FEASIBILITY STUDY
ON
EL-ARISH SEWERAGE AND
DRAINAGE SYSTEM
IN
THE NORTH SINAI PROVINCE
ARAB REPUBLIC OF EGYPT

FEASIBILITY REPORT

VOLUME ONE

EXECUTIVE SUMMARY

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Arab Republic of Egypt, the Japanese Government decided to conduct a feasibility study on the El-Arish Sewerage and Drainage System and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to El-Arish a survey team headed by Mr. Shohei Sata, Nihon Suido Consultants Co., Ltd., from 15th July to 4th November, 1984.

The team had discussions on the project with the officials concerned of the Government of Egypt and conducted a field survey in El-Arish and it's surrounding area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation extended to the team.

March, 1985.

Keisuke Arita
President
Japan International Cooperation Agency

FEASIBILITY STUDY

ON

EL-ARISH SEWERAGE AND DRAINAGE SYSTEM

CONSTITUENT VOLUMES

VOLUME - ONE	EXECUTIVE SUMMARY
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Units and Acronyms

Agencies

GOSSD	General Organization for Sewerage and Sanitary Drainage
NOPWASD	National Organization for Potable Water and Sanitary Drainage
NSG	The North Sinai Governorate
CAPMAS	Central Agency for Public Mobilization and Statistics
JICA	Japan International Cooperation Agency

Technical Terms

BOD	Biochemical Oxygen Demands at 5-day, $20^{0}C$
Cl	Chloride Ion
COD	Chemical Oxygen Demands
DO	Dissolved Oxygen
DWF	Dry Weather Flow
H_2S	Hydrogen Sulfide
MLSS	Mixed Liquor Suspended Solids
MPN	Most Probable Number
pH	The reciprocal of the logarithm of the hydrogen-ion concentration
SRT	Sludge Retention Time
SS	Suspended Solids
TS	Total Solids

Units

cm	Centimetre
gpcd	Grammes per capitaper diem
ha	Hectare
fd	Feddan (0.42 ha)
hr	Hour
km	Kilometre
lpcd	Litres per capita per diem
l/sec	Litres per second
m	Metre

Units and Acronyms

m/s	Metres per second
mm	Millimetre
m2	Square metre
m^3	Cubic metre
mg/l	Milligrammes per litre
m^3/day	Cubic metres per diem
m^3/min	Cubic metres per minute
m^3/m^2/day	Cubic metres per square metre per diem
kl/day	Kilolitres per diem
kW	Kilowatt

Economic and Financial Terms

B/C	Benefit to Cost Ratio
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
NPV	Net Present Value
PW	Present Worth
OCC	Opportunity Cost of Capital
p.a.	Per Annum

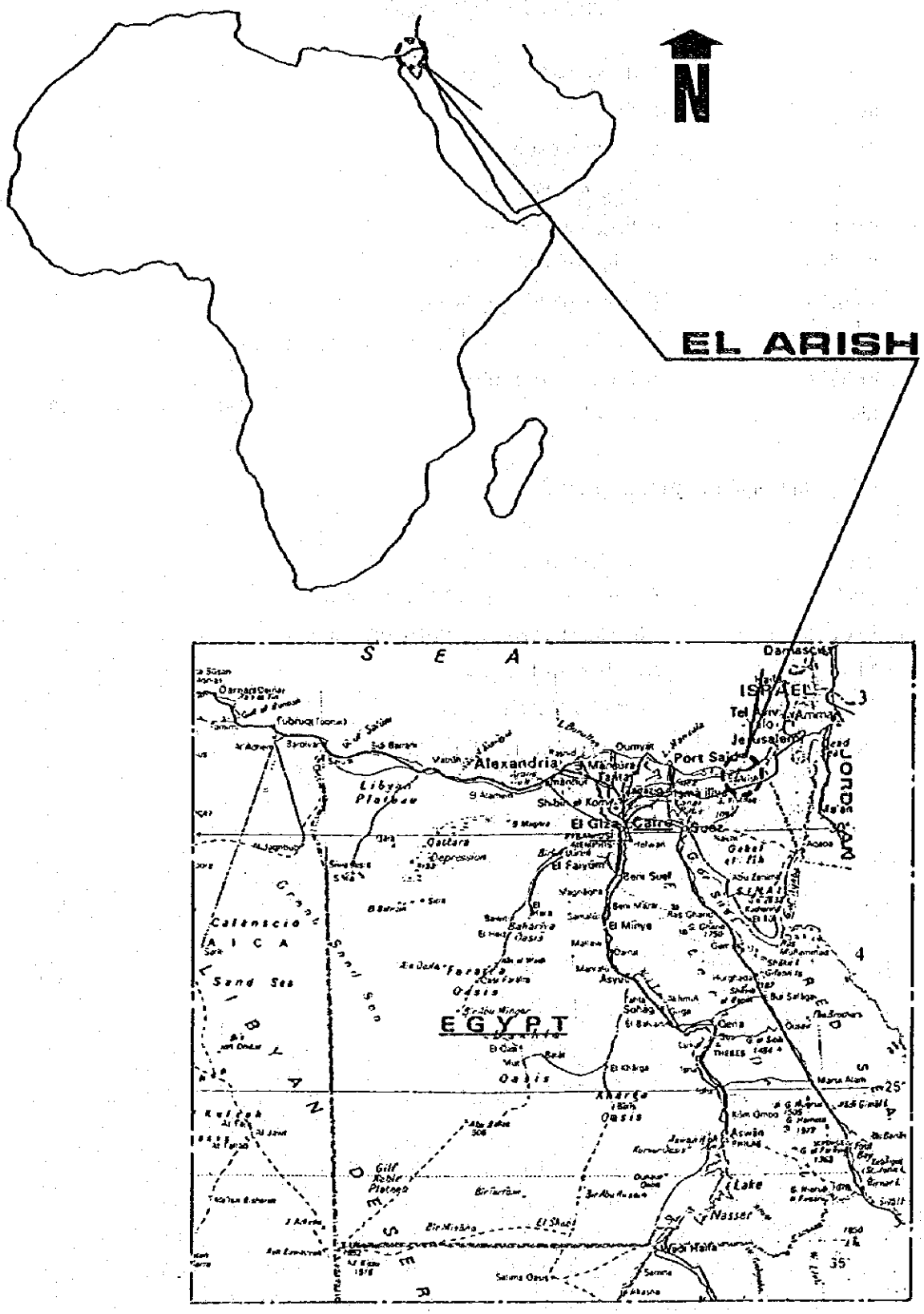


Figure 1 Location of the Study Area

PROJECT OUTLINE

The study team has conducted surveys in El-Arish and it's surrounding areas of 1,000 ha, comprising detailed field investigations, surveys and technical analyses of alternative plans for the various elements, and present legal, managerial, economic and financial matters to establish a feasibility study on sewerage, stormwater drainage and sewage reuse system.

Based on the field investigations and surveys, a long-terms plan for the system has been developed. The recommended long-term plan encompasses the sanitary sewers, pumping stations, sewage treatment plant, stormwater drainage, and treated sewage reuse facilities to cover a total of 894 ha urban area by the year 2005, with an estimated served population of 135,000. The total sewage flow, projected to reach approximately 20,000 m^3/day by 2005, will be transported eventually to the sewage treatment plant at Jarada for crop irrigation at the farm lands in Jarada.

The implementation of the programme will be divided into two successive construction stages, the first stage being from 1985 to 1992 and the Second stage from 1993 through 2005. Of the total sewerage implementation area of 894 ha, high priority districts of 402.59 ha or about 45 per cent of the sewerage districts is scheduled to be implemented under the first stage programme. Major features of the recommended project are summarized as follows:

Item	1st Stage		2nd Stage
	by 1992	by 2005	by 2005
1. Served Area (ha)			
El-Arish, Salem	402.59	402.59	894.
Masaid (NSG)	106.00	106.00	106.
Total	508.59	508.59	1,000.
2. Served Population			
El-Arish, Salem	50,500	91,000	135,000
Masaid (NSG)	20,000	20,000	20,000
Total	70,500	111,000	155,000
3. Sewage Flow (m^3/d)			
El-Arish, Salem	6,700	12,000	19,500
Masaid (NSG)	3,900	3,900	3,900
Total	10,600	15,900	23,400

The recommended project comprises the facilities as listed below.

Item	1st Stage		Final Stage	
	Size/capacity	No./length	Size/capacity	No./length
1. Gravity sewers	200 to 900 mm	80,230 m	200 to 900 mm	173,635 m
2. Pressure sewers	100 to 500 mm	24,510 m	100 to 500 mm	26,970 m
3. Pumping stations				
Main P.S.	3x6.8 m^3/m		27.1 m^3/min.	
El-Risa P.S.	3x6.8 m^3/m		27.1 m^3/min	
Manhole type P.S.	0.06 to 5.88 m^3/min	8 stations	0.06 to 5.88 m^3/min	22 stations
4. Sewage treatment plant	10,000 m^3/d	50 % of total system	20,000 m^3/d	100 % of system
5. Experimental farm facilities	8 feddan farm 4 feddan for facilities		8 feddan farm 4 feddan for facilities	

The project requires a total of L.E. 42,318,000 capital costs, of which L.E. 25,144,000 will be disbursed during the First Stage construction. The breakdown of the construction costs of both foreign exchange and local components by stages are as follows:

(L.E. 1,000)

	1st stage			2nd Stage			Total		
Item	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1) Sewers, manholes	2,764	9,100	11,364	1,336	10,400	11,736	3,600	19,500	23,100
2) Pumping stations	1,318	1,035	2,353	284	220	504	1,602	1,255	2,857
3) Treatment plant	2,356	3,641	6,002	598	916	1,500	2,945	4,557	7,052
4) Irrigation system	297	99	396	-	-	-	297	99	396
Sub-total	6,245	13,886	20,115	2,209	11,525	13,740	8,444	25,411	33,855
5) Engineering	402	604	1,006	275	412	687	677	1,016	1,693
6) Contingencies	1,241	2,776	4,023	448	2,305	2,747	1,689	5,081	6,770
Sub-total	1,649	3,380	5,029	717	2,717	3,434	2,366	6,097	8,463
Grand Total	7,884	17,260	25,144	2,926	14,248	17,174	10,810	31,508	42,318

The concluded indices of both financial and economic analyses of the proposed project area as follows:

Item	B/C	NPV (*)	FIRR	EIRR
Economic analysis	0.59	(-) 10,273	-	8.72
Financial analysis	0.63	(-) 8,200	9.47	-

Note: (*) L.E.1,000, discounted at 13 %

Concluded key indices of the sensitivity analysis are as follows:

Economic analysis

As for B/C

Cost	(-)10%	Benefit	(±) 0		0.65
"	0	"	(-)10%		0.53
"	(+)10%	"	0		0.53
"	0	"	(+)10%		0.64
"	(+)10%	"	(-)10%		0.48
"	(-)15%	"	0		0.68

As for EIRR

Cost	(-)10%	Benefit	(±) 0		9.52
"	0	"	(-)10%		7.95
"	(+)10%	"	0		8.02
"	0	"	(+)10%		9.45
"	(+)10%	"	(-)10%		7.25
"	(-)15%	"	0		9.52

Financial analysis

As for B/C

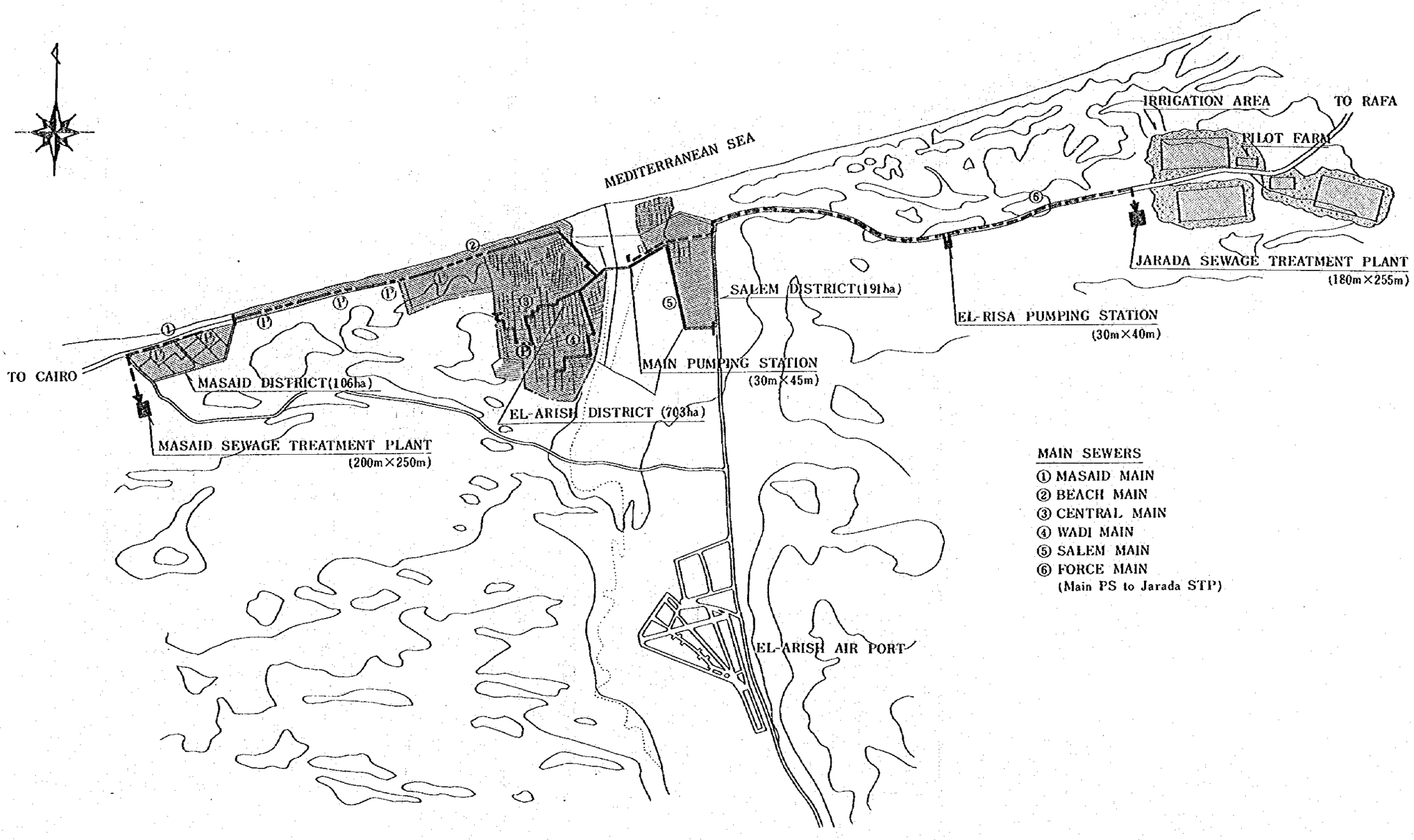
Cost	(+)10%	Benefit	(±) 0		0.57
"	0	"	(+)10%		0.69
"	(-)10%	"	0		0.70
"	0		(-)10		0.56
"	(+)10%	"	(-)10%		0.51
"	(-)15%	"	0		74

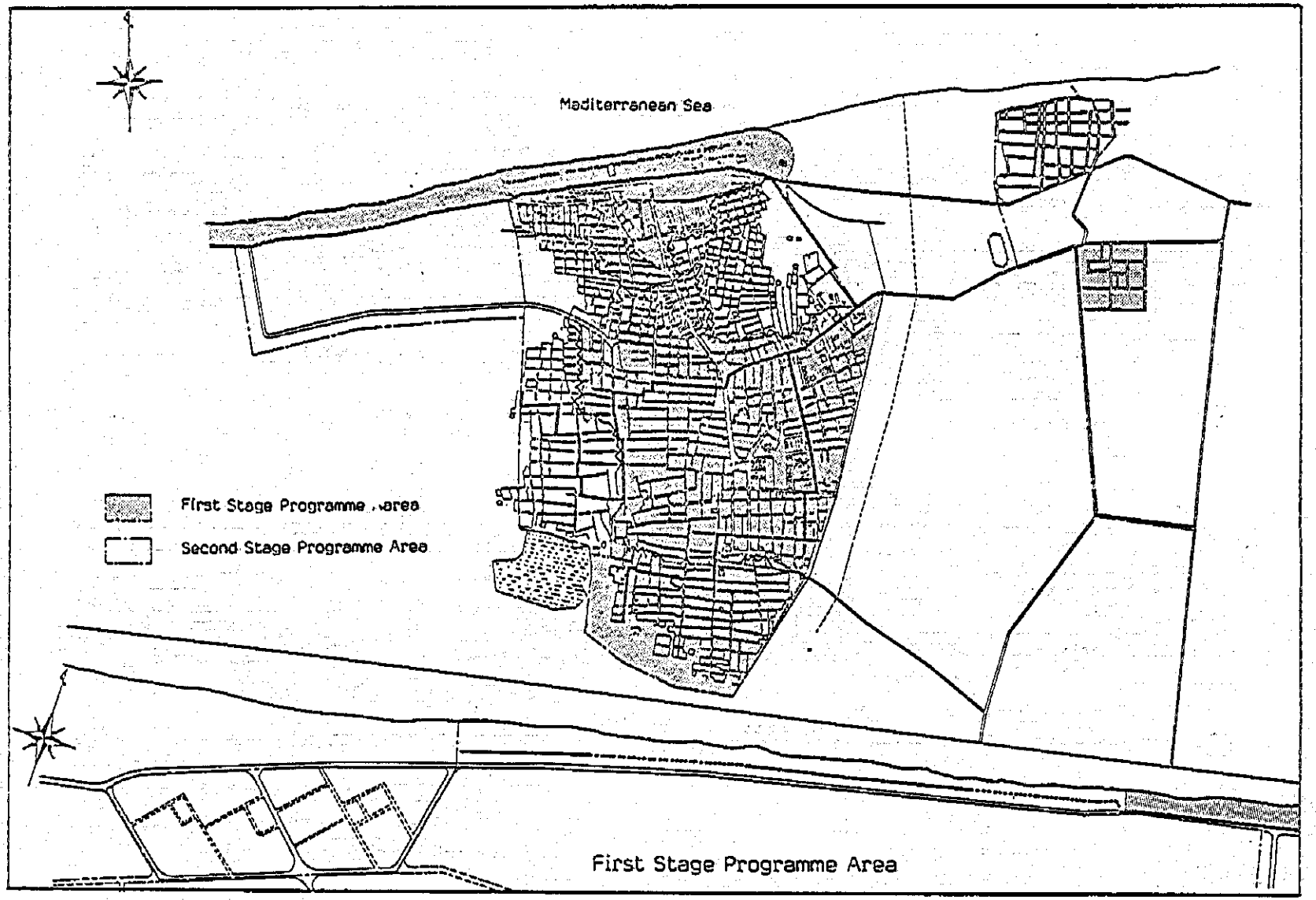
As for FIRR

Cost	(+)10%	Benefit	(±) 0		8.81
"	0	"	(+)10%		10.14
"	(-)10%	"	0		10.22
"	0		(-)10%		8.74
"	(+)10%	"	(-)10%		8.10
"	(-)15%	"	0		10.64

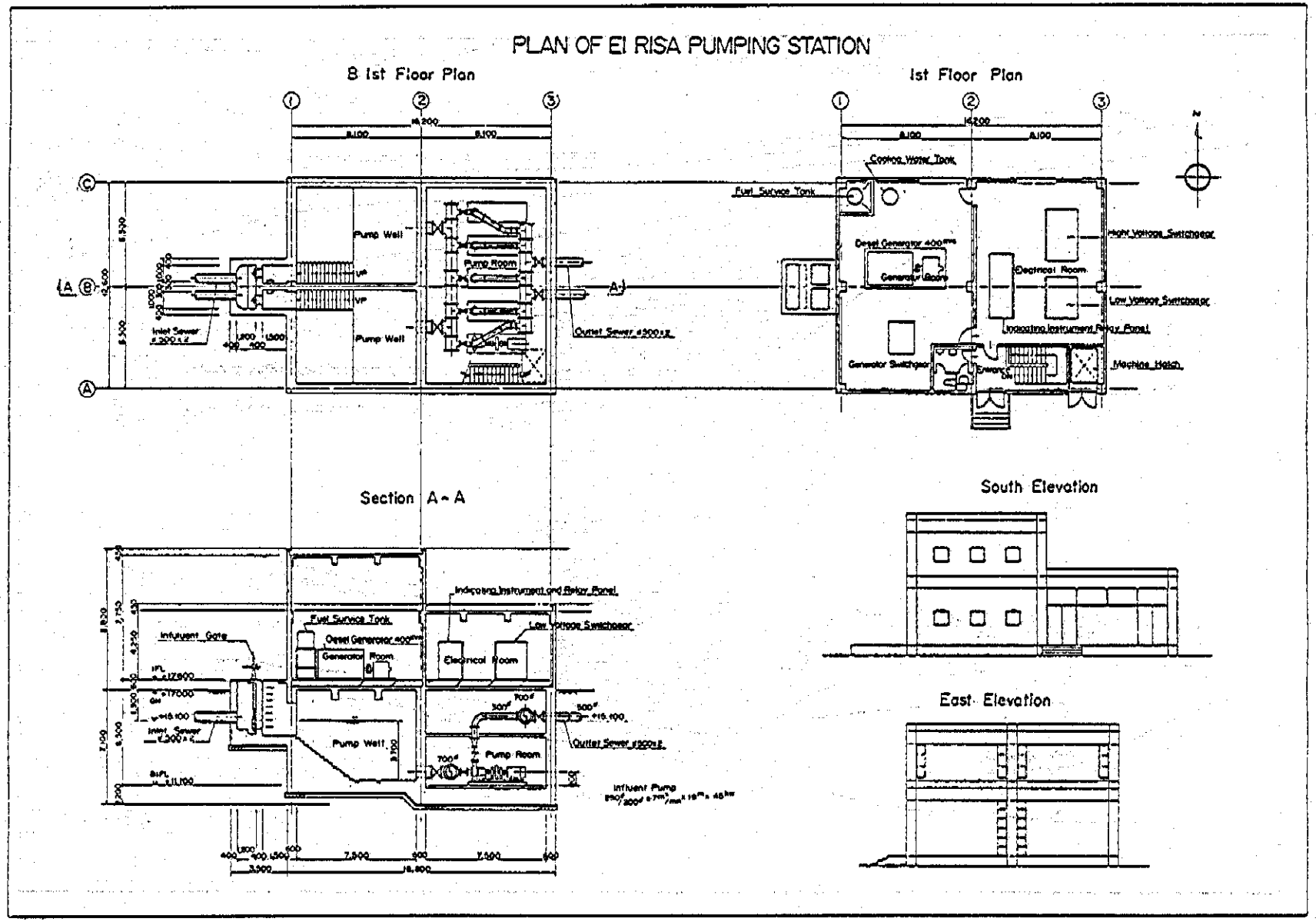
For the management of the new sewerage system, the expansion and modification of the existing Housing Department of North Sinai Governorate is considered to be the most appropriate at the present stage. The Department will be fully responsible for the planning, design, construction, operation and maintenance, and monitoring and surveillance of the system by expanding its organization with additional sufficient staff and provision with adequate financial support.

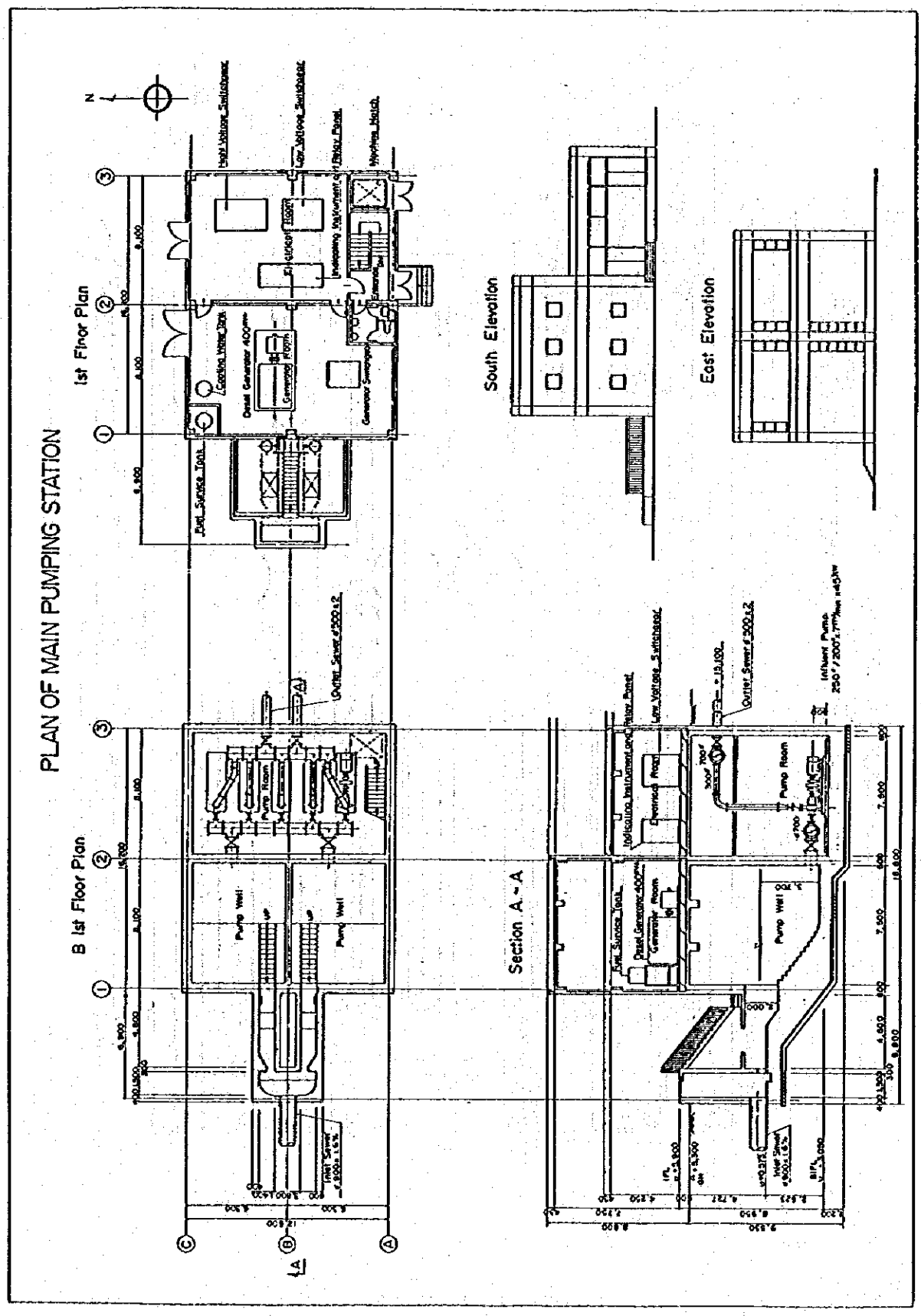
SYSTEM KEY PLAN

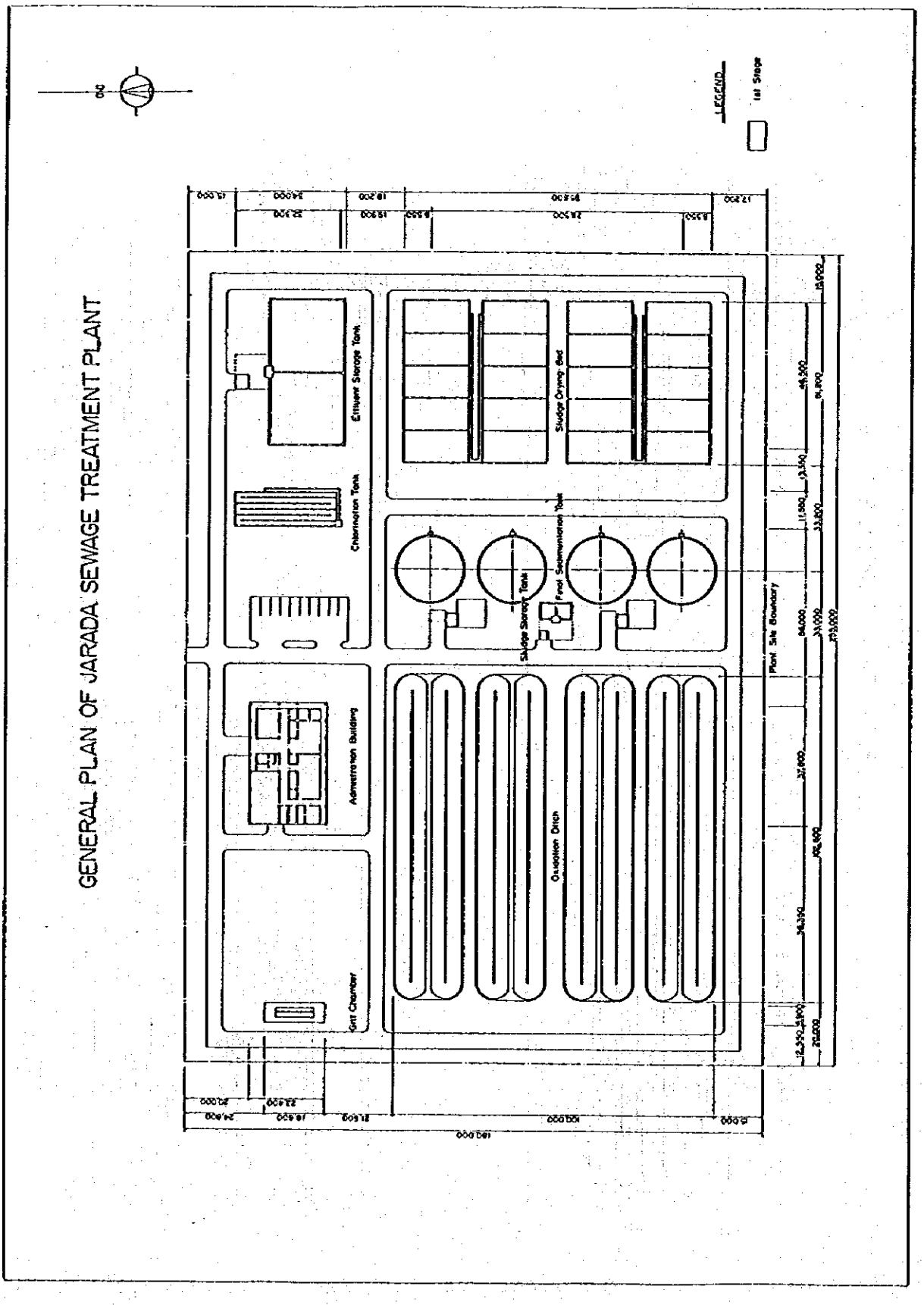


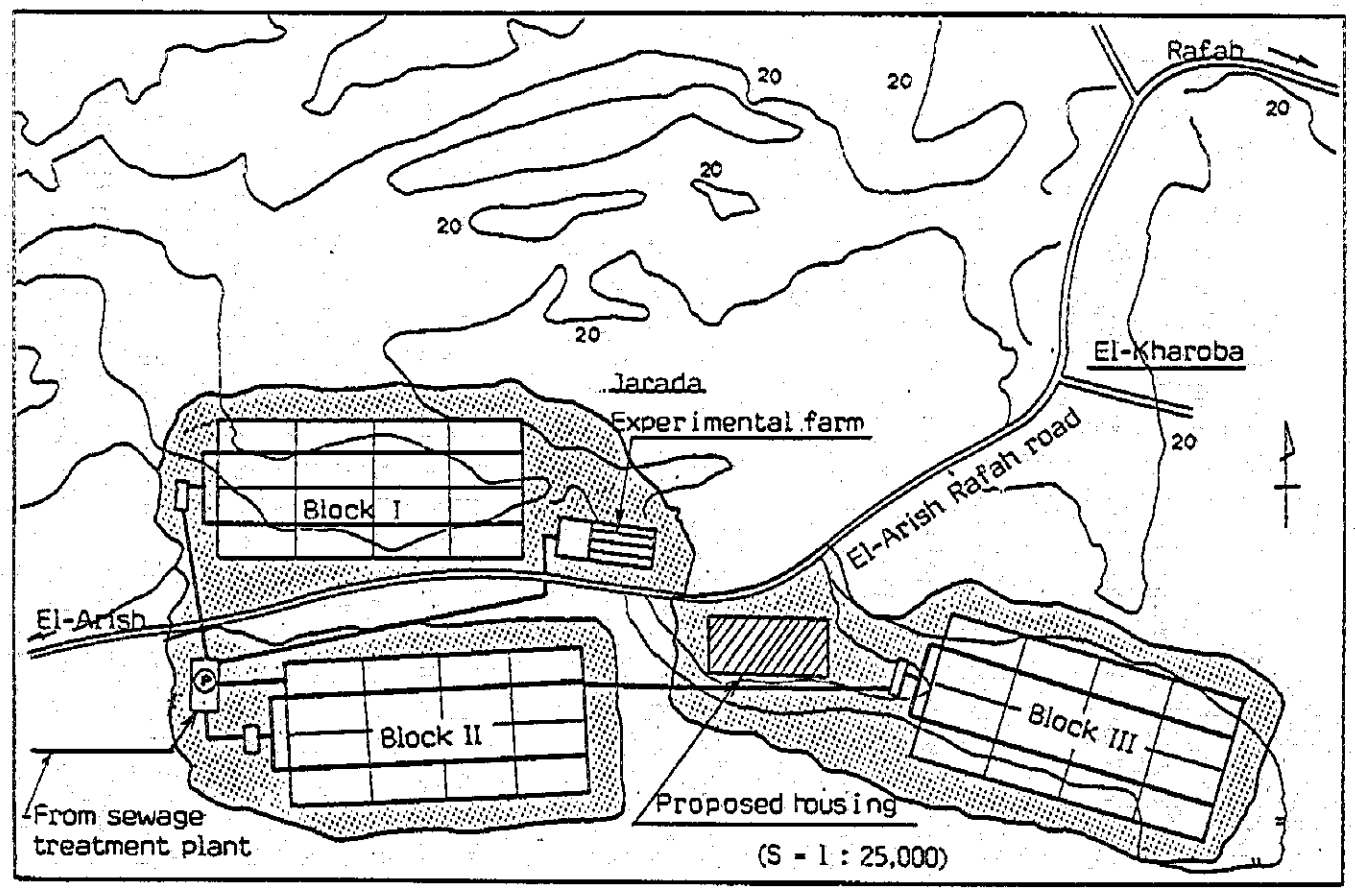

Mediterranean Sea
First Stage Programme Area
Second Stage Programme Area
First Stage Programme Area

PLAN OF El RISA PUMPING STATION




PLAN OF MAIN PUMPING STATION
1st Floor Plan
B 1st Floor Plan
South Elevation
East Elevation
Section A - A
Pump Room
Pump Well
Outlet Sewer
Inlet Sewer


GENERAL PLAN OF JARADA SEWAGE TREATMENT PLANT
LEGEND
1st Stage
Effluent Storage Tank
Chlorination Tank
Sludge Drying Bed
Final Sedimentation Tank
Sludge Storage Tank
Plant Site Boundary
Administration Building
Oxidation Ditch
Grit Chamber



Remarks: Proposed tree-planting area. In some parts of the area forage crops are cultivated for livestock rearing utilizing surplus of the treatment plant effluent, especially during the winter season

Location of Water Management Blocks, Experimental Farm, Housing Site and Others in the Proposed Jarada Area

I. INTRODUCTION

1.1. Project Background

El-Arish City, the capital of the North Sinai Province, lies at 33° 50' east longitude and 31° 10' north latitude, facing the Mediterranean Sea as shown in Figures 1 and 2. The present population of the City and its environs is estimated at approximately 70,000 which reside in about 800 ha area covering Salem and Masaid districts.

During the 12-year occupation of this region, no study and construction of the sewerage system has been made and thereby the deterioration of sanitary conditions in the area has now become a deplorable level, particularly the groundwater contamination by the uncontrolled wastewater discharge through the existing transh system.

In order to meet the basic demands of public sanitation in the area and to set up a good link between projects for drinking water and sanitary sewerage, the North Sinai Governorate (NSG) has taken up the sewerage construction project for El-Arish as one of the top priority programmes.

The Government of Arab Republic of Egypt requested the Japanese Government in 1984 for assistance in establishing the sewerage and treated sewage reuse programme for El-Arish area as the first step towards the implementation of the project.

In response to the request of the Government of Arab Republic of Egypt, the Government of Japan decided to undertake a feasiblity study on El-Arish sewerage and drainage system (Study), within the general frame work of technical cooperation between Japan and Egypt which is set forth in the agreement on technical cooperation between the Government of Japan and Arab Republic of Egypt entered into force on 31st January 1984.

The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programmes

of the Government of Japan, has undertaken the Study in close cooperation with NSG and the authorities concerned of the Government of Arab Republic of Egypt.

The Study comprises detailed field investigations, surveys and technical analyses of alternative plans for various elements, and presents legal, managerial, economic and financial matters as proposed for the implementation of the first stage programme for the sewerage, drainage and treated sewage reuse systems.

1.2. Purpose and Scope of the Study

The objectives of the Study are:

(a) To examine and assess the technical and economic feasibility of the sewerage and drainage system (the target year of 2005) in the city of El-Arish.

(b) To prepare the basic considerations on the potentiality of the eventual treated sewage reuse project.

The scope of the Study are:

(a) To carry out the feasibility study for the area of approximately 1,000 ha, covering El-Arish City and its environs.

(b) To undertake the field work in Egypt and analytical and design work in Japan, comprising:

- Data collection and review.
- Field survey for topography and water quality.
- Preparation of alternative plans.
- Identification of the appropriate plan in the form of items. including facilities planning, implementation planning, and organization operation, and management planning.
- Basic consideration on the potentiality of the eventual treated sewage

reuse project.

- Evaluation of the proposed system.

1.3. Undertaking of the Study

The Government of Japan has taken through JICA necessary measures to despatch the study team to Egypt and to perform the feasibility study and technology transfer to the Egyptian counterpart personnel in the course of the Study.

The Government of Arab Republic of Egypt has accorded privilages, immunities and other benefits to the study team, and through the authorities concerned, taken necessary steps to facilitate smooth conduct of the Study.

The study team commenced the Study on 9th July 1984, and the field work lasted until 4th November 1984. The work in Japan completed in mid-February 1985. The results of investigations and studies have been compiled and presented in the form of draft final report. The report was confirmed by all the agencies concerned in February 1985. Upon receipt of the agencies' advice and comments on the report and necessary additions and revisions thereon were made, the report was finalized in March 1985 as presented herein.

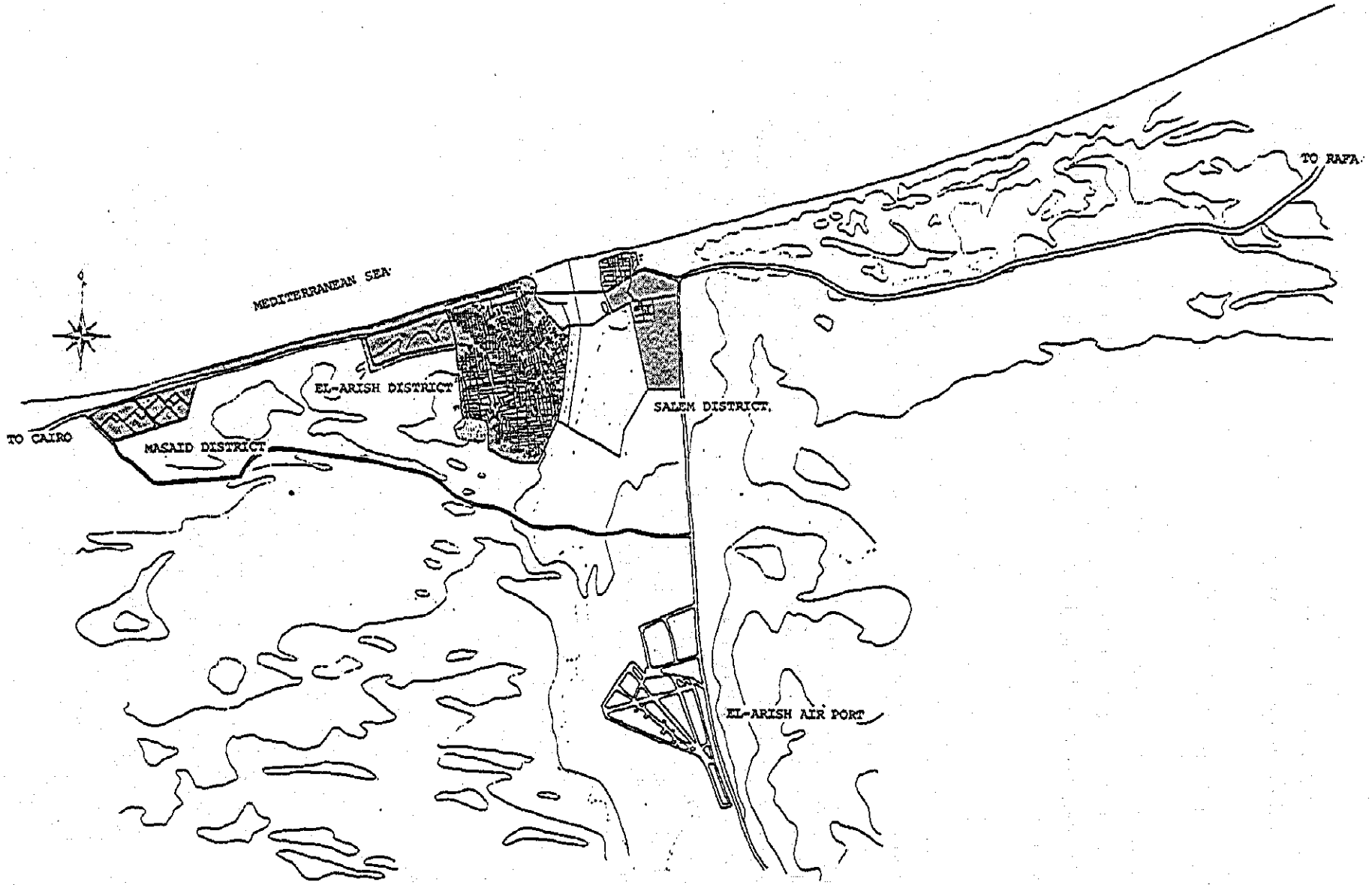


Figure 2 Study Area and Its Environs

II. PHYSICAL, SOCIAL AND ECONOMIC ASPECTS OF THE STUDY AREA

2.1. Socioeconomic and Social Aspects

(a) The economic activities in North Sinai consist mainly of tourism, agriculture, light industries, public administration and trading. The total investment of the North Sinai Governorate's (NSG) level is due to reach L.E. 1,560 million during the Five Year Plan from 1982/83 - 1986/87, over double of that for the past five years. Sinai is set the particular tasks, namely, establishment of agricultural settlements through land reclamation and better use of groundwater, establishment of industrial activities based on the available natural resources and modernization of fishing activities and better exploitation of touristic potentialities.

Expenditures conducted by NSG should be amounted to L.E. 54 million up to 1986/87. In 1982/83, some L.E. 9 million should be disbursed and over L.E. 13 million might be spent in 1986/87. As for sectional allocation of expenditure, utilities are standing out. Transportation is following it, but industry and services run rather behind them. The biggest portion in the sectoral total is shared to road pavement, with a little difference for potable water supply.

El-Arish is not only the capital and headquarter for NSG but also the provincial centre of living, commercial and trade, and industrial activities in the area. Affluent groundwater as the conventional assets accompanying white-and-beach on the Mediterranean coast with green date-palm groves invite people from inland and upland together with tourists, domestic and foreign. Establishment of tourists centre in El-Arish is strongly recommended by the Sinai Development Study and Integral Rural Development Project for Sinai Northern Uplands is just completed its study in July, 1984.

However, because of wars and Israeli occupation for long years, development of this central city in the area is just launched. The place inhibited

some 70,000 is in the very beginning stage of activity and is now starting to progress.

(b) The North Sinai coast subregion of Sinai, with 117,000 people or 15 per cent of the Sinai total, has by far the highest population density of Sinai's five subregions. Eighty per cent of this subregion's population are concentrated in the northern corner from El-Arish through Rafah.

The 1984 population in El-Arish is estimated to be 57,000, of which 51,000 reside in the study area. In addition, a total of 13,000 tourists, workers and transients stay in El-Arish over short period, particularly during summar seasons. These temporary populations are considered to stay within the sewerage planning area, thus making the total present population for the sewerage planning to be about 64,000.

(c) A land use plan for El-Arish City and its environs has been under consideration by the NSG; however, the plan is still tentative and subject to the final approval by the Government. Land use plan projections have been made for six categories of land use, including commercial, commercial-residential, residential, institutional, tourist and green areas.

(d) There are many licensed establishments both of secondary and tertiary activities, but most of the businesses are small in scale and in general use small amount of water. There are approximately 8,500 registered automobiles in the City. The car repair factories and transportation services are the major industries in the City. Other industries are hardware stores, concrete factories, clothing manufacturers, embroidery and handicraft shops, wood and furniture factories and restraurants, but all of these are small in scale.

(e) The most common crop in the area is barley which is grown in scattered small areas under intermittent cultivation. Besides the barley, watermelon and caster beans are widely grown, but the profitability of these crops is not so high compared with other vegetables and fruits.

2.2. Physical Characteristics of the Area

(a) The El-Arish region is an area of low relief terrain. The land forms predominantly sand dunes, sand sheets, and coastal depressions, in different structures. Soils consist principally of unconsolidated deposits formed from alluvial, aeolian, or lacstrine deposits and developed primarily under arid conditions.

The groundwater elevations are in general low except those in Masaid and other low-lying districts.

(b) El-Arish is situated on the alluvial delta of the Wadi El-Arish, facing to the Mediterranean Sea in the north. Ground elevations range from 2 to over 30 metres above the mean sea water level, with the highest point of the area near the grave yard.

(c) Rainfalls of the area have mostly concentrated in winter from November through March, accounting for almost 85 per cent of the annual precipitation. These rainfalls occurred in 18 days and the number of days having the rainstorms of more than 10 mm per day was 3.5. The maximum ever recorded rainfall was 59 mm per day in May followed by the second heaviest rainfall of 52 mm per day in October.

Rainfall data by self-registering record papers are available from Meteorological Authority in Cairo for the last ten years, from 1960 through 1966, 1980, 1981 and 1983.

(d) Relative humidity in the area ranged between the lowest monthly mean of 14 per cent in April and the monthly highest mean of 100 per cent in January, March, April and December. The monthly average temperatures recorded in the last ten years ranged from the lowest 19.3 °C in January to 31 °C in August , having the minimum temperature of 8.5 °C in January.

2.3. Public Facilities

(a) El-Arish's water supply source fully depends on the groundwater extracted through the existing 22 deep wells located mostly in the southern part of the city. The wells have been in operation to produce the water of 19,000 m^3/day at the maximum. A plan is now underway to add 4 more wells in Masaid housing development area in the immediate future to supply the water to the residenmts in the new apartment housing area.

The water is in general transmitted directly to the main water pipelines ranging between 6 and 12 " in diameters. When the water consumption is low and surplus water is available, such water is lifted to two reservoirs for the peak demands.

According to the NSG's information, a total of about 9,000 private houses and institutions were connected to the water supply system in 1982. Most of the houses are provided with a water meters, but many of which were out of use.

(b) Presently, no public sewerage system has been in operation in El-Arish and its suburban areas except those for Masaid housing area. All other wastewaters produced from residences, commercial and institutional areas are disposed of directly into ground through transh system.

The transh system is composed of flush toilet, bath, kitchen utensils, sewer pipelines and transh. The transh is a kind of soakaway pit, either circular or rectangular in shape somewhat similar to septic tanks, sited just below ground level, in which the excreta, mixed with the sullage water, is retained for a few days. Comparatively high permeabilityof soils enables the residences to use the transh system without noticeable troubles for years, except those in some low-lying areas. In general, transhes are cleaned once every few years depending on the conditions.

The discharge of most of the wastewaters without treatment is a major course of the groundwater pollution in the area. Results of the water quality survey on the existing city water supply wells indicate that water in some of the wells contains coliform bacteria and ammonia nitrogen, showing that the groundwater contamination by human wastes is now in progress. Such conditions will result in serious adverse environmental and public health problems. If no immediate action is taken to alleviate the wastewater burden on the groundwater, it is evident that the pollution will become more serious in the immediate future.

(c) Because of the relatively low precipitations coupled with the soil characters, stagnation of rainfall runoffs has not been serious problem, except at some places in low-lying area. In the low-lying areas, stromwater pipes have been provided by the City Council to discharge surface runoffs of rainstorms to the Wadi by gravity. Many of the existing drains are clogged by either sand, debris, or sludge, thereby pipe capacities are significantly reduced. At many a locations, household sanitary pipes are illigally connected to the stormwater drains. Presently, the collected stormwater is discharged to the Wadi through five outlets.

(d) Roads in El-Arish City are classified into two categories depending on the purpose for the use and scale, namely,outside roads, and inside roads. The outside roads have 7.5 metres wide pavement and 50 metres wide reserved land for the future expoansion, while those of the inside roads are 21 and 25 metres. The outside roads are under the control of the General Authority of Road and Bridge, whereas the mangement of the inside roads are the NSG Management Road and Transportation's responsibility.

(e) Canal Electricity Distribution Company (CEDCO) is responsible for development and operation of electric power generation, transmission and maintenance in Sinai. Currently, the maximum generating capacity of power plants in El-Arish is 7,000 kW according to the information by the electric company. A plan is underway to add 16,000 kW capacity within 1984, thus the total rated capacity of power stations by the end of 1984 would be 23,000 kW.

(f) Traditionally, the livestock sector is one of the major businesses in the area. Goats, camels and sheeps produce milk, meat, fibre, hide and many others. Beside these livestock, there are small number of donkeys, very few horses and less than 100 beef cattles. Animals are slaughtered in a slaughter house. The total numbers slaughtered animals from 1980 to 1983 ranges from 1,960 to 2,805.

Fishery in El-Arish is mostly of coastal fishing and small in scale. Most of the catches are consumed in El-Arish and its suburban area. Small amount of fish caught in El-Mazar is brought to El-Arish and marketed. No particular processing of fish is made but only salting of small quantity of fish.

(g) There are nearly 20 hotel facilities with capabilities of over 1,000 beds and additional 10 facilities with some 1,200 beds are under construction or are projected. Besides, youth-hostel and shallets as well as tents specially for young generation and family circles are rather innumerably set up.

In 1983, Tourism Department of NSG counted 71,161 as the total tourists who seemed to stay in the City.Among them, except the tourists for lodging facilities of sporting/recreation, the occupied numbers of hotel guests reached 62,705, of which 34,798 or 55.5 per cent were the guests in high-season as the latter half of the year with 50,685 tourist-nights. In the first half of 1984, although in off-season, the occupied number was 30,269 which were 8.3 per cent increase compared to the same period of 1983. Their tourist-nights in the period were 54,579 that were equivalent to 7.7 per cent increase compared with even the high-season's records in the latter half of 1983. An equivalent of some L.E. 2 million might be able to expect as a yearly gain to El-Arish.

(h) A general hospital of NSG has been in service in El-Arish as the centre of the medical and health services for people in the region. The hospital is provided with modern facilities and equipment for medical treatment, operation and examination, with a total of 140

beds as of August 1984. A central laboratory is attached to the hospital, however, without facilities to conduct water quality analysis. According to the information from the hospital, the number of each such diseases as cholera, typhoid fever and dysentery in the region were annualy only few cases and are ignoreble level so far as the sewerage planning is concerned.

2.4. Wellwater and Wastewater Characteristics

(a) For groundwater survey, totally 19 deep wells have been sampled and tested. In the water of the wells located adjacent to residences the total bacteria of 100 or more colonies/ml were traced. These wells were apparently contaminated by wastewaters discharged from the transh system of the nearby households. Chloride ion concentrations ranged between 500 mg/l and 1,200 mg/l.

(b) The wastewater survey conducted at an apartment housing complex in El-Salem district and a hotel sewage treatment plant indicated that the average domestic sewage BOD concentration was 130 mg/l, having SS concentrations of 20.5 to 271 mg/l. The hotel wastewater had twice as high BOD and COD values as the domestic sewage, but the total nitrogen level of 40 to 60 mg/l and total phosphate of 7 mg/l were almost same as those of the sewage from the housings.

(c) Fluctuation of sewage flows measured at houses in El-Salem, serving approximately 100 persons, indicated that three clear sewage flow peaks occurred during a day, two peaks during daylight hours at around 8:00 a.m. and 1:00 to 2:00 p.m., and the third peak occurred at 7:00 to 9:00 p.m. in night hours. The peak flow was about 2.3 times higher than the 18-hour average sewage flow.

(d) The septic tank effluent at El-Salem housing complex was relatively in stable condition, having COD_{cr} of 200 mg/l, total nitrogen of 50 to 60 mg/l, and total phosphate of 5 to 7 mg/l. As the anaerobic digestion undergoes in the spetic tank, the tank effluent often deteriorated due mainly to the flow-out of sloughed scum.

(e) The daily average per capita sewage flow rate in 1984 has been estimated to be 120 lpcd. The daily maximum and hourly maximum per capita sewage flow rates have been projected to be 160 lpcd and 10 lpch, respectively.

Based on the present population in the study area and the estimated sewage flow rates, current domestic sewage discharge in the study area of 1,000 ha has been estimated at approximately 14,400 m^3/day.

2.5. Need for a Project

At present, El-Arish and its suburban areas have no comprehensive modern sewerage system except for Masaid housing development area, and all the domestic and commercial wastewaters are being discharged directly into soil through the transh system without receiving any treatment.

Areas dependent on soakaway drainage for wastewater disposal are very likely to have problems in the future if water use is significantly increased, since the maximum amount of water that can be disposed of in this way is limited by the rate of seapage into the ground. The seapage rate from the transh into the underlying soil may become considerably less than the rate of water consumption of an urban household with an individual water connection.

The ever-increasing population and the improvement of the living conditions in the area have rapidly increased the water use, and now the groundwater contamination by the uncontrolled wastewater discharge has become a deplorable level, requiring immediate actions to prevent further degradation of the groundwater as well as the beach. Further groundwater contamination in the area will no doubt cause serious damage to the environment and to the development of the area, especially to tourism and development of the rich recreational use of the sand beach.

The observation of existing situation apparently indicates that a comprehensive sewerage system construction programme be immediately implemented. If no modern sewerage system is provided, the sanitary conditions will become progressively worse. Moreover, the sewage treatment plant effluent

will be fully utilized for agricultural and other purposes as a new water source. If the project is not implemented at this time, the cost escalation due to the inflation might hamper the project implementation at later stage.

III. FUNDAMENTAL PLANNING CONSIDERATIONS

In pursuance of the ultimate objective of improving environmental sanitary conditions throughout the Study Area, investigations have been made into the adequacy of the existing waste disposal, drainage and treated sewage reuse facilities, and methods whereby deficiencies can be eliminated.

On the basis of the results of investigations, design bases for the systems have been developed in relation to project implementation, population estimates, wastewater productions, stormwater flows, characteristics of groundwaters and wastewaters, design criteria, treatment process selection, treated sewage reuse for irrigation, and various engineering alternative plans.

The results of investigations and studies are summarized in the following:

3.1. Study Area

The Study Area has been thoroughly investigated and reviewed in the light of existing physical and development conditions, future development schemes, and the results of the topographic surveys conducted under the Study, to designate the area for sewerage planning. The Study Area thus identified encompasses approximately 1,000 ha urban districts, covering the existing Masaid sewerage district of 106 ha constructed by NSG for its housing complex, as shown in Figure 3 and tabulated below:

- Existing urban districts	El-Arish	432 ha
"	Abu-Saghal	43 "
- NSG's housing development areas	El-Masaid	106 "
"	El-Salem	114 "
- Housing development areas expected in immediate future	North of El-Salem	34 "
- Tourist development areas	Along beach	111 "
- Future development areas tributary to study area	Ayaiba Masaid	160 "
Total of the Study Area		1,000 "

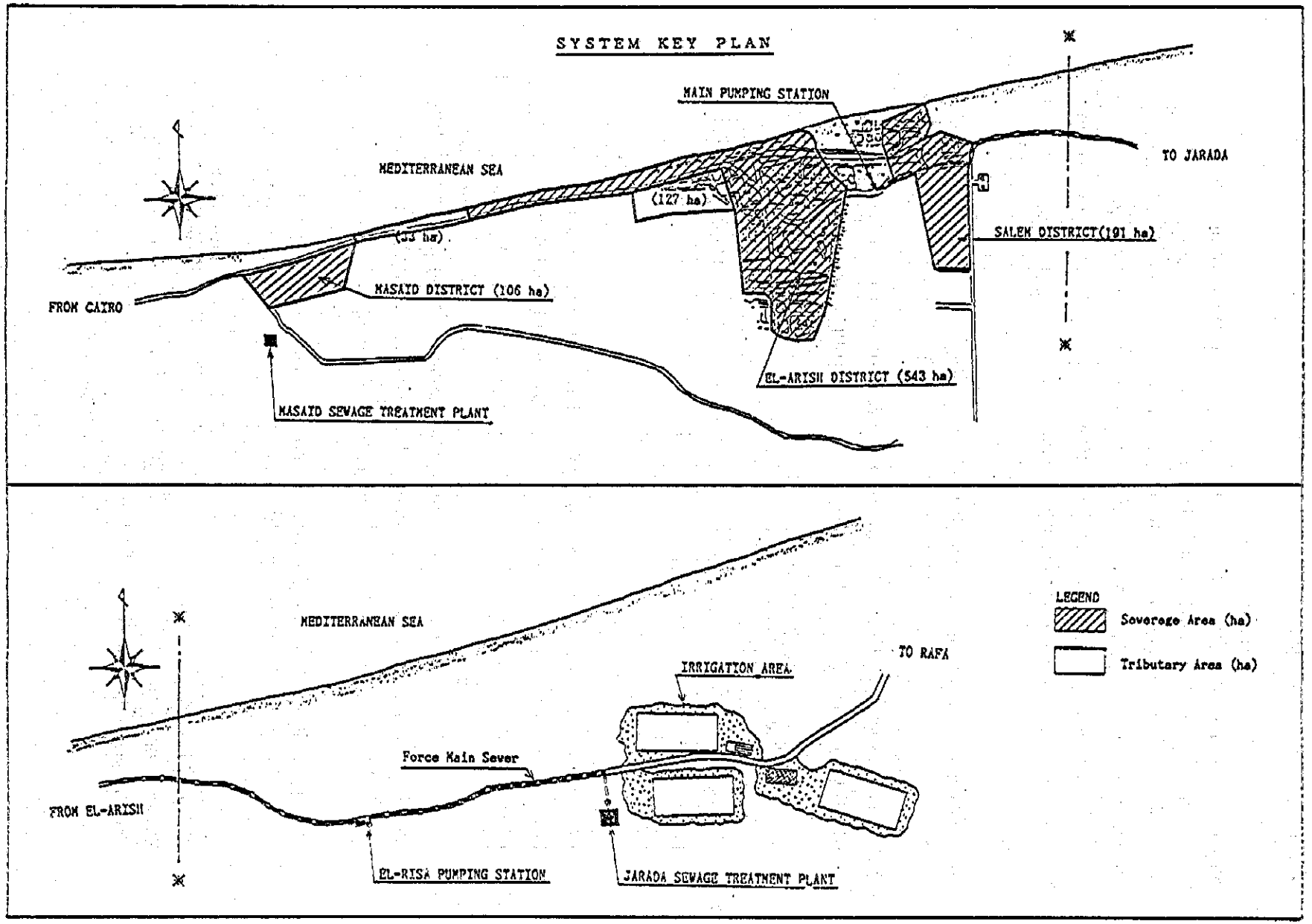


Figure 3 Sewerage Planning Area

3.2. Population Estimates

Population projections for the Study Area have been made taking into account the future population densities of the area and availability of water resources to supply a sufficient drinking water to the population. The population in the Study Area in 2005 thus estimated is 155,000, of which 150,000 persons are expected to reside within the sewerage planning area and the rest outside the planning area.

3.3. Wastewater Quantities and Qualities

(a) Per capita sewage flow rates in the year 2005 have been estimated based on the results of the field survey and studies, as shown in Table 1.

Table 1 Estimated Per Capita Sewage Flow Rates (lpcd)

Year	Daily Average	Daily Maximum	Hourly Maximum
1984	120 lpcd	160 lpcd	10 lpch
2005	150 "	200 "	12.5 "

In addition to the sewage, an average infiltration rate of 8 m3/ha/day is consiederd for the sewer planning and design in the Masaid sewerage district.

(b) Based on the estimated population in the Study Area and the estimated per capita sewage flow rates, over-all wastewater quantities have been calculated as shown in the following table.

Table 2 Estimated Wastewater Production in the Study Area by District

Item	El-Arish Dist.	Masaid District
Served area (ha)	894	106
Served population	130,000	20,000
Groundwater (m^3/day)	-	900

(To be continued)

Table 2 Estimated Wastewater Production in the Study Area by District

(Continued)

Item	El-Arish Dist.	Masaid Dist.
Daily average flow (m^3/day)	19,500	3,900
Daily maximum flow (m^3/day)	26,000	4,900
Hourly maximum flow (m^3/hr)	1,625	288

Note: El-Arish district includes the future tributary area of 127 ha

(e) On the basis of the wastewater field survey and comparison with those in other similar cities of both Egypt and other countries, the present average per capita BOD contribution is estimated to be 20 g. This will increase at a rate of 1 g annually reachning at 40 g by the year 2005. As the daily average per capita sewage flow is 150 lpcd, the BOD concentration of the sewage in 2005 is estimated to be 270 mg/l. In the same manner, concentrations of SS, COD, T-N and T-P have been projected at 270 mg/l, 220 mg/l, 80 mg/l and 10 mg/l, respectively.

3.4. Stormwater Quantities

All available rainfall data records for the past ten years have been collected from the National Meteorological Agency, and rainfall formulae for frequencies of 3, 5, 7 and 10 years developed for the planning purpose. Other necessary factors for the drainage system planning, such as runoff coefficients, inlet times, and rainfall frequencies to be adopted have also been elaborated.

3.5. Engineering Considerations for System Planning

(a) To select the most appropriate wastewater system for the area, all feasible alternative wastewater collection, treatment and disposal systems have been delineated and analysed from technical, environmental and economic viewpoints. The study has been carried out on three

alternative systems, namely 1) on-site sanitation, 2) smallbore sewerage, and 3) conventional sewerage. The on-site sanitation system is in principle same as the existing transh system but with additional septic tank and other auxiliary facilities to abate wastewater loading to the ground to some extent. Through this system, all the wastewater infiltrates into the ground and therefore cannot recover the wastewater as a new water resource. Furthermore, this will not contribute to the significant improvement of the groundwater contamination in the area. For these reasons, this alternative was screened out from further evaluation.

The smallbore sewerage system is less costly than the conventional sewerage system because of its reduced size of sewer pipes, however, such small size sewers (minimum diameter of 15 cm or smaller for branch and lateral pipes) can easily be clogged by sand intrusion due to the soil conditions prevailing in the area. As observed in the existing drainage pipelines, this will be the most serious problem and operation and maintenance costs for the system will be tremendous, thus this alternative plan was also excluded. In view of these conditions, the conventional sewerage system has been selected as the most appropriate wastewater system for El-Arish area.

(b) In selecting the most appropriate sewage treatment process, six possible alternative biological treatment processes have been evaluated, namely 1) conventional activated sludge, 2) extended aeration, 3) oxidation ditch, 4) modified aeration, 5) aerated lagoon, and 6) oxidation pond. The study revealed that the oxidation process was superior to other alternative methods in terms of cost effectiveness, simplicity of process, high nutrients removal, ease of operation and maintenance of the system, and reliability of operation. Characteristics of each alternative process are summarized in Table 3.

(c) An alternative study was made on three possible treatment plant construction sites located in between the urban area and Jarada area. Each of the alternative plans has been evaluated on availability of water sources, costs effectiveness, and other various intangible matters. The evaluation indicates that the sit close to the Jarada farm lands is the most suitable for the treatment plant construction.

Table 3 Characteristics of Treatment Processes

(Unit 10^3 L.E)

Item / Treatment Process	Characteristics	Operation & Maintenance (O/M)			Rate of BOD Removal	Evaporation rate to inflow	Land area (m^2)	Land cost	Construction Cost	O/M cost (year)	Capital cost (year)	Treatment cost (year)	Remark
		Easiness	Number of Checking Points	High Technology Requirement									
Conventional Activated Sludge Process	1) High treatment efficiency, 2) widely used process 3) Construction & O/M costs are comparably economical, 4) Plant occupied area is rather small 5) Not capable for variation of inflow sewage quality 6) Higher production of sludge 7) Complicated plant operation 8) Sludge driving bed system is not suitable (sludge digestion tank required) 9) Difficulty in aeration due to sand accumulation	Comparably Easy	Many	Required	> 90%	0.06%	31,600	31.6	7,799	79.2	594.9	674.1	Most popular treatment process, especially in large plants
Extended Aeration Process	1) Primary sedimentation is not required 2) Capable for variation of inflow for various ubfkiv sewage quality 3) Sludge generation is low 4) Advanced in N removal 5) Low treatment efficiency in SS 6) Odor production is high 7) Large plant area is required 8) Carry over of sludge is high 9) Difficulty in aeration due to sand accumulation	Easy	Less	Required	> 90%	0.13%	39,600	39.6	7,913	91.9	575.7	667.6	Process developed for less sludge generation, suitable to small plants
Oxidation Ditch Process	1) Primary sedimentation is not required 2) Capable for various inflow sewage quality 3) Sludge generation is low 4) O/M is rather simple 6) Comparably large plant area is required 7) Odor production is high 8) Carry over of sludge is high	Easy	Less	Less Required	> 90%	0.22%	46,400	46.4	7,502	129.2	532.0	661.2	Process developed for high treatment efficiency with low O/M costs and less mechanical facility, suitable for small plants
Modified Aeration Process	1) Suitable for low BOD load inflow sewage treatment 2) Most economical in construction & O/M costs 3) Changeable to conventional activated sludge process 4) Not capable for variation of inflow sewage quality 5) Low treatment efficiency 6) Sludge drying bed system is not suitable (Sludge digestion tank required	Comparably Easy	Many	Required	± 60%	0.05%	30,600	30.6	7,297	60.4	554.0	614.4	Process is not for high level treatment, different from others
Aerated Lagoon Process	1) Most simple in O/M (Mechanical portion is small) 2) No return sludge required 3) Effective in bacteria treatment 4) Large plant area is required (Next to oxidation pond process) 5) Algal growth problem in reuse 6) Problems in evapolation and sand accumulation 7) Large amount of safty fences required	Very Easy	Less	Not Required	> 90%	1.5%	86,800	86.8	8,154	49.6	616.7	666.3	Process is developed with oxidation pond with mechanical aeration facility
Oxidation Pond Process	1) Most simple in O/M (Mechanical portion is smallest) 2) Effective in bacteria treatment 3) Largest plant area is required 4) Algal growth problem in reuse 5) Problems in evapolation and sand accumulation 6) Large amount of safty fences required	Very Easy	None	Not Required	> 90%	11.3%	557,800	557.8	11,429	12.3	811.6	832.9	Most simple old process but required large land area, suitable for hot climate regeon plants

3.6. Reuse of Treatment Plant Effluent

(a) The treated sewage is a usable resource if appropriate precautions are taken. If properly managed, the nutrients and trace elements in the treatment plant effluent can be an asset to agriculture. The details of the effluent reuse for agriculture must be determined based on water, soil and environmental considerations. Judged from the present knowledge and experience, the effluent can be efficiently utilized for crop irrigation in areas where the water quality fits with the guidelines by the World Health Organization (WHO).

Although the treated sewage effluent is in general safe after the secondary treatment process, care must be taken to protect the health of farmers from the possible diseases. Also, the possibility of transmitting certain parasites or diseases through cattle that gaze on pastures irrigated with the treated sewage should be investigated. In view of these respects, it is mandatory to undertake investigations on such matters at an experimental basis at a selected experimental farm near the treatment plant.

(b) An investigation has been carried out on selecting a potential farm land for efficient reuse of the treatment plant effluent as the irrigation water. Four alternative sites have been selected and studied, including 1) Lower Wadi El-Arish, 2) West of lower Wadi El-Arish, 3) Middle Wadi El-Arish, and 4) El-Arish - Rafah strip area. The former three candidate areas are mostly desert lands, and a great amount of investment will be required to develop the crop irrigation farm lands, whereas Alternative 4 does not require such an investment because most of the lands are already cultivated. For these reasons, the farm lands of Alternative 4 near Jarada area is selected as the most suitable land for crop irrigation.

(c) For the efficient reuse of the treatment plant effluent for crop irrigation, a study has been made and the following crops have been selected as appropriate ones:

Winter crops; berseem, bareley, potatoes, and broad beans.
Summar crops; okra, water melon, and green paper.

Perennial crops; citrus, olive, and alfalfa.

Neceaasry irrigation water for the farm lands of 611-feddan in Jarada may be able to be supplied fully by the expected treatment plant effluent of 20,000 m^3/day or 0.231 m^3/sec by the year 2005. As most of the Jarada area comprises sand and sand dunes, a drip irrigation is recommended.

(d) It is a well known fact that nitrogen sensitivity crops are easily affected at a nitrogen concentration of 5 mg/l. When nitrogen concentration is higher than 30 mg/l (30 kg N per 1,000 m^3 of water), problems may be presumed for such crops, whereas for non-sensitive crops, nitrogen contents of 30 mg/l or higher may be adequate for high crop production.

When excessive quantities of nitrogen are contained in irrigation water, necessary countermeasures must be taken for the success of the crop cultivation. Details of the countermeasures should be determined on the basis of the results to be obtained from the experiment conducted at the Jarada experimental farms. Major countermeasures may include the followings:

i) Application of nitrogen non-sensitive crops rather than sensitive crops.

ii) Actual application rates of nitrogen for fertilization to crops should be determined in due consideration on the amount of nitrogen obtainable from the irrigation water.

iii) Study and investigation on blending and improving the irrigation water quality should be made to reduce nitrogen to the more acceptable levels where and when alternative water source or treatment process are available.

(e) It must be noted, however, that in conducting farming practices, algae and aquatic plants in streams, ponds, lakes, canals, pipelines and other facilities are often stimulated, and when temperature, sunlight and other nutrients are optimum conditions for the growth, these can grow rapidly and blooms can occur. The excessive growth may result in plugged pipelines, sprinklers, emitters of drip systems and valves to the point that either mechanical control such as with screens and filters, or chemical control such as with copper sulphate may become necessary to adopt.

(f) An experimental irrigation farm land of at least 8-feddan will be required for testing of various kinds of crops for certain period, and at the same time to investigate the effect of the treated sewage reuse to the farmers' health. For the purpose, an experimental water management system is planned, comprising necessary housings and facilities for crop irrigation. Also, a total of 4-feddan area will be needed for office, laboratory, staff quarters, garage, water storage tanks, etc. Thus, totally 12-feddan experimental farm area is necessary.

(g) For a reference purpose, the construction cost of the entire 611 feddan crop irrigation fam lands have been estimated at about L.E. 1.244 million. If the crop irrigation system is integrated in the project, EIRR and B/C ratio of the entire project will be 9.36 per cent and 0.59, respectively. These figures were calculated to give only an outline of the project and to show a magnitude of the project scale.

(h) The possible reuse of the treated sewage for other various purposes such as domestic and industrial uses has also been studied. The oxidation ditch process could produce a high quality effluent but not be sufficient enough for the purpose of direct domestic uses. Therefore, higher treatment processes will be required for such cases to treat the secondary treatment effluent further by means of biological and/or physical-chemical treatment processes, if such tertiary treatment becomes mandatory in the future.

3.7. Design Criteria

Criteria for sewerage and drainage systems planning and design have been established as summarized in the following:

(a) The Manning equation shall be used for the gravity sewer planning and design.

(b) No public sewer shall be less than 200 mm in diameter, but for house connections, pipes of 150 mm in diameter be used.

(c) Gravity sewers up to 600 mm in diameter should be normally of clay or PVC pipes with compression type joints. Gravity sewers of 700 mm in diameter or larger should be of reinforced concrete pipes, and pressure sewers be of ductile iron pipes.

(d) All gravity sewers shall be designed to give mean velocities of flow, when flowing full or half-full, of not less than 60 cm/sec, based on the Manning's formula using an 'n' value of 0.013.

(e) In general, sewer depth shall not be less than one metre unless special protection measures against the expected loads are considered.

(f) Manholes shall be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; and at distances of 30 to 200 metres according to the sizes of sewer, with a minimum diameter of 900 mm.

(g) For large pumping stations to lift the sewage from submain or main sewers should in general be of the dry well type, whereas small capacity intermediate pumping stations be of submersible type provided in manholes.

(h) The oxidation ditch process shall be applied to the sewerage system. The projected quality of the plant effluent is as follows:

(i) For the stormwater drainage planning in El-Arish drainage district, a stormwater transh system using a circular type transh should be used, while for Masaid drainage district a stormwater infiltration basin system with 40 cm deep should be adopted.

IV. RECOMMENDATIONS

4.1. Proposed Development Plan

The feasibility study for sewerage and drainage system proposes a two-stage construction period of 20 years starting in 1985 and ending 2005, including various wastewater, stormwater and effluent reuse management facilities that would be established throughout the study area.

(a) The sewerage system should be in principle a separate system which receives only domestic wastewater and unavoidable infiltration. For the sewerage planning area, a group of the more probable alternative sewerage system was designed and analysed with resepct to technical and economic aspects, including effects of the sewerage system on the groundwater contamination and efficient reuse of the treated sewage for crop irrigation or other purposes.

The recommended sewerage system of physical facilities, developed after considering numerous alternatives. encompasses; 1) a system of trunk mains, submains, branch and lateral sewers, .2) pumping stations and force mains, 3) oxidation ditch sewage treatment plant, and 4) facilities for experimental treated sewage effluent reuse system at Jarada.

The total sewage flow will be transported eventually to the sewage treatment plant at Jarada area, and after being treated by the secondary process it will be used for crop irrigation. The features from a highly efficient system, in that the facilities for discharge of the treated effluent will minimize the effects on environmental values, while at the same time they can solve the deterioration of groundwater in the area.

The sewerage programme covers the entire study area of 1,000 ha, within which approximately 155,000 people will reside. The proposed sewerage system for the entire study area is shown in Figure 4 and these facilities are tabulated in Table 4.

Table 4. Summary of the Proposed Sewerage Facilities

Component	Size or Capacity	No. or Length
1. Sewers and manholes		
Gravity sewers	200 to 900 mm dia.	173,635 m
Pressure sewers	100 to 500 mm dia.	26,970 m
Total		200,605 m
2. Pumping stations		
Main pumping station	6.8 m^3/min.	1
El-Risa pumping station	6.8 m^3/min.	1
Manhole type pumping stations	0.064 to 5.88 m^3/min	22
3. Jarada sewage treatment plant	20,000 m^3/day	1
4. Experiemental irrigation farm facilities at Jarada	12 feddans	1

Note: Facilities in Masaid District are not included.

(b) For storm drainage system in El-Arish district, the stormwater transh system is proposed. The system consists of catch basins and a stormwater transh installed in general at every road crossing or at every 0.25 ha drainage tributary.

For Masaid drainage district, shallow infiltration basins are proposed. The system consists of stormwater inlet manhole, connecting pipeline, and infiltration basin of 40 cm deep.

(c) The sewage treatment plant effluent will be conveyed to water storage tanks for three management blocks and an experiemental farm through the main pipeline and then pumped up to deliver it to hydrants in each field through the secondary pipelines. The proposed irrigation area is composed of the following lands:

Farm land	576 feddan
Experimental farm	12 "
Reserved area	23 "
Total	611 feddan

The irrigation method proposed for the project is a drip system which has been widely applied to the crop irrigation in the region and is the most suitable system for the soils and crops in the area. The system should have the capacity sufficient to supply the maximum water requirement of 7.0 mm/day which is the net consumptive use in June.

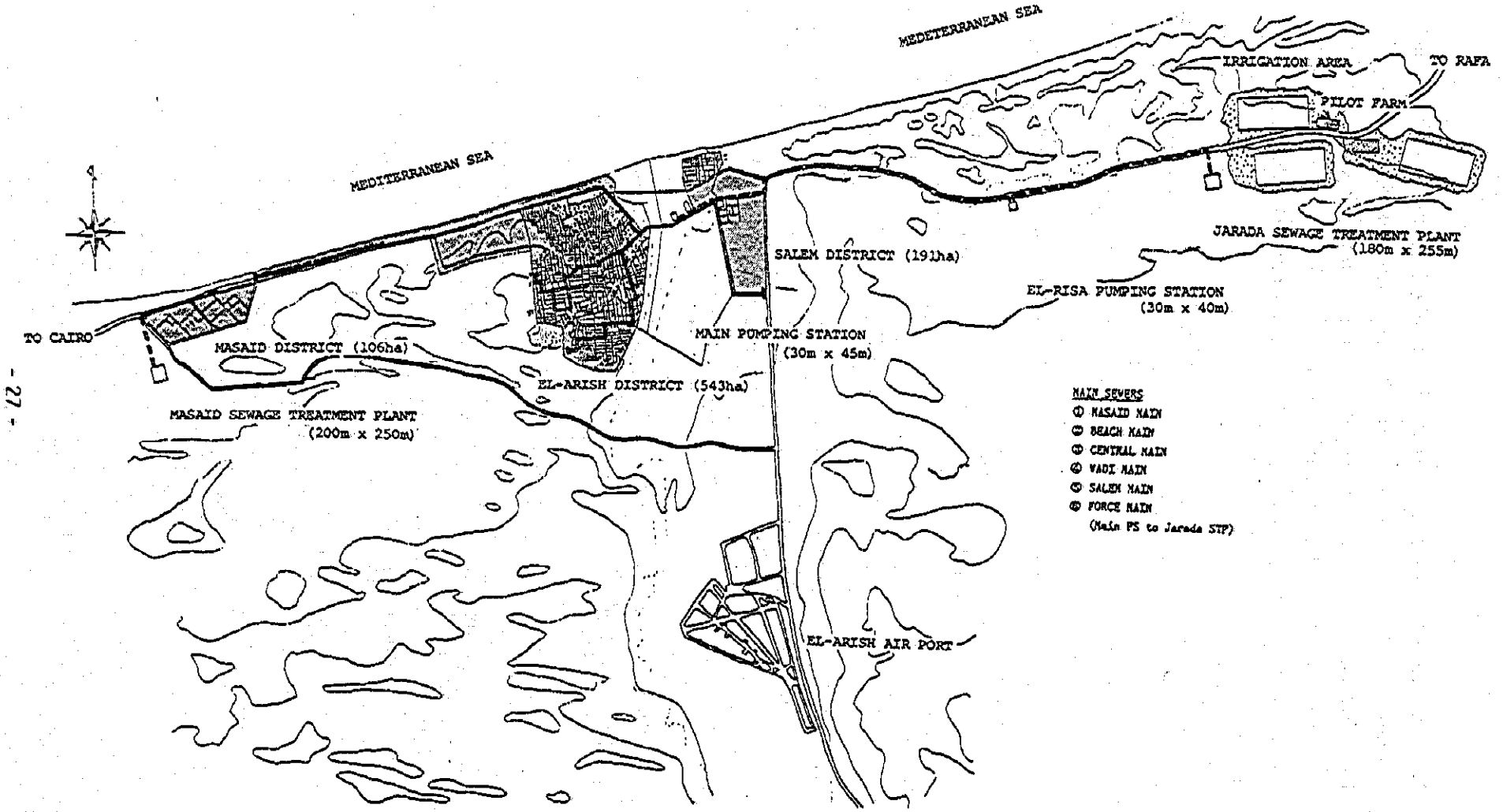


Figure 4 Sewerage System Layout Plan

4.2. Priority of Sewerage Construction

(a) The total programme comprises a series of two successive construction stages, namely 1) First Stage from 1985 to 1992 , and 2) Second Stage from 1993to 2005. The programme encompasses only the sewerage and experimental farm facilities construction but excludes the stormwater drainage system which may be implemented under a different programme.

(b) In order to determine the priority and a reasonable magnitude of the investment for sewerage implementation during the First Stage Programme, each of the 11 sewerage districts and subdistricts have been evaluated. These have been assessed with regard to such major elements of importance as:

- Population density of the districts.
- Daytime population movements in the districts.
- Cost effectiveness of the system and promptitude for connecting branch and lateral sewers to main sewers and pumping stations.
- Extent of groundwater contamination.
- Urgency for sanitation improvement requirements for tourists.
- Topographic conditons of the districts.
- Housing and institutional development grogrammes.

Based on the above evaluation results, all the districts have been given the order of the priority for implementation, as summarized in Table 5 and as shown in Figure 5.

The results are considered a good indication of the over-all need of the various districts and therefore used for determining of the sewerage construction staging.

(c) To determine the magnitude of the investment, all the possible combinations of the districts for the First Stage construction programme, raning from the scale of the sewerage area of a quarter of the entire sewerage planning districts to the whole sewerage planning area. Each of the combinations

has then been evaluated in its scale of investment and other economic and financial aspects and finally five best alternative combinations have been selected for further analysis. The selected five alternative combinations are as follows:

- Schemes 1, covering areas of 36.4 per cent of the entire sewerage planning area, with a total tributary of 325.78 ha (Sewerage districts (1), (2) and (4) as shown in Figure 5).

- Scheme 2, covering 45 per cent of the entire sewerage planning area, with a total tributary of 402.59 ha (Sewerage districts (1), (2), (3) and (4), as shown in Figure 5).

- Scheme 3, covering the entire sewerage planning area of 894 ha, excluding Masaid district.

- Scheme 4, covering 23.4 per cent of the entire sewerage planning area, with a total tributary of209.19 ha (Sewerage districts (1) and (2), as shown in Figure 5).

- Scheme 5, covering 32 per cent of the entire sewerage planning area, with a total tributary of 286 ha (Sewerage districts (1), (2) and (3), as shown in Figure 5).

Table 5 Priority of Sewerage Implementation by District

Order of priority	District	Population density	Daytime population	Cost effectiveness	Groundwater contamination	Tourist population	Road network	Overall evaluation
1	El-Arish (1)	B	A	B	C	D	B	A
"	Salem (1)	A	B	A	C	D	A	A
2	El-Arish (2)	B	B	B	C	D	B	B
"	Abu Saghal (2)	B	D	B	C	D	C	B
3	El-Arish (3)	B	D	C	A	D	C	B
4	El-Arish (4)	B	B	C	C	A	C	B
5	El-Arish (5)	B	D	C	C	D	D	D
"	Masaid	C	B	D	C	A	B	C
"	Salem (5)	A	C	B	C	D	D	D
6	Ayaiba	B	D	D	C	B	D	D
"	Salem (6)	A	D	D	C	D	D	D

Note: A = highest priority. B, C, and D = in the decreasing order for priority.

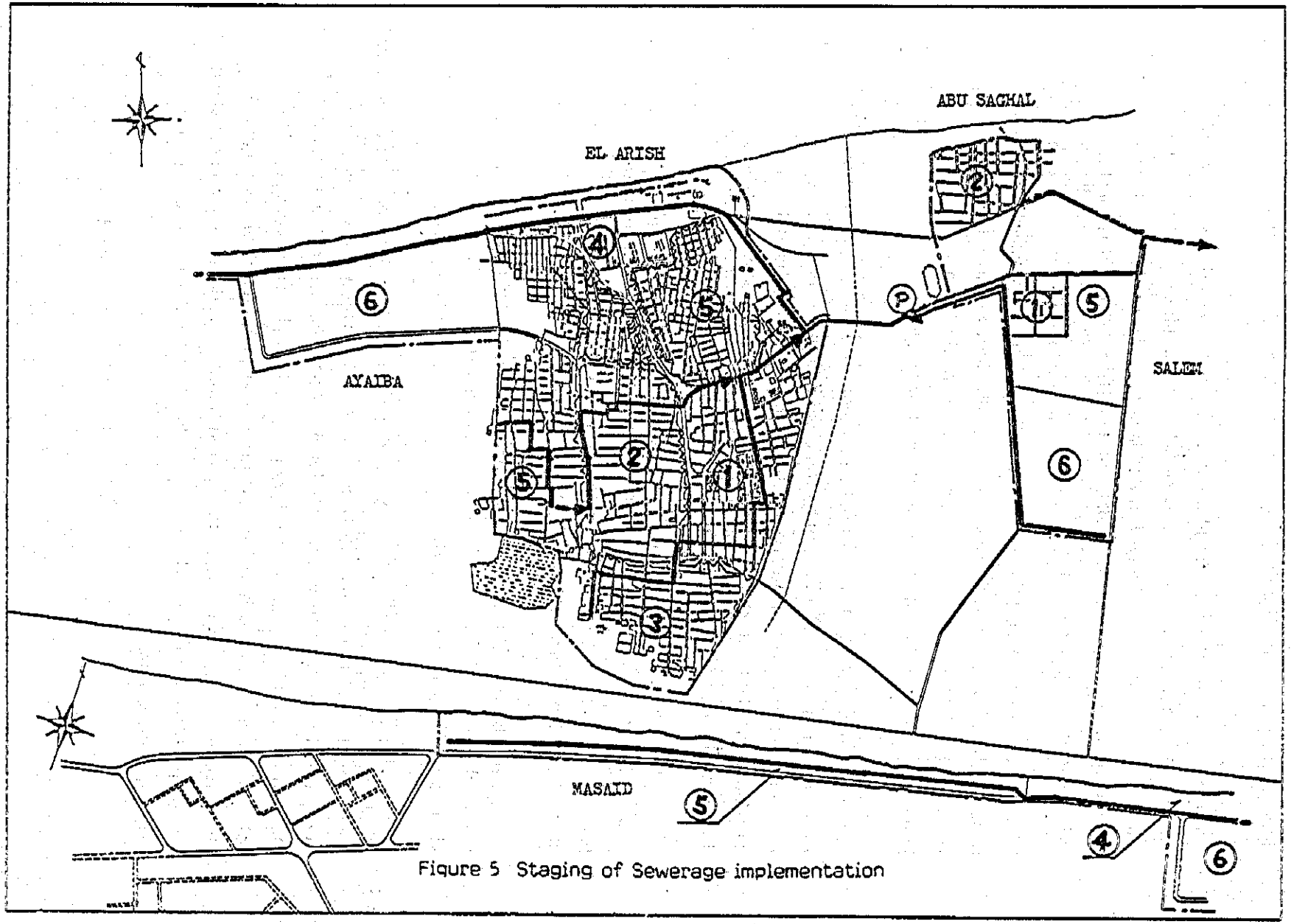


Figure 5 Staging of Sewerage implementation

4.3. Financial Analysis of the Project

(a) The five alternative sewerage plans have been compared in their faesibility with regarding economic and financial viewpoints. For the analyses, construction, and operation and maintenance costs of the plans have been estimated, together with the benefits expected from the provision of the sewerage programme.

Of the five alternative plans, Scheme 4 projection was seemingly the best on the whole, but the worst at the precedent stage although the burden of the construction cost was the easiest, to which the heaviest burden should be undertaken at the sequent stage.

Schemes 5 and 1 showed the computed indices in a close match each other on the whole. The computed indices of Scheme 5 at the precedence was, however, relatively inferior to that of Scheme 1. The burden allocated for the sequence of Scheme 5 was also relatively heavier than of Scheme 1, too.

Scheme 1 as the continuous tailing after the first stage projection might be still not cancelled yet, since the area was overlooked to grow so fast and actively. The computed indices of Scheme 1 also showed a quite appropriate level among the projection.

In view of the above evaluation results, three schemes have finally been selected, i.e., Schemes 1,2 and 3 for further precise examination as the candidature for the optimum scheme for the project.

(b) The project benefit, in response to the project cost as investment, comprises three major categories, namely. 1) benefit to be derived from saving the cost, which should be otherwise obviously and/or continuously spent if the project might not be realized, 2) benefit brought from reducing the loss, which should be otherwise definitely and/or unavoidably damaged if the project might not be made up, and 3) benefit produced from generating the gain which should be otherwise absolutely nonentity if the project might not come out.

More specifically, the benefits will include:

- Saving cost benefits derived from elimination of the transh system after the new sewerage system is provided and households are connected to the public sewers.

- Reduction for possible stagnation of tourism development, which might be caused by not only environmental deterioration in natural features of the region but also assumed loss derived from promoting hotel and/or recreation facilities.

- Reduction for expenditures of sewerage.

- Reduction for possible expenditure in pioneering groundwater resources together with additional and/or connected supplying equipment.

- Reduction for additional purchase of vacuum pumping lorry for cleaning the transh.

- Creation of land for arability in the present mere desert, plantation land for forage cropping and trees, and farming and consequently harvesting crops.

All of these expected benefits were evaluated and estimated in terms of L.E. for B/C analysis and other computations.

(c) The computation of the cost versus benefit is convergently processes, and following computations of B/C and NPV as well as FIRR at the domestic market price in 1984 have been obtained:

Alternatives	B/C	(*) NPV	FIRR
Scheme 1	0.63	(-) 7,819	9.50
Scheme 2	0.63	(-) 8,200	9.47
Scheme 3	0.57	(-) 11,248	8.93

(*) L.E. 1,000 Discounted at 13 %.

A computation was simultaneously processed as for the precedence (The First Stage) of the project, on the cases of Schemes 1 and 2, the results of which showed that B/C and FIRR for Scheme 1 were 0.23 and 0.59, and for Scheme 2 were 0.25 and 1.25.

Computation for the sensitivity analysis has been processed incorporating the oscillated conditions ranging from (±) 5 % to (±) 15 % cutting-input both of the cost and the benefit. The computation suggests, as shown in Table 6, that candidature for the optimum scheme would be converged into Scheme 1 or Scheme 2, in which the latter might outweigh. The key indices of the analysis, together with the concluded ones of the financial analysis, shows that they are seemingly nearly same but the former is distinctly inferior to the latter at the precedent stage of the project in particular.

(d) The preceding analyses revealed that the Scheme 2 was superior to other alternative plans and is selected as the optimum plan for the implementation of sewerage project. The Scheme 2 area is shown in Figure 6.

Table 6 Summary of Construction Cost

(LE 1,000)

	Sheme 1			Scheme 2			Scheme 3		
	D.	F.	T.	D.	F.	T.	D.	F.	T.
Sewer									
P.	7,568	2,242	9,810	9,100	22,64	11,364			
S.	11,932	1,358	13,290	10,400	1,336	11,736			
T.	19,500	3,600	23,100	19,500	3,600	23,100	19,500	6,600	23,100
Pumping									
P.	1,001	1,255	2,256	1,035	1,318	1,353			
S.	254	347	601	220	284	504			
T	1,255	1,602	2,857	1,255	1,602	2,857	1,255	1,602	2,857
Treatment									
P.	3,646	2,356	6,002	3,646	2,356	6,002			
S.	911	589	1,590	911	589	1,500			
T.	4,557	2,945	7,502	4,557	2,945	7,502	4,557	2,945	7,502
Farm. Plant									
P.	99	297	396	99	297	396			
S.	-	-	-	-	-	-			
T.	99	297	396	99	297	396	99	297	396
D/D									
P.	554	369	923	604	402	1,006			
S.	462	307	769	412	275	687			
T.	1,016	676	1,692	1,016	677	1,693	1,016	677	1,693
Supervision									
P.	2,463	1,228	3,691	2,776	1,247	4,023			
S.	2,617	461	3,078	2,307	449	2,747			
T.	5,080	1,689	6,769	5,083	1,787	6,770	5,081	1,689	6,770
Grand Total									
P.	15,331	7,747	23,078	17,260	7,884	25,144			
S.	16,176	3,062	19,238	14,250	2,924	17,174			
T.	31,507 (74.5%)	10,809 (25.5%)	42,316 (100.0%)	31,510 (74.5%)	10,808 (25.5%)	42,318 (100.0%)	31,508 (74.5%)	10.810 (25.5%)	42,318 (100.0%)

Remerks : D. ; domestic component F. ; foreign component
P. ; precedent stage S. ; sequent stage
T. ; total

Table 7 Maintenance and Operating Cost

	Scheme 1			Scheme 2			Scheme 3		
	D.	F.	T.	D.	F.	T.	D.	F.	T.
Sewer									
P.	10	24	34	10	24	34			
S.	120	288	408	125	300	425			
T.	130	312	442	135	324	459	130	312	442
Pumping									
P.	87	-	87	109	-	109			
S.	1,401	-	1,401	1,409	-	1,409			
T.	1,488	-	1,488	1,578	-	1,578	1,792	-	1,792
Treatment									
P.	63	6	69	79	8	87			
S.	1,016	98	1,114	1,063	104	1,167			
T.	1,079	104	1,183	1,142	112	1,254	1,297	126	1,423
Famr. Plant									
P.	75	464	539	75	464	539			
S.	308	1,376	1,684	308	12	1,684			
T.	383	1,840	2,223	383	1,840	2,223	383	1,840	2,223
Grand Total									
P.	235	494	729	272	496	769			
S.	2,845	1,762	4,607	2,965	1,780	4,745			
T.	3,080	2,256	5,336	3,238	2,276	5,514	3,602	2,278	5,880

Remarks : D. ; domestic component F. ; foreign component
P. ; precedent stage S. ; sequent stage
T. ; total

Table 8 Concluded Key Indices of the Sensitivity Analysis

As for B/C			Scheme 1	Scheme 2	Scheme 3
Cost(+)10%	Benefit(±)0		0.57 (0.21)	0.57 (0.23)	0.52
" 0	"	(+)10%	0.69(0.25)	0.69 (0.28)	0.63
" (-)10%	"	0	0.70 (0.25)	0.70 (0.28)	0.63
" 0	"	(-)10%	0.57 (0.21)	0.56 (0.23)	0.51
" (+)10%	"	(-)10%	0.51 (0.19)	0.51 (0.21)	0.47
" (-)15%	"	0	0.74(0.27)	0.74 (0.30)	0.67

As for FIRR					
Cost(+)10%	Benefit(±) 0		8.84 (-0.08)	8.81 (0.60)	8.31
" 0	"	(+)10%	10.18 (1.25)	10.14 (1.91)	9.57
" (-)10%	"	0	10.25 (1.32)	10.22 (1.98)	9.64
" 0	"	(-)10%	8.77 (-0.15)	8.74 (0.53)	8.25
" (+)10%	"	(-)10%	8.13 (-0.82)	8.10 (-0.13)	7.65
" (-)15%	"	0	10.67 (1.71)	10,64 (2.37)	10,03

REMARKS : Figures in ( ) are the indices at the precedent stage of the construction

Table 9 (A) Consolidated Statement of Projected Income and Cash-Flow up to 40th Year After Launching (In case of 30-year-amortization with 10-year grace period and 3.5 % p.a. interest as for foreign component)

(L.E. 1,000)

	Income			Outlay					Balance 1)		Accumulated 2)	
Year No.	Charge	Subsidty	Total	MD*	MA**	Interest***	Depreciation****	Total				
1	0	0	0	0	0	293	(0)	293 (293)	-293	(-293)	-2,931	(-293)
2	0	0	0	0	0	293	(27)	293 (320)	-293	(320)	-586	(-613)
3	0	0	0	0	0	293	(41)	293 (334)	-293	(334)	-879	(-947)
4	0	0	0	0	0	293	(101)	293 (394)	-293	(-394)	-1,172	(-1,341)
5	0	0	0	0	0	293	(162)	293 (455)	-293	(-455)	-1,465	(-1,796)
6	0	0	0	0	119	293	(233)	412 (645)	-293	(-645)	-1,758	(-2,411)
7	43	147	190	378	119	293	(256)	790 (1,064)	-600	(-856)	-2,358	(-3,297)
8	51	177	228	391	119	293	(279)	803 (1,082)	-575	(-854)	-2,933	(-4,151)
9	60	207	267	405	119	293	(304)	817 (1,121)	-550	(-854)	-3,483	(-5,005)
10	71	243	314	439	119	458	(323)	1,016 (1,339)	-702	(-1,025)	-4,185	(-6,030)
11	82	280	362	451	119	448	(342)	1,018 (1,360)	-656	(-998)	-4,841	(-7,028)
12	92	317	409	391	119	439	(369)	949 (1,318)	-540	(-090)	-5,381	(-7,937)
13	101	346	447	401	119	429	(396)	949 (1,345)	-502	(-898)	-5,843	(-8,835)
14	114	391	505	373	119	419	(415)	991 (1,326)	-406	(-821)	-6,289	(-9,656)
15	126	436	562	386	119	409	(420)	914 (1,334)	-352	(-772)	-6,641	(-10,428)
16	139	480	619	399	119	400	(425)	918 (1,343)	-299	(-724)	-6,940	(-11,152)
17	156	539	695	262	119	390	(429)	771 (1,200)	-76	(-505)	-7,016	(-11,657)
18	173	598	771	280	119	380	(431)	779 (1,210)	+ 8	(-439)	-7,008	(-12,096)
19	190	657	847	298	119	370	(433)	787 (1,220)	60	(-373)	-6,948	(-12,469)
20	214	738	952	319	119	361	(435)	799 (1,234)	153	(-282)	-6,795	(-12,751)
21	236	811	1,042	341	119	345	(437)	805 (1,242)	242	(-195)	-6,553	(-12,946)
22	236	811	1,047	341	119	330	(437)	790 (1,227)	357	(-180)	-6,296	(-13,126)
23	236	811	1,047	341	119	314	(437)	774 (1,211)	273	(-164)	-6,023	(-13,290)
24	236	811	1,047	231	129	300	(437)	760 (1,197)	287	(-150)	-5,736	(-13,440)
25	236	811	1,047	341	119	284	(437)	774 (1,181)	303	(-134)	-5,433	(-13,574)
26	236	811	1,047	341	119	269	(437)	729 (1,166)	318	(-119)	-5,115	(-13,693)
27	236	811	1,047	341	119	253	(437)	713 (1,150)	334	(-103)	-4,781	(-13,796)
28	236	811	1,047	341	119	239	(437)	669 (1,136)	348	(-89)	-4,433	(-13,885)
29	236	811	1,047	341	119	223	(437)	683 (1,120)	364	(-73)	-4,069	(-13,958)
30	236	811	1,047	341	119	208	(437)	668 (1,105)	379	(-58)	-3,690	(-14,016)
31	236	811	1,047	341	119	192	(437)	652 (1,089)	395	(-42)	-3,295	(-14,058)
32	236	811	1,047	341	119	177	(424)	637 (1,061)	410	(-14)	-2,885	(-14,072)
33	236	811	1,047	341	119	162	(410)	622 (1,032)	425	(+15)	-2,460	(-14,057)
34	236	811	1,047	341	119	147	(396)	607 (1,003)	440	(44)	-2,020	(-14,013)
35	236	811	1,047	341	119	131	(336)	591 (927)	456	(120)	-1,564	(-13,893)
36	236	811	1,047	341	119	116	(275)	576 (851)	471	(196)	-1,093	(-13,697)
37	236	811	1,047	341	119	101	(204)	561 (765)	486	(282)	-607	(-13,415)
38	236	811	1,047	341	119	86	(181)	546 (727)	501	(320)	-106	(-13,095)
39	236	811	1,047	341	119	70	(158)	530 (688)	517	(359)	+411	(-12,736)
40	236	811	1,047	341	119	56	(133)	516 (649)	531	(398)	942	(-12,338)
41	236	811	1,047	341	119	49	(114)	509 (623)	538	(424)	1,480	(-11,914)

* Maintenance & Operation

** Maintenance & Administration as for "Head Office"

*** Only as to foreign component

**** Only as to foreign component

1) the figures in ( ) are the one with depreciation for foreign component

2) the figures in ( ) the one with depreciation for foreign component

Table 9 (B) Consolidated Statement of Projected Income and Cash-Flow up to 40th Year After Launching (In case of 30-year-amortization with 10 Year grace period and 4.5 % p.a. interest as for foreign component)

(L.E. 1,000)

Year	Income			Outlay					Balance			
	Charge	Subsidy	Total	MO *1	MA *2	Interest *3	Depreciation *3	Total *4	Single year base *4		Accumulated *4	
1	0	0	0	0	0	377	(0)	377 (0)	- 377	(- 377)	- 377	(- 377)
2	0	0	0	0	0	377	(27)	377 (404)	- 377	(- 404)	- 754	(- 781)
3	0	0	0	0	0	377	(41)	377 (418)	- 377	(- 418)	- 1,131	(- 1,199)
4	0	0	0	0	0	377	(101)	377 (478)	- 377	(- 478)	- 1,508	(- 1,677)
5	0	0	0	0	0	377	(162)	377 (539)	- 377	(- 539)	- 1,885	(- 2,216)
6	0	0	0	0	119	377	(233)	496 (729)	- 496	(- 729)	- 2,381	(- 2,945)
7	43	147	190	378	119	377	(256)	874 (1,130)	- 684	(- 940)	- 3,065	(- 3,885)
8	51	177	228	391	119	377	(279)	887 (1,166)	- 659	(- 938)	- 3,724	(- 4,823)
9	60	207	267	405	119	377	(304)	901 (1,205)	- 634	(- 938)	- 4,358	(- 5,761)
10	71	243	314	439	119	589	(323)	1,147 (1,470)	- 833	(- 1,156)	- 5,191	(- 6,917)
11	82	280	362	451	119	577	(342)	1,147 (1,489)	- 785	(- 1,127)	- 5,976	(- 8,044)
12	92	317	409	391	119	564	(369)	1,074 (1,443)	- 638	(- 1,034)	- 6,614	(- 9,078)
13	101	346	447	401	119	551	(396)	1,071 (1,467)	- 624	(-1,020)	- 7,238	(- 10,098)
14	114	391	505	373	119	539	(415)	1,031 (1,446)	- 526	(- 941)	- 7,764	(- 11,039)
15	126	436	562	386	119	526	(420)	1,031 (1,451)	- 469	(- 889)	- 8,233	(- 11,928)
16	139	480	619	399	119	514	(425)	1,032 (1,457)	- 413	(- 838)	- 8,646	(- 12,766)
17	156	539	695	262	119	501	(429)	882 (1,311)	- 187	(- 616)	- 8,833	(- 13,382)
18	173	598	771	280	119	489	(431)	888 (1,319)	- 117	(- 548)	- 8,950	(- 13,930)
19	190	657	847	298	119	476	(433)	893 (1,326)	- 46	(- 479)	- 8,996	(- 14,409)
20	214	738	952	319	119	464	(435)	902 (1,337)	+ 50	(- 385)	- 8,946	(- 14,794)
21	236	811	1,047	341	119	444	(437)	904 (1,341)	143	(- 294)	- 8,803	(- 15,088)
22	236	811	1,047	341	119	424	(437)	884 (1,321)	163	(- 274)	- 8,640	(- 15,362)
23	236	811	1,047	341	119	404	(437)	864 (1,301)	183	(- 254)	- 8,457	(- 15,616)
24	236	811	1,047	341	119	384	(437)	844 (1,281)	203	(- 234)	- 8,254	(- 15,850)
25	236	811	1,047	341	119	365	(437	825 (1,262)	222	(- 215)	- 8,026	(- 16,065)
26	236	811	1,047	341	119	345	(437)	805 (1,242)	242	(- 195)	- 7,784	(- 16,260)
27	236	811	1,047	341	119	326	(437)	786 (1,223)	261	(- 176)	- 7,523	(- 16,436)
28	236	811	1,047	341	119	306	(437)	766 (1,203)	281	(- 156)	- 7,242	(- 16,592)
29	236	811	1,047	341	119	287	(437)	747 (1,184)	300	(- 137)	- 6,942	(- 16,729)
30	236	811	1,047	341	119	267	(437)	727 (1,164)	320	(- 117)	- 6,622	(- 16,846)
31	236	811	1,047	341	119	247	(437)	707 (1,144)	340	(- 97)	- 6,282	(- 16,943)
32	236	811	1,047	341	119	228	(424)	688 (1,112)	359	(- 65)	- 5,923	(- 17,008)
33	236	811	1,047	341	119	208	(410)	668 (1,078)	379	(- 31)	- 5,544	(- 17,039)
34	236	811	1,047	341	119	189	(396)	649 (1,045)	398	(+ 2)	- 5,146	(- 17,037)
35	236	811	1,047	341	119	169	(336)	629 (965)	418	(82)	- 4,728	(- 16,955)
36	236	811	1,047	341	119	150	(275)	610 (885)	437	(162)	- 4,291	(- 16,793)
37	236	811	1,047	341	119	130	(204)	590 (794)	457	(253)	- 3,834	(- 16,540)
38	236	811	1,047	341	119	111	(181)	571 (752)	476	(295)	- 3,358	(- 16,245)
39	236	811	1,047	341	119	89	(158)	549 (707)	498	(340)	- 2,860	(- 15,905)
40	236	811	1,047	341	119	71	(133)	531 (664)	516	(383)	- 2,344	(- 15,522)
41	236	811	1,047	341	119	63	(114)	523 (637)	524	(410)	- 1,820	(- 15,112)

*1 : Maintenance and operation
*2 : Management and administration as for "Head Office"
*3 : Only as to foreign component
*4 : The figures in () are the one with depreciation for foreign component.

Table 10 (A) Statement for Projected Balance Sheet (In case of 30-year-amortization with 10-year grace and 3.5 % p.a. interest as for foreign component)

(L.E. 1,000)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21th
Assets																					
Fixed assets:																					
Project in service		1,006	3,778	7,031	11,717	16,361	20,463	22,381	24,373	26,144	27,646	29,268	31,212	33,145	34,552	35,421	36,308	37,388	38,270	39,158	40,046
Depreciation (-)		34	94	112	160	160	142	69	69	61	52	56	67	67	49	31	31	37	31	31	31
Net fixed assets in service		972	3,684	6,919	11,557	16,201	20,321	22,321	24,304	16,083	27,594	29,212	31,145	33,078	34,503	35,390	36,277	37,351	38,239	39,127	40,015
Construction in progress	1,006	2,806	3,347	4,798	9,804	4,262	2,060	2,061	1,840	1,563	1,674	2,000	2,000	1,474	918	918	1,111	919	919	919	919
Total	1,006	3,770	7,031	11,717	20,463	23,381		24,373	26,144	27,646	29,268	31,212	33,145	34,552	35,421	36,300	37,388	38,270	39,158	40,046	40,934
Current assets:																					
Cash & account receivable							190	228	267	314	362	409	447	505	562	619	695	771	847	952	1,047
Total assets	1,006	3,778	7,031	11,717	16,361	20,463	22,571	24,601	26,411	27,960	29,630	31,621	33,592	35,057	35,983	36,927	38,083	39,041	40,005	40,998	41,981
Liabilities																					
Long term debt (foreign loan)	402	822	1,242	3,054	4,876	7,019	7,451	7,884	8,381	8,800	8,900	9,606	10,232	10,640	10,653	10,666	10,756	10,769	10,782	10,795	10,800
Current liabilities																					
Total liabilities	402	822	1,242	3,054	4,876	7,019	7,451	7,884	8,381	8,880	8,980	9,606	10,232	10,640	10,653	10,666	10,756	10,769	10,782	10,795	10,800
Equity																					
Central Government																					
Construction Subsidities:	604	2,990	5,917	8,903	11,885	14,004	15,632	17,260	18,603	19,067	21,241	22,615	23,909	25,055	25,960	26,865	27,806	28,792	29,698	30,604	31,510
1. Interest	293	586	879	1,172	1,465	1,750	2,051	2,344	2,811	3,278	3,726	4,164	4,592	5,010	5,419	5,018	6,207	6,586	6,950	7,298	7,630
2. MD cost							378	769	1,174	1,613	2,064	2,455	2,856	3,229	3,615	4,014	4,276	4,556	4,854	5,173	5,514
3. Operation expenses			119	238	357	476	595	714	833	952	1,077	1,190	1,309	1,428	1,547	1,666	1,785	1,904	2,023	2,142	2,216
Total	897	3,576	6,915	10,313	13,707	16,238	18,656	21,087	23,421	15,710	28,102	30,424	32,746	34,722	36,541	38,363	40,154	41,838	43,525	45,217	46,915
Retained earning	-293	-506	-879	-1,172	-1,465	-1,758	-2,051	-2,344	-2,811	-3,278	-3,726	-4,164	-4,592	-5,000	-5,419	-5,878	-6,207	-6,586	-6,950	-7,298	-7,630
1. Interest							-370	-769	-1,174	-1,613	-2,064	-2,455	-2,856	-3,299	-3,615	-4,014	-4,276	-4,556	-4,854	-5,173	-5,514
2. MD cost			-119	-238	-357	-476	-595	-714	-833	-952	-1,071	-1,190	-1,309	-1,428	-1,547	-1,666	-1,785	-1,904	-2,023	-2,142	-2,261
3. Operation expense		-34	-120	-240	-400	-500	-702	-771	-840	-901	-953	-1,009	-1,076	-1,142	-1,192	-1,223	-1,254	-1,291	-1,322	-1,353	-1,284
4. Revenue							190	228	267	314	362	409	447	505	562	619	695	771	847	952	1,047
Total	-293	-620	-1,126	-1,650	-2,222	-2,794	-3,356	-4,370	-5,391	-6,430	-7,452	-8,409	-9,386	-10,305	-11,211	-12,102	-12,827	-13,566	-14,302	-15,014	-15,742
Total equity	604	2,956	5,789	8,663	11,485	13,444	15,120	16,717	18,030	19,200	20,650	22,015	23,360	24,417	25,330	26,261	27,327	28,272	29,223	30,203	31,173
Total liabilities & Equity	1,006	3,778	7,031	11,717	16,361	20,463	22,571	24,601	26,411	27,960	29,630	31,621	33,592	35,057	35,983	36,927	38,083	39,041	40,005	40,998	41,981

Table 10 (B) Statement for Projected Balance Sheet (In case of 30-year-amortization with 10-year grace and 4.5 % p.a. interest as for foreign component)

(L.E. 1,000)

	1st Year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21th
Assets																					
Fixed assets :																					
Project in service		1,006	3,778	7,031	11,717	16,361	20,463	22,381	24,373	26,144	27,646	29,268	31,212	33,145	33,552	35,421	36,308	37,388	38,270	39,158	40,046
Depreciation (-)		34	94	112	160	160	142	69	69	61	52	56	67	67	49	31	31	37	31	31	31
Net fixed assets in service		972	3,684	6,919	11,557	16,201	20,321	22,312	24,304	26,083	27,594	29,212	31,145	33,078	34,503	35,390	36,277	37,351	38,239	39,127	40,015
Construction in service	1,006	2,806	3,347	4,798	9,804	4,262	2,060	2,061	1,840	1,563	1,674	2,000	2,000	1,474	918	918	1,111	919	919	919	919
Total	1,006	3,778	7,031	11,717	16,361	20,463	22,381	24,373	26,144	27,646	29,268	31,212	33,145	34,552	35,421	36,308	37,388	38,270	39,158	40,046	40,934
Current assets :																					
Cash & account receivable							190	228	267	314	362	409	447	505	562	619	695	771	847	952	1,047
Total assets	1,006	3,778	7,031	11,717	16,361	20,463	22,571	24,601	26,411	27,960	29,630	31,621	33,592	35,057	35,983	36,927	38,083	39,041	40,005	40,998	41,981
Liabilities																					
Long term debt (foreign loan)	402	822	1,242	3,054	4,876	7,019	7,699	8,380	9,127	9,689	10,253	11,068	11,884	12,443	12,606	12,770	12,893	12,940	12,987	13,035	13,084
Current liabilities																					
Total Liabilities	402	822	1,242	3,054	4,876	7,019	7,699	8,380	9,127	9,689	10,253	11,068	11,884	12,443	12,606	12,770	12,893	12,940	12,987	13,035	13,084
Equity																					
Central Government																					
Construction	604	2,990	5,917	8,983	11,885	14,004	15,632	17,260	18,603	19,867	21,241	22,615	23,989	25,055	25,960	26,865	27,886	28,792	29,698	30,604	31,510
Subsidies																					
1. Interest	377	754	1,131	1,508	1,885	2,262	2,639	3,016	3,605	4,194	4,770	5,334	5,885	6,424	6,950	7,463	7,964	8,452	8,921	9,370	9,799
2. MO cost							130	273	428	604	791	993	1,204	1,426	1,662	1,910	2,139	2,385	2,649	2,933	3,238
3. Operation expenses			119	238	357	476	595	714	833	952	1,071	1,190	1,309	1,428	1,547	1,666	1,785	1,904	2,023	2,142	2,216
Total	981	3,744	7,167	10,649	14,127	16,742	18,996	21,263	23,469	25,617	27,873	30,132	32,387	34,333	36,119	37,904	39,774	41,533	43,291	45,049	46,808
Retained earning																					
1. Interest	-377	-754	-1,131	-1,508	-1,885	-2,262	-2,639	-3,016	-3,605	-4,194	-4,770	-5,334	- 5,885	- 6,424	- 6,950	- 7,463	- 7,964	- 8,452	- 8,921	- 9,370	- 9,799
2. MO cost							- 378	- 769	-1,174	-1,613	-2,064	-2,455	- 2,855	- 3,229	- 3,615	- 4,014	- 4,276	- 4,556	- 4,854	- 5,173	- 5,514
3. Operation expenses			- 119	- 238	- 357	- 476	- 595	- 714	- 833	- 952	-1,071	-1,190	- 1,309	- 1,428	- 1,547	- 1,666	- 1,785	- 1,904	- 2,023	- 2,142	- 2,261
4. Depreciation		- 34	- 128	- 240	- 400	- 500	- 702	- 771	- 840	- 901	- 953	-1,009	- 1,076	- 1,143	- 1,192	- 1,223	- 1,254	- 1,291	- 1,322	- 1,353	- 1,384
5. Revenue							190	228	267	314	362	409	447	505	562	619	695	771	847	952	1,047
Total	-377	-788	-1,378	-1,986	-2,642	-3,238	-4,124	-5,042	-6,185	-7,346	-8,496	-9,579	-10,697	-11,719	-12,742	-13,747	-14,584	-15,432	-16,273	-17,086	-17,911
Total equity	604	2,956	5,789	8,663	11,485	13,444	14,872	16,221	17,284	18,271	19,377	20,553	21,708	22,614	23,377	24,157	25,190	26,101	27,018	27,963	28,897
Total liabilities & equity	1,006	3,778	7,031	11,717	16,361	20,463	22,571	24,601	26,411	27,960	29,630	31,621	33,592	35,057	35,983	36,927	38,083	39,041	40,005	40,998	41,981

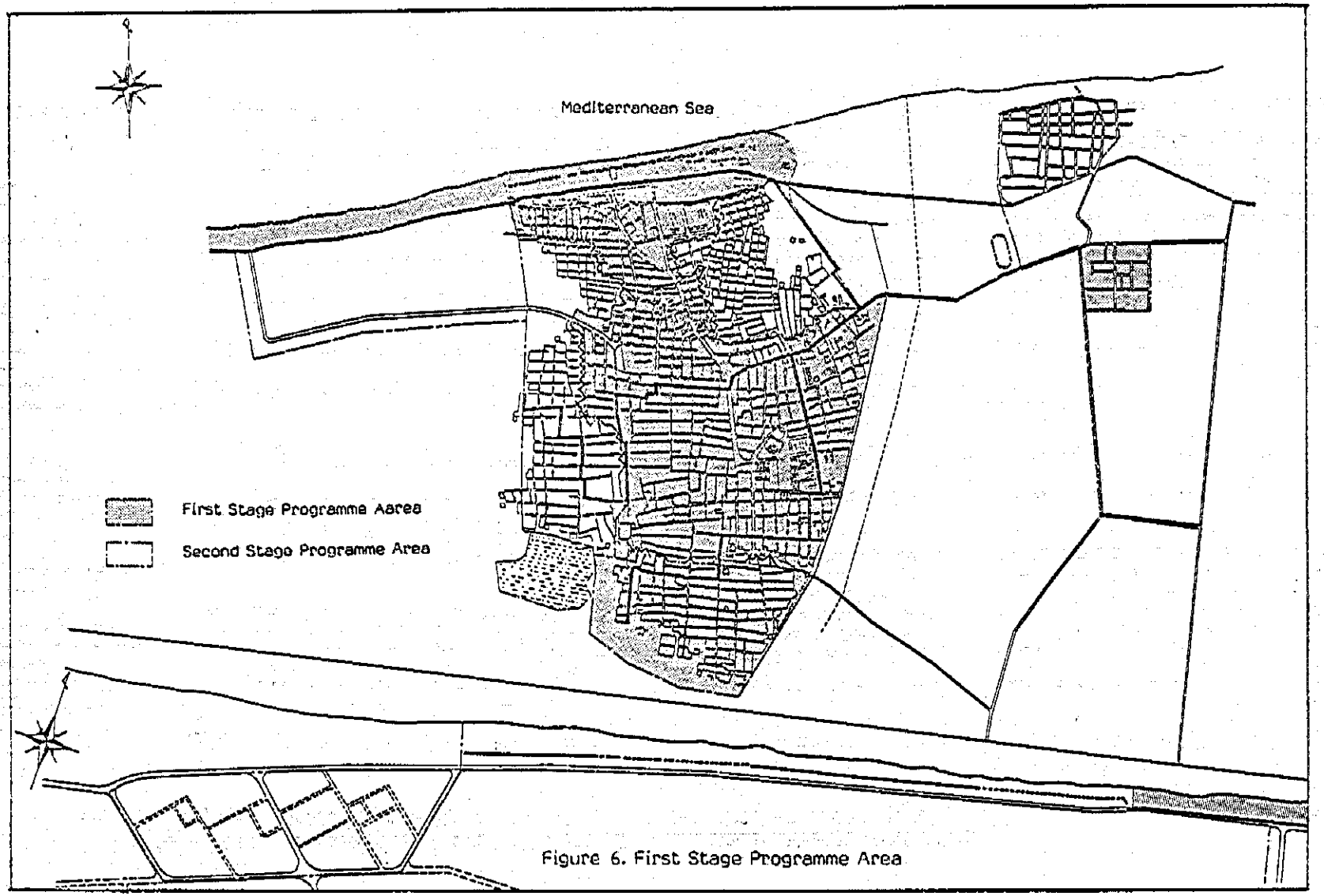


Figure 6. First Stage Programme Area

4.4. Economic Analysis of the Project

(a) The economic analysis has been made to appraise the contribution of the project in return for spending capital, material and manpower which are the resources of the states and the people. The analysis therefore has been processed at the base of national economy. The appraisal also comprises the analysis to diversify the domestic component by capital equipment, labour and others such as management and administration To meet such requirements, a conversion factor is prevailingly adapted. The conversion factors were quoted those circumspectly prepared and precisely computed by the World Bank in cooperation with the Institute for National Planning of ARE.

(b) The prerequisit conditions for OCC and the project-life as well as the targeted year necessary for working out of B/C, NPV and EIRR are same as in the case of the financial analysis. In addition, the consolidated computation of the project cost multiplying domestic and foreign components with thei individual interest, i.e. domestic 13 per cent and foreign 3.5 per cent, have been processed and confronted to the project benefit. The consolidated computation is conducted in the sensitivity analysis as for the optimum plan.

(c) Computation for the cost versus benefit at the base of economic account indicates the concluded indices of B/C and NPV as well as EIRR as the following table:

Table 11 Concluded Indices of the Economic Analysis

	B/C	NPV *	EIRR
Scheme 1	0.59 (0.19)	(-) 9,611 (- 14,702)	8.77 (- 0.52)
Scheme 2	0.59 (0.22)	(-) 10,273 (- 15,451)	8.72 (0.44)
Scheme 3	0/55	(-) 12,613	8.75

* LE 1,000

Remarks : discounted at 13%.
figures in ( ) are the assumed indices at the precedent stage of the project.

(d) Computation for the sensitivity analysis is presented in accordance with the methodological approach in the same manner as was the case of the financial analysis. The oscillated conditions are ranged from (±) 5 % to (±) 15 % by 5 % cutting-input for both of the cost and benefit, respectively. The concluded key-indices of the sensitivity analysis are as shown in Table 10. The computation brings forth the similar result as was in the case of the financial analysis, i.e., Scheme 2 should suggest to be finally selected of as the optimum plan.

Table 12 Concluded Key-Indices of the sensitivity Analysis

As for B/C			Scheme 1	Scheme 2	Scheme 3
Cost(-)10%	Benefit(±)	0	0.66	0.65	0.61
" 0	"	(-)10%	0.53	0.53	0.50
" (+)10%	"	0	0.54	0.53	0.50
" 0	"	(+)10%	0.53	0.64	0.61
" (+)10%	"	(-) 10%	0.48	0.48	0.45
" (-)15%	"	0	0.69	0.68	0.65

As for EIRR					
Cost(-)10%	Benefit(±)	0	9.58	9.52	9.45
" 0	"	(-)10%	7.98	7.95	8.08
"(+)10%	"	0	8.05	8.02	8.14
" 0	"	(+)10%	7.98	9.45	9.39
" (+)10%	"	(-)10%	7.23	7.25	7.48
" (-)15%	"	0	10.02	9.52	9.84

4.5. Staged Construction Programme

After the high priority districts were identified, a staged construction programme for the sewerage facilities has been developed, considering the size of the project and availability of materials and contractors. The First Stage Programme is scheduled to commence in 1985 and after detailed design for the facilities are completed, the construction works will start in 1986 and last until the end of 1992 over an eight-year period. The Second Stage Programme is scheduled to start from 1993 and continue up to the end of 2005.

(a) The First Stage Programme construction comprises 1) Gravity sewers, 2) Pressure sewers, 3) Pumping stations, 4) Sewage treatment plant at Jarada, and 5) Experimental irrigation farm lands, as shown in Figure 6 and Table 13.

Table 13 Summary of the First Stage Programme Facilities

Component	Size of Capacity	No. or Units
Gravity sewers	200 to 900 mm dia.	80,230 m
Pressure sewers	100 to 500 mm dia.	24,510 m
Pumping Stations		
Main P.S.	3 x 6.8 m^3/min.	1
El-Risa P.S.	3 x 6.8 m^3/min.	1
Small manhole type P.S.	0.06 to 5.88 m^3/min.	8
Sewage treatment plant	10,000 m^3/day	50 % of the final capacity
Experimental farm	12 feddan	

(b) The Second Stage Programme construction is scheduled to complete entire sewerage system to cover the sewerage planning area of 894 ha, excluding the Masaid district. The facilities to be constructed are as shown in Table 14.

Table 14 Summary of the Second Stage Programme Facilities

Component	Size or Capacity	No. or Unit
Gravity sewers	200 to 900 mm dia.	93,405 m
Pressure sewer	100 to 350 mm dia.	2,460 m
Pumping stations		
Main P.S.	Expansion of capacity to 27.1 m^3/min.	1
El-Risa P.S.	Expansion of capacity to 27.1 m^3/min.	1
Small manhole P.S.	0.06 to 5.88 m^3/min.	14
Sewage treatment plant	Expansion of 10,000 m^3/day facilities	
Experimental farm	-	-

(c) Construction schedule of the First Stage Programme is shown in Figure 7. As illustrated in the figure, the design work is scheduled to start in 1985 and when the succeeding tendering are let in 1985 and 1986, the construction works will start from 1986. Both trunk mains and branch and lateral sewers construction will be undertaken simultaneously but the trunk sewers construction is scheduled to complete by the end of 1990 so as to connect households to the public sewers at the soonest. The construction procedures for pumping stations and sewage treatment plant will be that the civil works are to be completed earlier than installation of equipment. The experimental irrigation farm land will start construction from 1988 and complete by the end of 1990, so that when the sewage treatment plant starts its operation and effluent is ready for the use, the experimental farm will be able to start its function from 1991.

When the major sewers, pumping stations and sewage treatment plant are completed at the end of 1990, the system as a whole may be able to start the operation, although branch and lateral sewers in remaining ditricts will be simultaneously continue the construction until the end of 1992.

All the sewage inflowing from the first stage programme areas, projected to reach approximately 6,700 m^3/day and 12,000 m^3/day by the years 1992 and 2005, respectively, is planned to be discharged to the farm lands at Jarada for crop irrigation; however, if the farm lands and irrigation facilities are not fully completed in time of the commencement of the sewerage system operation, the surplus effluent will be transported to the Water Management Block II (Refer to Plate in the Project Outline) for tree-planting and forage growing, thus enabling all the effluent to be safely and effectively utilized until such time when the entire farm lands are ready for receiving the whole effluent.

4.6. Construction Costs for the Proposed Programme

The recommended programme for implementing the sewerage and effluent reuse systems calls for design, construction, operation and maintenance of the facilities. The whole programme is divided into two consecutive construction stages,the first stage from 1985 to 1992 and the second stage from 1993 through 2005.

The construction cost for each size of the sewer pipes has been derived from the unit construction cost which corresponds to the design depth of sewer. The costs of pumping stations and sewage treatment plant have been estimated based on the unit costs for labours and materials available in El-Arish and equipment to be imported from foreign countries. In order to verify the estimated costs, quotations were obtained from government agencies, contractors and/or manufacturers having experience in the field both in Egypt and foreign countries. The capital costs required for the programme are summarized in Table 15.

Figure 7 Proposed Construction Schedule

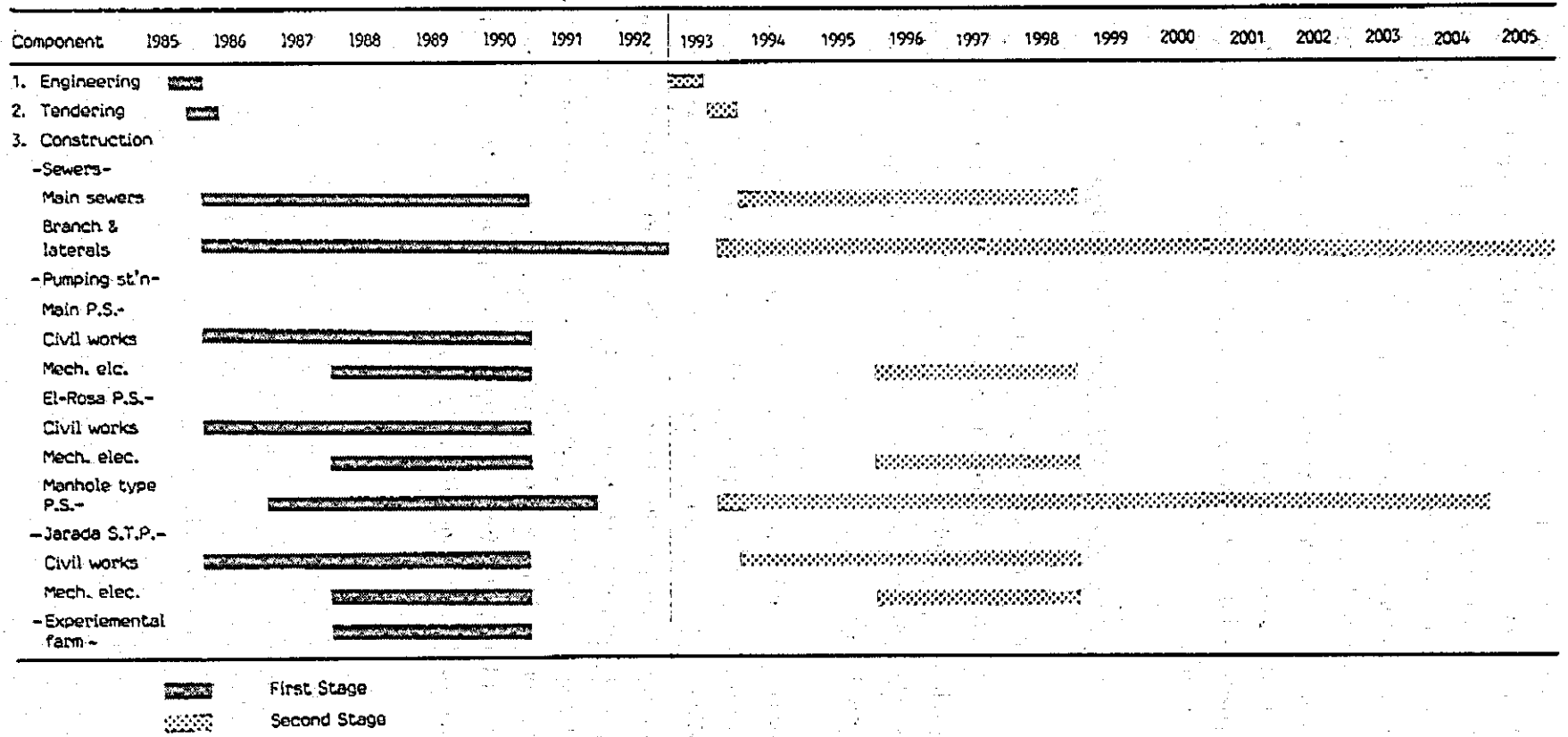


Table 15 Summary of the Programme Costs

(L.E. 1,000)

Item	1st stage			2nd Stage			Total		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1) Sewers, manboles	2,264	9,100	11,364	1,336	10,400	11,736	3,600	19,500	23,100
2) Pumping stations	1,318	1,035	2,353	284	220	504	1,602	1,255	2,857
3) Treatment plant	2,356	3,641	6,002	598	916	1,500	2,945	4,557	7,052
4) Irrigation system	297	99	396	-	-	-	297	99	396
Sub-total	6,245	13,886	20,115	2,209	11,525	13,740	8,444	25,411	33,855
5) Engineering	402	604	1,006	275	412	687	677	1,016	1,693
6) Contingencies	1,241	2,776	4,023	448	2,305	2,747	1,689	5,081	6,770
Sub-total	1,649	3,380	5,029	717	2,717	3,434	2,366	6,097	8,463
Grand Total	7,884	17,260	25,144	2,926	14,248	17,174	10,810	31,508	42,318

4.7. Institutional Study

The institutional study covers the review and evaluation of the existing practice and consideration of the alternative plans together with necessary legislation provisions. On the basis of the study results thus derived, an organization for the new sewerage and effluent reuse system has been elaborated as illustrated in Figure 8.

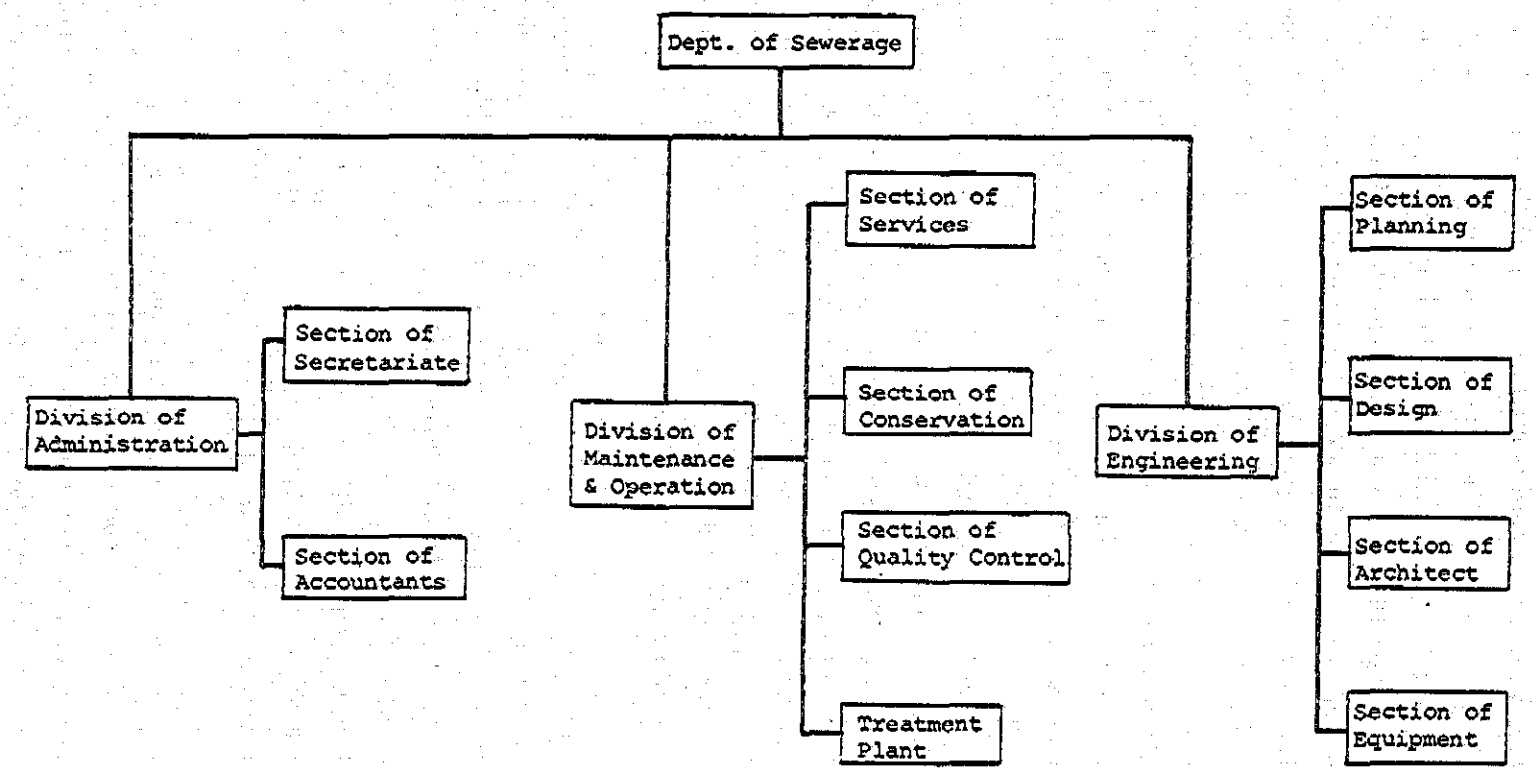
The expansion and modification of the existing Housing Department of NSG is considered to be the most feasible institutional arrangement at the present stage. Saving for initial effort and fund required to put the new organization, availability of personnel required, economies in operation and maintenance, and administration by coordination with other departments of NSG and sufficient provision of existing legislation to effect the proposed new organization are the major factors that would support the organizational plan.

It is therefore recommended that the Housing Department of NSG be fully responsible for the planning, design, construction, operation, maintenance, and monitoring and surveillance of the sewerage system by expanding its organization with additional sufficient staff and provision with adequate financial support. The new organization will undertake these work with administrative assistance and coordination of the other departments of NSG for services on book keeping and accounting finance and treasury exclusively for sewerage services.

The proposed management system comprises three Divisions under the Department of Sewerage, namely 1) Division of Administration, 2) Division of Operation and Maintenance, and 3) Division of Engineering. At the end of the First Stage Programme, a total of 45 staff will be required to manage and control the new system.

Figure 8

Outline of Structure
for Sewer-System Organization



4.8. Socio-Environmental Outlook

The most obvious impact of the project will be the improvements expected in the public health of the residents of El-Arish and its surrounding areas through the provision of the new sewerage system. All the wastewaters currently infiltrated into the ground will be shut off and collected by the sewers, and finally treated at the treatment plant to the level acceptable to the environ and reuse purpose, thereby the danger of the groundwater contamination that has already become a deplorable level will be greatly reduced. All the sewage treatment plant effluent will is planned to be reused for irrigation of crops or other purposes as required and no effluent will be directly discharged either to the Wadi or the sea. On account of this, it is expected that the overall environmental impact of the sewerage system will be positive.

Presently the agricultural production is essentially limited to only rainy season operation in the project area. The project will provide a sewage treatment plant which can produce a quantity of some 20,000 m^3/day new water source for irrigation and possibly for industrial purposes. The estimated quality of the treatment plant effluent shows that its characteristics may not cause significant adverse effects to the crop growing, if the treatment plant is properly operated and suitable crops are selected for sewage reuse.

The quality of the treated sewage effluent is important both for the health of farmers in contact with it and for particular application for which it is used. Although the treatment plant effluent is in general safer than the raw sewage, care must be taken to protect the health of farmers from the possible risks. The possibility of transmitting certain parasites or dieases through cattle that gaze on pastures irrigated with the treated sewage should be investigated when the proposed experimental farm is made available.

Since the sewage treatment plant construction site is selected at an isolated area several kilometres removed from the residential and commercial districts of the city, the impact to environ by the treatment facilities will not be significant. Construction activities of the treat-

ment plant may not affect to the nearby farmers and residents. Noise and vibration to be caused by the excavations, pillings, construction equipment may not be untolerable level in view of the isolated location of construction.

In planning and design of the treatment plant facilities, particular care must be taken to prevent and control unwanted and annoying odours, sound and vibration which might be originated in the treatment plant facilities.

In abating odours from the facilities, a consideration was given to the configuration of the plant facilities, locating such units as grit chambers and other odour creating facilities as far as practicable away from the residences or other facilities with due consideration on wind direction. Odour levels expected at the treatment plant site boundary have been found to be within acceptable levels.

In reducing the noise at the sources, consideration was given in planning and design of the facilities. Shielding and improving the muffling of combustion engines and compressors, restricting the operation of noise-producing equipment to certain hours of the day, and improving vibration characteristics of equipment are the major counter measures to reduce the noise level from the plant. In addition, the treatment plant site will be provided with solid barriers, planting of belts of trees and other vegitation receiving the effluent, and the use of sound-proof materials and shape of building exteriors, which are measures that reduce the propagation of sound.

Excavations for sewers and pumping stations throughout the project area will cause traffic interruption for several years, however, this problem can be avoided as much as possible by the well scheduled construction programmes. The excavations may also cause soil erosion, but such erosion will be limited by minimizing excavation on steeply sloping the land and by requiring reasonable soil conservation measures by the contractors.

In view of the above conditions, the overall environmental impacts of the sewerage system is expected to be positive.

4.9. Recommended Actions

Several steps are essential if the project is to be successfully and efficiently implemented:

(a) The National Organization for Potable Water and Sanitary Drainage (NOPWASD) and other agencies concerned must approve the project.

(b) Project finance must be arranged by the North Sinai Governorate, from the Ministry of Finance for local currency costs and from international lending agencies for the foreign currency costs.

(c) The necessary changes in institutional responsibilities for the sewerage must be implemented as soon as possible to enable the North Sinai Governorate to control and implement the project.

(d) The North Sinai Governorate's organization must be modified and strengthened, with extensive training and retraining of staff.

(e) Preliminary steps must be taken towards acquiring the land necessary for the sewage treatment plant, pumping stations and farm lands for water reuse.

(f) Necessary actions must be taken to implement a project for providing irrigation farm lands with auxiliary facilities as soon as possible so that the expected surplus treatment plant effluent of 6,400 m^3/day by 1992 and 12,000 m^3/day by 2005 can be effectively utilized.

ANNEX

ANNEX

PROJECT ORGANIZATION

1. Government of Egypt

The Government of Egypt provided through the North Sinai Governorate (NSG) the necessary counterpart staff to the Japanese study team throughout the period for the study at the project site. At the beginning of the study work, the following government personnel were attached to the Project:

Eng. Ibrahim Kalaf	General Manager of Housing Dept.
Eng. Mohamed El Sherief	Secretary of Housing Dept.
Eng. Salem Abd El Hady	El-Arish City Council
Eng. Said El Sherief	NSG
Eng. Abd El Magied Nassier Selmi	Housing Dept.
Eng. Hamdy El Sherief	Information Management NSG
Eng. Hassan Shabaan	Housing Dept.
Mr. Magdy Gamal Serry	Planning Statistics Office NSG
Eng. Gomma Abbas	Housing Dept.
Eng. Mohammed Nassar	Agricultural Dept.
Dr. Wahby Abdallah	NSG

In addition to the above personnel, many other supporting staff from the various agencies have participated the Study and assisted the study team in efficient and smooth undertaking of the study work throughout the study period.

2. JICA Study Team

The JICA study team comprises the following personnel of Nihon Suido Consultants Co., Ltd:

Mr. Shohei Sata	Team Leader, responsible for over-all control of the progress of work and liaison between the governments of Egypt and the study team. Also, responsible for the study on city planning of the study area.
Mr. Gakuji Kimura	Agricultural Expert, responsible for planning of agricultural programme, particularly of the treated sewage reuse for crop irrigation.
Mr. Masaaki O'Hashi	Economist, responsible for developing financial and economic planning of the project.
Mr. Junichi Yamashita	Sewerage Engineer, mainly in charge of sewage treatment plant planning and design.
Mr. Yasushi Hirau	Sewerage Engineer, in charge of sanitary and storm sewer system planning and design.
Mr. Hajime Sakurai	Sewerage Engineer, responsible for sewerage planning and cost estimates.
Mr. Ikuo Tanaka	Sewerage Engineer, responsible for sanitary and storm sewerage planning and design.
Mr. Kazuo Inoue	Sewerage Engineer, responsible for planning and design of sewage treatment plant.
Mr. Kazuo Ikeda	Mechanical/Electrical Engineer, responsible for planning and design of mechanical and electrical equipment for the sewage treatment plant.
Mr. Akio Kasai	Biochemist, responsible for water quality and quantity survey.

3. Advisory Committee

The Committee comprises the following personnel:

Dr. Hideo Fujii	Chairman, responsible for advising and guiding the study team members for sewerage and drainage plan-

	ning and design.
	Executive Director, Headquarters on Research and Training, Japan Sewage Works Agency.
Mr. Ichiro Seto	Adviser for city planning and drainage system of the project.
	Assistant Director, River Basin Sewerage Sewerage Division, Sewerage and Sewage Purification Department, City Bureau, Ministry of Construction.
Mr. Yasuo Hoshikuma	Adviser for water quality and treated sewage reuse plan.
	Chief, Sewage Works Division, Water Quality Control Department, Public Works Research Institute, Ministry of Construction.
Mr. Takashi Yamazaki	Adviser for sewerage system planning.
	Deputy Chief, the Designing Department, Sewage Works Bureau. The City of Yokohama.
Mr. Nobuo Kimura	Project Coordinator.
	Deputy Head, Second Development Survey Division, Social Development Cooperation Department, Japan International Cooperation Agency.

ORGANIZATION FOR FEASIBILITY STUDY