic parameters in Irbid is concerned with growth patterns in the absence of:

1. Increased water supply.
2. Improved water distribution.
3. Enhanced water quality.
4. Improved stormwater drainage.
5. Municipal sewage collection and treatment.
6. Citywide solid waste collection and disposal.

Only a portion of the projected growth for the Municipality of Irbid is attributable to the above improvements in the quality of life. Some of the other contributions to growth in Irbid, as reviewed in the socioeconomic study, include:

1. Improvements in agriculture.
2. Enhanced electric power.
3. Yarmouk University expansion.
4. As yet undeveloped nonagricultural opportunities.
5. Jordanian-Syrian Free Trade Zone.

It can be seen, then, that Irbid is experiencing, and will very likely continue to experience, a strong growth trajectory. This is currently taking place in the absence of the improvements described, and is to some extent independent of them. The continued inadequacy of water distribution and quality, however, and sewage collection can act as a constraint upon growth in Irbid. Some of the direct constraints would include:

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1. Lack of water for road and building construction.

2. Lack of water for improved agriculture, industry, and water-intensive commerce, such as laundries and car washes.

3. Unavailability of a high standard of living to attract professional and middle class persons to Irbid.

The "without project" effects can extend into most of the other factors which will be responsible for Irbid's continued growth.

F.1.1 Future Conditions

Future growth, along with changes in lifestyle and community development, can be analyzed in terms of the following basic socioeconomic parameters:

1. Population.
2. Income.
3. Employment.
4. Land use.
5. Property values.
6. Public health.

1. Population.

The population projection accepted for this study (Table 2-10) includes as an assumption the improvement of water distribution, sewerage, and solid waste systems in Irbid. As a consequence "without project" population projections are less than "with project" projections. Table F-1 presents data from the Yarmouk River study and a similar study for the City of Zarqa. An analysis of the difference between high and intermediate population projections yields an approximation for "with" and "without project" conditions, respectively. (The Zarqa project includes only sewerage and stormwater systems.) In this case, the "without project" projection is 8.9 to 10.0 percent lower than the "with project" projection.

Table F-2 sets forth estimates of "without project" projections applying the national growth rate as opposed to the Irbid growth rate, and a growth rate trajectory of 3.5 percent per year, diminishing to 3.0 percent per year after 1985. The latter trajectory was derived from a comparison of 1963 and 1978 building coverage. At this point the "without project" projection is approximately 20 percent less than the "with project" comparison. The data from the Yarmouk River study factor-out projected growth due to the expansion of Yarmouk University and the Irbid industrial estate.

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Table F-1

"With" and "Without Project"
Population Projection Differences
(Percent Difference High Projection Over Intermediate)

Yarmouk River Feasibility Study
(See Table 2-10)

Year	1980	1985	1990	2000
High projection--intermediate	0	3,000	7,000	26,000
Percent difference	0	1.5	3.1	8.9

Zarqa Wastewater Disposal and Stormwater Systems
(P 4-7)

Drainage Preliminary Design Report

Year	1980	1985	1990	2000
High projection--intermediate	2,000	12,500	24,000	76,000
Percent difference	0.4	2.4	4.0	10.0

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Table F-2

City of Irbid
Estimated "Without Project" Population
Projections Using National Growth Rate and
Irbid Intrinsic Growth Rate

Year	"With Project" Projection	"Without" Apply National Rate	Percent Difference	"Without" Apply Irbid Rate	Percent Difference
1975	128	128	--	128	--
1978	146	146	--	146	--
1985	199	198	0.5	199	0
2000	360	299	20.4	302	19.2

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2. Income.

Table 2-3 shows current per capita incomes in Irbid. Already there is a substantial affluent community in Irbid associated with Yarmouk University and the extensive commercial area in the center of town. While it is not possible with available information to project income, we can list the sources of higher incomes in the future.

1. Expanded Yarmouk University.
2. Expanding commercial and industrial estates.
3. The Jordanian-Syrian Free Trade Zone.
4. Construction industry.

As is the case with population parameters, these factors are not absolutely dependent on the development of enhanced water supply and sanitary facilities. The constraints imposed by the insufficiency of existing systems, however, would preclude or greatly restrict the income enhancement we can expect.

3. Employment.

Two studies present labor force statistics for the Irbid Governorate. The Yarmouk River study cites 20 percent as a gross participation rate in 1974 (p. 66). The JICA report cites the following current data taken from the First Census of Population and Housing:

Participation Rate
(percent)

	Male	Female
0 to 15 years	34.0	3.3
Over 15 years	73.0	6.6

Gross rate = 19.6 percent

(JICA report, p. IV-38)

These data agree with other data for "cities" as a category in 1974 (JICA report, p. IV-24). Also, the JICA study predicts a 30 percent gross population rate for the Governorate by the year 2000.

With these data there are two possible methods for deriving the "without project" labor participation rates:

1,02

1. Apply current rates to "without project" population projection.

2. Apply escalated rates to "without project" projection.

Since the JICA report attributes the increase in overall (gross) participation to an increase in the female participation, it seems reasonable to use escalated rates. This is true because the increase in the female labor force is a result of large-scale socioeconomic change, and not dependent on water-sewerage facilities. Using 20 percent as the current gross rate, 25 percent for 1990, and 30 percent for 2000 applied to the "without project" population projections, the following labor force estimates are obtained:

"Without Project"
Irbid Municipality Labor Force

	1979	1990	2000
Participation rate	0.20	0.25	0.30
Labor force	29,000	60,000	98,000

4. Land Use.

Figure 2-3 depicts current land use, and Figure 2-7 shows future land use in Irbid. Using the figure of 0.024 commercial shops per capita, the "without project" projections of commercial shop equivalents are:

Year	Total Number of Shop Equivalents
1978	3,504
1990	5,901
2000	7,727

Industrial development is related to the provision of basic water and sanitary services directly in terms of the availability of water for water-intensive industry, and indirectly in terms of labor force availability. Without the proposed project water-intensive industry will not be attracted to Irbid under "without project" conditions. While this direct effect on the Irbid industrial estate is potentially great, it should be pointed out that few water-intensive industries are projected for the area. Without the proposed project there is an 8.2 percent reduction in the labor force which may require a reduction in the total projected industrial area from over 100 hectares to approximately 90 hectares.

Since residential land use is a function of population, the land use reduction will simply be in direct proportion to the difference between the "with" and "without project" population projections.

5. Property Values.

In Irbid, property values are already very high. Unofficial estimates by the office of the city engineer indicate that residential land in the developing parts of town has risen from 0.500 JD per square meter to 5.000 JD per square meter within 10 years. Unofficial estimates of the price of rural land to the north of Irbid are from 1.000 JD to 2.000 JD per square meter. It is beyond the scope of this study to measure the "with" and "without project" changes in property values. This would necessitate a detailed economic analysis which would be compounded by inflation. It is important to point out that both the "with" and "without project" land use projections predict saturation pressures on land within the existing City limits. As a result, at least within the City limits, similar forces will be acting on property values under both "with" and "without" conditions.

6. Public Health.

Tables 2-6, 2-7, and 2-8 summarize the current public health situation in Irbid. It would be incorrect to apply current per capita rates of disease incidence as a "without project" condition. If the population of Irbid were to increase without improvements in water quality and sanitation, the per capita rates of disease incidence would themselves increase. This would be due to:

1. Greater densities.
2. Less water available.
3. Decreased water quality (increased contamination).

F.2 "WITH PROJECT" CONDITIONS

With the provision of increased water supply, enhanced water quality, sewerage disposal, solid waste management, and stormwater drainage, there will be general benefits to the community, as well as specific benefits related to:

1. Income.
2. Employment.
3. Public health.

The general benefits to the community of a project like this are discussed in the following paragraphs.

Benefits can be estimated on the basis of willingness to pay using available data on current supply, demand, and tariffs. In addition, benefits are inputed from analysis of the secondary benefits to Irbid through evaluation of the "with" and "without" impacts of new and improved public services to Amman.

The future "with project" state of the socioeconomic variables discussed, depends to a considerable extent on the "with project" population projections.

F.2.1 Population

Tables 2-2 and 2-10 present the current and future "with project" population projections. It has been established that by the year 2000 the "with project" population projection is at least 10 percent higher than the "without project" projection. This amounts to an increase of slightly more than 34,000 persons.

F.2.2 Income

The income enhancement in Irbid brought about as a result of this project will be both direct and indirect. The direct income enhancement will result from the in-migration of affluent families. The indirect income enhancement will result from increasing incomes from other sources such as:

1. Construction industry.
2. Expanding Yarmouk University.
3. The Jordanian-Syrian Free Trade Zone.
4. Expanding commercial and industrial estates.

The development of an adequate water source and distribution system will especially contribute to these indirect "with project" effects.

F.2.3 Employment

The "with project" increase in labor participation is attributed solely and directly to the increased population. Applying the accepted participation rates to the "with project" population forecasts yields the following data for the Municipality of Irbid.

"With Project"
Irbid Municipality Labor Force

	1978	1990	2000
Participation rate	0.20	0.25	0.30
Labor force	29,000	61,000	106,000

1.0b

By the year 2000, the "with project" labor force is 8.2 percent higher than the "without project" labor force.

F.2.4 Land Use

The "with project" land use projections are discussed extensively in Chapter 2. The demand on residential land will be intense under both "with" and "without project" conditions. In addition, increased pressure for high use and multiunit buildings can be expected. This is, in part, due to the provision of adequate sewerage.

As stated, the industrial estate can be expanded by 10 percent as a result of this project.

The enhancement of commercial development is also evaluated on a per capita basis. The following data present the "with" and "without project" comparisons:

Total Shop Equivalents

Year	With	Without	Percent Difference
1978	3,504	3,504	0.0
1990	5,952	5,901	0.9
2000	8,640	7,727	11.8

It can be seen that by the year 2000 the commercial estate is almost 12 percent larger as a result of this project.

F.2.5 Property Values

It would be purely speculative to predict the magnitude of the "with project" enhancement in property values. Except for the fact that increased municipal facilities make property in serviced areas more desirable, there is no further basis for determining property value enhancement.

F.2.6 Public Health

Chapter 2 discusses in detail the possible abatement of waterborne diseases due to this project. With the improvements in water supply and sewerage collection, it can be expected that the incidence of waterborne disease will be greatly reduced.

APPENDIX G

BIBLIOGRAPHY

G.1 ENVIRONMENTAL BIBLIOGRAPHY

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The environmental assessment was prepared by persons who are qualified in environmental impact analysis, and who have visited Irbid and are fully aware of the nature of the project and its possible impacts. These individuals and their qualifications are listed as follows:

- William Goode -- Principal Author

Graduate of Indiana University, B.A. Biology; M.S. candidate, Environmental Engineering, Illinois Institute of Technology. Six years experience in environmental consulting with Roy F. Weston, Inc. Extensive experience in environmental impact analysis.

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- Thomas J. Tuffey, Ph.D. -- Vice President, Resources Engineering

Environmental assessment supervisor for the Irbid project. Project Director, Project Manager, and Principal Investigator on numerous projects concerned with environmental assessment of major water resources and wastewater facilities plans.

- James Miller, President, Weston International -- Irbid Project Director.

- Douglas P. Hunsinger -- Irbid Project Manager.

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