CHAPTER 9

PROPOSED SEWERAGE SYSTEM

9 PROPOSED SEWERAGE SYSTEM

9.1 WASTEWATER COLLECTION SYSTEM

9.1.1 Main Collectors

The interceptors and main collectors will receive both domestic and industrial wastewater through either separate or combined sewer reticulations. The sewers will then transport the wastewater to the wastewater treatment plants by gravity flow. The main collectors and interceptors to be built under the Master Plan range in diameter from 200 mm to 3,000 mm with an estimated total length of 169,200 meters, covering each wastewater treatment district in six Regions; namely, Central, North 1, South 1, South 2, South 3 and East 1.

The ultimate sewerage system layout plan for the Study Area is shown in Fig. 9-1. The topography of the Area is such that the interceptors and collectors should follow the major drainage basin pattern. To do otherwise would require excessively deep excavations and sub-mains, branches and other sewers. The recommended main collector system is based on construction of tunneled and open-cut conduits. The wastewater is conveyed by gravity flow to the point of discharge. The interceptors and main collector profiles were carefully determined so that no lift pumping stations will be required.

For ease of identification, the layout of each main collector has been indicated in Fig. 9-1 and is summarized below with a brief description of size and length.

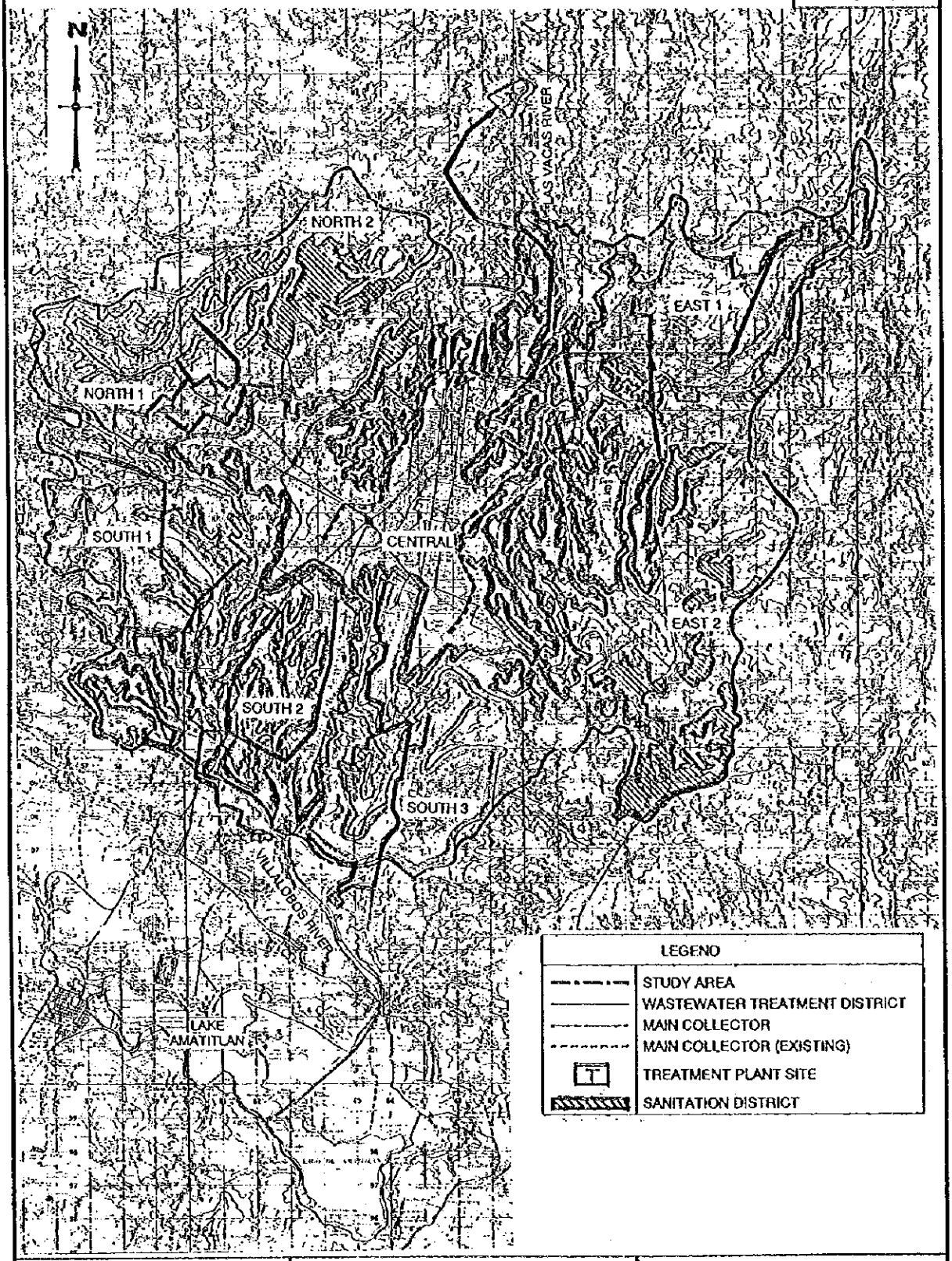
Table 9-1 Summary of Collector Sewers Proposed for Each Wastewater Treatment District

Region	Unit Design Flow Rate ($m^3/s/ha$)	Diameter (mm)	Length (m)
Central	0.000684 * 0.000848	3,000	10,060
North 1	0.000759	250 - 1,500	23,940
South 1	0.000727	250 - 1,500	27,760
South 2	0.000445	250 - 1,500	39,840
South 3	0.000523	200 - 1,500	35,930
East 1	0.000497	250 - 1,500	31,670

Source : Study Team

Note: * indicates flow from combined sewerage catchment. All others are separate.

Fig. 9 - 1



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE ULTIMATE SEWER SYSTEM LAYOUT IN STUDY AREA

Plan layout of the major collectors are illustrated in Supporting Report L with corresponding hydraulic computations. Unit design flow rate, size and length of the main collectors serving each of the wastewater treatent district in six Regions are shown in Table 9-1.

A break down of the component sewers of the major collectors by wastewater treatment district is shown in Table 9-2:

Table 9-2 Size and Length of Collectors for Wastewater Treatment Districts

Sewer Size (mm)	Length of Main Collector (m)					
	Central	North 1	South 1	South 2	South 3	East 1
200	-	-	-	-	1,350	-
250	-	560	1,770	6,900	-	2,430
300	-	1,060	6,780	5,060	6,230	1,540
350	-	-	2,400	6,750	7,250	4,450
400	-	1,050	-	1,050	4,790	-
450	-	260	6,060	1,670	-	1,560
500	-	4,030	1,400	4,540	2,090	1,400
600	-	2,190	-	-	4,650	1,440
700	-	930	-	-	1,580	-
800	-	1,970	-	-	-	-
1,500	-	11,890	9,350	13,870	7,990	18,850
3,000	10,060	-	-	-	-	-
Total	10,060	23,940	27,760	39,840	35,930	31,670

Source : Study Team

9.1.2 Sub-main, Branch and Lateral Sewers

The proposed sewerage system includes the provision of new sewer reticulations consisting of I) sub-mains, ii) branches, and iii) laterals for the areas wherein no sewer reticulations have been provided yet. The wastewater collected from households, industries, commercial sector, etc. through house connections, flows by gravity to lateral or branch sewers, and then is led to sub-main sewers. Although profiles for these smaller sewers have not been prepared for master planning purposes, (except for some of the major branch sewers which are influential in determining the invert elevations in sub-main and main sewers), profiles have been examined to check whether main or sub-main sewers could receive wastewater from the most remote locations in the catchment.

9.2 WASTEWATER TREATMENT SYSTEM

9.2.1 Basic Conditions for Design of Wastewater Treatment Plants (WWTP)

Following is a summary of design conditions for WWTP facilities, which are discussed in the preceding sections.

a) Basic Concept

In this Study, following need to be considered in the design of WWTP. They are :

- considering the existing financial condition of EMPAGUA, important point is to reduce the operation cost of WWTP.
- since WWTP site is of complicated slope, large amount of cut and fill is inevitable during construction. However, influent wastewater is received at a higher level compared to receiving water, having high potential energy.

Based on the above, basic concepts for the treatment plant design are as follows :

- all flows must be under gravity
- no mechanical equipment requiring electric power be used

b) Design Flow Rates for Wastewater Treatment Plants

Table 9-3 Design Flow Rates for Wastewater Treatment Plants

Region	Wastewater Flow Rate (m3/d)			Wet Weather Flow Rate (m³/d)
	Daily Average	Daily Maximum	Hourly Maximum	
Central	238,000	261,000	390,000	1,087,000
North 1	89,000	97,000	144,000	—
South 1	64,000	70,000	103,000	—
South 2	51,000	55,000	86,000	—
South 3	66,000	72,000	107,000	—
East 1	121,000	131,000	196,000	—

Source : Study Team

c) Water Quality

Table 9-4 Treated Water Quality

Parameter	Concentration (mg/L)		
	Influent	Effluent	
		Primary	Secondary
BOD_5	280	182	56
SS	280	126	56

Note : Detailed discussion is included in Supporting Report J. Annex JB

Source : Study Team

d) Treatment Process Flow

Wastewater treatment process flow is as shown in Fig. 9 - 2.

e) Wastewater Flow Rates for Design

Table 9-5 Wastewater Flow Rates for Design

Facility	Treatment Capacity	Hydraulic Capacity
Liquid Treatment	Daily Maximum Flow Rate	Hourly Maximum Flow Rate
Sludge Treatment	Planned Sludge Quantity (Based on Daily Average Flow Rate)	Same as for Treatment Capacity

Source : Study Team

9.2.2 Summary of Proposed Facilities

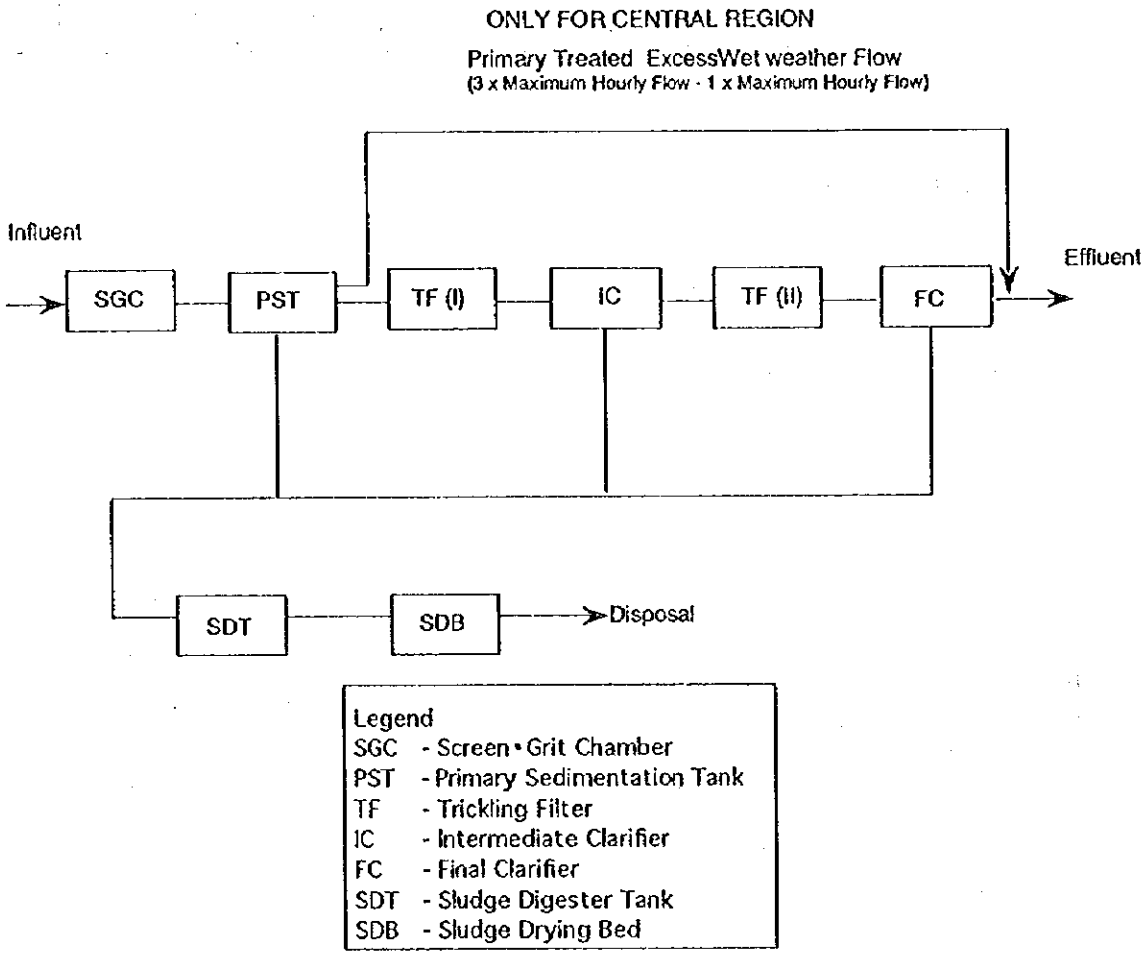
a) Facility Design

1) Number of Treatment Trains

Following are considered to determine the number of trains. They are :

- wastewater quantity for each construction stage until the ultimate stage
- limits on capacity of each tank of unit process (for example structure, shape, dimensions etc.)

Fig. 9 - 2



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC FLOW DIAGRAM FOR WASTEWATER TREATMENT SYSTEM

The former varies between treatment plants and in case of the treatment capacity encountered in this Study, capacity of a single train will be in the order of several thousand cubic meters per day. Therefore considering the latter and based on experience, capacity of a single train is set to be around 10,000 m^3/d.

2) Shape of Each Treatment Facility

Basically all treatment facilities are reinforced concrete structures and the shape is either circular or rectangular depending on the function of each facility.

3) Buildings etc.

Administration building, Store-house, Building for Workers (for washing, waiting etc.) are necessary.

4) Water Quality Laboratory

Water quality testing is very important for the operation and maintenance of WWTP. However, it is proposed that water quality testing be carried out at the existing laboratory (owned by EMPAGUA). Water Quality Laboratory will not be built within the WWTP for the following reasons :

- Availability of skilled personnel for water quality testing is limited and for the personnel to remain in WWTP is difficult.
- Procurement and maintenance of water quality testing equipment solely for WWTP is expensive.
- So far there is no experience. To facilitate smooth O/M in the beginning, only the minimum number of parameters necessary for O/M be carried out at the beginning, Testing can be done at the existing laboratory of EMPAGUA.
- Water quality parameters to be tested are BOD, COD, SS and pH.
- Settleable solids which is one of the parameters in the existing effluent standards could be carried out in the WWTP without difficulty.

b) Summary of Proposed Facilities

Design of WWTP facilities for each Region was carried out for the basic conditions shown in Section 9.2.1 and 9.2.2 a). Design details can be found in Supporting Report M. A summary of the number and size of facilities is shown in Table 9-6.

Table 9-6 Outline of Treatment Facilities

Facility	Central		North1		South1		South2		South3		East1	
	Dimensions	No.	Dimensions	No.	Dimensions	No.	Dimensions	No.	Dimensions	No.	Dimensions	No.
Primary Sedimentation Tank	φ 13.00m×h 11.89m	40	φ 12.50m×h 11.46m	16	φ 13.50m×h 12.33m	10	φ 13.50m×h 12.33m	8	φ 12.50m×h 11.46m	12	φ 13.00m×h 11.89m	20
Trickling Filter (First Step)	φ 39.00m×h 2.00m	40	φ 38.00m×h 2.00m	16	φ 41.00m×h 2.00m	10	φ 40.00m×h 2.00m	8	φ 38.00m×h 2.00m	12	φ 39.00m×h 2.00m	20
Intermediate Clarifier	φ 13.00m×h 11.89m	40	φ 12.50m×h 11.46m	16	φ 13.50m×h 12.33m	10	φ 13.50m×h 12.33m	8	φ 12.50m×h 11.46m	12	φ 13.00m×h 11.89m	20
Trickling Filter (Second Step)	φ 39.00m×h 2.00m	20	φ 38.00m×h 2.00m	8	φ 41.00m×h 2.00m	5	φ 40.00m×h 2.00m	4	φ 38.00m×h 2.00m	6	φ 39.00m×h 2.00m	10
Final Clarifier	φ 18.00m×h 16.22m	40	φ 17.50m×h 15.79m	16	φ 18.50m×h 16.66m	10	φ 18.50m×h 16.66m	8	φ 17.50m×h 15.79m	12	φ 18.00m×h 16.22m	20
Sludge Digester Tank	φ 17.50m×h 9.75m	40	φ 17.50m×h 9.75m	16	φ 18.00m×h 10.00m	10	φ 18.00m×h 10.00m	8	φ 17.00m×h 9.50m	12	φ 18.00m×h 10.00m	20
Sludge Drying Bed	W 40.00m×L100.00m	20	W 40.00m×L100.00m	8	W 40.00m×L110.00m	5	W 40.00m×L110.00m	4	W 40.00m×L 95.00m	6	W 40.00m×L105.00m	10
Design Flowrate Daily Average m³/d	238.000		89.000		64.000		51.000		66.000		121.000	
Daily Maximum m³/d	261.000		97.000		70.000		55.000		72.000		131.000	
Hourly Maximum m³/d	390.000		144.000		103.000		86.000		107.000		196.000	
Hourly Maximum Wet Weather m³/d	1.087.000		——		——		——		——		——	
Sludge Generation t/d	90.0		49.8		24.3		19.3		25.0		45.8	

Source : Study Team

9.2.3 Disposal and Reuse

a) Sludge Disposal and Reuse

Sludge produced from the wastewater treatment process is handled in the same way as solid waste materials are managed. On account of this, the dried sludge is to be hauled to designated waste solid dump sites in consultation with the responsible agencies for solid waste disposal management. Screenings and other wastes produced from the treatment plant facilities should be handled in the same manner as the dried sludge.

Many agencies have long been using wastewater sludge as material for composting, to overcome the shortage of land available for filling, and such products are widely accepted by users as good quality organic fertilizers.

b) Effluent Reuse

Another possibility for reuse is the case of treated effluent. In urban areas effluent may be used for various purposes except for drinking water, and in agricultural areas effluent is widely used as a source of irrigation. In practice, to carry out effluent reuse, it is necessary to solve various similar problems as for sludge reuse.

Since the wastewater treatment process uses micro-organisms, the wastewater treatment process itself can be said to constitute a natural, ecological process. Therefore, the policy for wastewater and sludge reuse, which constitutes natural recycling, should be encouraged.

c) Policy for Disposal and Reuse

Because the magnitude of this project is large and it is the first time that construction of these type of facilities has been carried out in Guatemala, reuse of wastewater effluent and sludge is not considered in the initial program. The treated wastewater effluent will be discharged directly into public waterways and the sludge will be disposed of by landfilling. At a later stage, this issue could be re-evaluated. Table 9 - 7 shows a summary of the issues involved when effluent and sludge reuse are considered:

Table 9 - 7 Consideration of Treated Wastewater and Sludge Reuse

Item	Treated Wastewater	Sludge (Dried)
Use	Irrigation	Fertilizer
Quantity	As constantly produced throughout the year, it is difficult to adjust production quantity to meet users varied demand.	As constantly produced throughout years, sludge stock facility is needed to meet users varied demand.
Quality	As effluent is either from primary or secondary treatment without chlorination, guarantee's of quality and legal responsibility for consequences of reuse need to be considered.	As industrial wastewater's may contain hazardous heavy metals, guarantee's of quality and legal responsibility for sludge use need to be examined.
Transportation, Supply and Marketing	Energy for pumping will be required to transport effluent, except for gravity supply to areas downstream of treatment plant.	Transportation costs will be incurred. For promotion and marketing of products, new distribution routes should be established.

Source : Study Team

9.3 COST ESTIMATION

9.3.1 Basis of Cost Estimation

The major components involved in the preliminary cost estimation and the method used are described below. The total investment cost is composed of direct construction cost, land acquisition cost, engineering fee, administration fee and contingency. Only the engineering fee is considered to be a foreign currency element, other items are considered in the local currency.

a) Direct Construction Cost

The direct construction cost of the sewerage system is estimated based on the preliminary design for Master Plan and unit construction costs obtained from a survey conducted in Guatemala from April 1995 to July 1995. The unit construction costs of sewerage were estimated based on data of actual costs obtained from EMPAGUA, which are shown in Table O3 -1 in Supporting Report O. The other unit costs of construction and materials are described in Table O3-2. These costs were investigated by the JICA Study Team in Guatemala in June 1995.

The direct construction costs are estimated as total costs including materials, labor (including some benefits), but excluding consumption tax (IVA).

b) Land Acquisition Cost

The land area required for the wastewater treatment plant in each Region is shown in Table 9 - 8. The land cost of sewer pipeline installation is not considered since pipes will, in principle, be installed beneath existing roads and under hills / mountains on Government reserved land.

Table 9 - 8 Land Area Required for Wastewater Treatment Plants

Region	Area Required (ha)
Central	67.0
North 1	27.7
North 2	0.0
South 1	19.1
South 2	15.6
South 3	20.7
East 1	34.9
East 2	0.0
Total	185.0

Source : Study Team

c) Engineering Fee

The engineering fee is for design and supervision of construction work by consultants. It has been assumed to be six (6) percent of the direct construction cost.

d) Administration Fee

The administration fee is the cost of administrative works required for this project. It has been assumed to be three (3) percent of the direct construction cost.

e) Contingency

The contingency has been estimated as ten (10) percent of the direct construction cost.

9.3.2 Investment Cost

The investment required to construct collectors and wastewater treatment plant for each Region is summarized in Table 9 - 9. The direct construction cost and land acquisition cost are further broken down in Tables O1-6 through O1-9 in Supporting Report O.

Table 9 - 9 Summary of Total Investment Cost

[Unit : Million Quetzal]

Region	Direct Construction	Land Acquisition	Engineering Fee	Administration Fee	Contingency	Total
Central	368.7	26.8	22.1	11.1	36.9	465.5
North 1	265.9	9.7	16.0	8.0	26.6	326.2
North 2	0.0	0.0	0.0	0.0	0.0	0.0
South 1	171.5	11.5	10.3	5.1	17.2	215.6
South 2	143.0	9.4	8.6	4.3	14.3	179.5
South 3	254.1	12.4	15.2	7.6	25.4	314.8
East 1	317.0	20.9	19.0	9.5	31.7	398.2
East 2	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,520.2	90.7	91.2	45.6	152.0	1,899.7

Source : Study Team

Note 1. Engineering Fee = (Direct Construction Cost) x 0.06
2 Administration Fee = (Direct Construction Cost) x 0.03
3. Contingency = (Direct Construction Cost) x 0.10
4. Cost : as of September 1995.

9.3.3 Operation and Maintenance Costs

The annual operation and maintenance (O/M) cost of a sewerage system consists of the costs for both the wastewater treatment plants and sewer pipelines. The O/M cost of wastewater treatment plants is composed of personnel expenses, the cost of disposal/transportation of the sludge generated and for carrying out repairs. Costs for sewer pipelines are composed of personnel expenses and repair costs.

The conditions assumed for O/M cost estimation are described below.

a) Required Staff

Wastewater Treatment Plant : The required number of staff for routine operational work is estimated as two (2) persons per train. The staff required for laboratory analysis work have not been included.

Sewer Pipelines : Major work includes cleaning and surveying the sewers. The number of staff required for cleaning is estimated as 15 man days per kilometer of sewer and for survey works 3 man days per kilometer.

b) Cost of Disposal/Transportation of Sludge Generated in Wastewater Treatment Plants

The water content of sludge is estimated to be 60 % after removal from sludge drying beds. Dried sludge will be transferred to another site for final disposal.

c) Repair Work

The required annual repair cost is assumed to be 0.5 % of the direct construction cost. This should be sufficient since the system will comprise of concrete structures including sedimentation tanks, trickling filters, digestion tanks and sludge drying beds.

A summary of the required annual O/M costs at 1995 prices for the full operational capacity is shown in Table 9 - 10 and a further breakdown is described in Tables O1-10 through O1-13 in Supporting Report O.

Table 9-10 Summary of O/M Cost for Sewerage System

[Unit : Thousand Quetzal/Year]

Item	Central	North 1	South 1	South 2	South 3	East 1
1 Wastewater Treatment Plant						
- Personnel Costs	1,200	480	300	240	360	600
- Transportation Cost of sludge	1,288	401	291	231	301	549
- Repair Costs (0.5% of C/C)	1,161	469	296	237	353	584
Sub-Total	3,589	1,350	887	708	1,014	1,733
2 Sewer Pipelines						
- Personnel Costs	2,404	845	648	880	928	1,417
- Repair Costs (0.5% of C/C)	682	862	562	477	917	1,001
Sub-Total	3,086	1,707	1,210	1,357	1,845	2,418
Total O/M Cost	6,524	3,057	2,097	2,065	2,857	4,151

Note : Cost is as of September 1995.
Source : Study Team

9.4 O/M GUIDELINES

Implementation of sewerage works consists of a sequence of investigation, planning, design, construction and O/M. The first four activities are done within an initial period while O/M should be carried out for the life span of the facility; from the commencement of operation, daily O/M is essential. Further, information and data obtained through O/M is very useful and would be important for planning the expansion of facilities etc. and for planning facilities for other regions in Guatemala. O/M information is also useful for setting the sewage service charge etc.

Therefore, O/M is an essential element in the implementation of sewerage works and is a deciding factor in the success of a sewerage works project.

9.4.1 Sewers

a) General

The sewer facilities are to collect and transport the wastewater to the wastewater treatment plant and consist of pipes, manholes, diversions, inspection chambers, house connections etc. Because the sewerage system has a direct bearing on the daily lives of citizens, it is important that the responsible agency is always aware of the condition of the facilities and carries out proper operation and maintenance.

b) Purpose of O/M

The purpose of O/M of a sewerage system is to maintain the various elements in the condition intended at the design stage to achieve the following aims:

1) To maintain the design capacity of sewers,
2) To prevent damage of facilities by other construction work,
3) To prevent accidents caused by physical breakdown and corrosion of pipes,
4) To extend the useful life of the sewers,
5) To reduce infiltration of excess infiltration.

Where sewer O/M is not performed properly, sand may be deposited in the sewer invert, corrosion may occur, stormwater inundation may result, odour problems may arise etc., therefore it is imperative that inspection of sewers be routinely carried out and that the wastewater quality be monitored to prevent the inflow of wastewater harmful to the proper functioning of the pipes and treatment works.

c) O/M Work

In order to achieve the purpose of O/M of sewer pipes, an appropriate management plan, including preventative maintenance, is mandatory. Systematic maintenance is required to make the sewer system function in the most efficient way. The sewer O/M work should include the activities listed in Table 9 - 11.

Table 9 - 11 Scope of O/M of Sewer System

Purpose of Work	Scope of Work Necessary
Survey of Present Condition of Sewers	- Visual inspection and logging of condition of inside and outside of sewers and diversion manholes. - Inspection of internal condition of pipes by staff and using CCTV cameras. - Transfer of constructed facilities from regulatory agencies and / or private sector. - Investigation of flooding problems including lifting of manhole covers due to surcharging. - Investigation of odour problems and establishment of counter measures.
Maintenance of Sewer Functions	- Sewer cleaning work. - Supervision of construction work in proximity to sewers. - Repair of damaged facilities and pipes.
Improvement of Sewers	- Improvement and rehabilitation work to renovate pipes and other facilities. - Increase capacity of interceptors. - Improvement measures to prevent flooding. - Conversion of combined system to separate system

9.4.2 Wastewater Treatment Plant

a) O/M Items and Contents

Table 9 - 12 shows a summary of the principal O/M items.

Table 9 - 12 Description of Principal O/M Items

Item	Description
Operation of facilities	- Liquid treatment, sludge treatment and sludge disposal
Monitoring	- Wastewater and treated water quality and flow rate
Check need for repairs	- Damage, leakage and minor repairs (outside help is not necessary)
Cleaning	- Cleaning of facilities, (Screens, channels, connecting pipes etc.), and weed cutting
O/M Documents	- O/M reports (flow rate, water quality, sludge quantity and record of each O/M activity) - Maintain archive of design drawings/reports (storage of planning and design reports, storage of original drawings etc.) - Maintenance of records of correspondence, meetings etc. with other agencies. - Maintenance of construction and repair records (as built drawing, photographs, etc.)

b) Monitoring Parameters for Plant Operation

The most basic parameters for operation of the treatment process are flow rate and wastewater quality. The method of obtaining data for the above will depend on the type of facilities used. Table 9-13 shows the data necessary for the facilities proposed.

Table 9 - 13 Monitoring Parameters for Plant Operation

Item	Flow rate	Wastewater Quality
Location of Measurement	Influent Sewage	Influent sewage, primary effluent, and final effluent.
Measurement Method	Gauge reading using Parshall Flume	Settleable Solids: at the plant, BOD, COD, SS etc: at the water works Central Laboratory.

c) O/M for Each Treatment Facility

Screen and Grit Chamber

These facilities play an important role to protect blockage of subsequent treatment facilities by removing garbage and sand found in the raw sewage. Therefore, it is necessary to withdraw screened garbage and settled sand during operation. Especially, if screened

garbage is left to accumulate at the screen, sewage will overflow from the channel without treatment.

Withdrawal of screened garbage and settled sand is to be done manually. Therefore, it is essential to follow good hygienic practices such as wearing gloves, and protective clothing, washing hands etc. and considering safety, the work should be carried out by more than two persons.

Sedimentation Tanks (including Clarifiers)

Settled sludge accumulated in the bottom part of the tank is withdrawn and conveyed to the sludge treatment facilities using static water pressure (siphoning) by opening the valve of the sludge removal pipe which extends to the bottom of the sedimentation tank.

Operation requires only opening and closing of the valve of sludge pipe, however it is necessary that frequency of sludge withdrawal should be based on the sludge accumulation rate. In other words, frequent withdrawal will overload the sludge treatment facilities while infrequent withdrawal of sludge will result in possible blockage of sludge pipe due to increased concentration of settled sludge with time.

Further accumulation of sludge over long period of time affects the water quality of sedimentation tank due to sludge floating, septicity of sludge, etc. Especially, special care should be taken in the operation of final clarifies. Operators should have a through understanding of the above principles for proper operation.

Trickling Filter

Trickling filter is the main treatment facility for liquid treatment, and the final effluent quality is affected by its operation and maintenance. Facilities of trickling filter can be divided into distribution equipment and filter bed, and following are the major items for each facility.

- Distribution Equipment
  - Greasing of rotating axle
  - Cleaning of distribution arm.
- Filter -bed
  - Cleaning of garbage etc.
  - Removal of filter-fly. (by flooding filter bed at regular intervals)

Frequency of the above O/M items depends on the operating conditions and approximately in the range of once in one to two months.

Sludge Digester Tank

Settled sludge conveyed from the sedimentation tanks (and clarifier) is retained in the tank for long period of time during which digestion of sludge occurs. Sludge digestion tank is the facility for breaking down settled sludge conveyed from the sedimentation tank by retaining for long period of time. Digested sludge is removed from the bottom part of the tank, and the sludge withdrawal is similar to sedimentation tank.

Sludge Drying Bed

Either digested sludge or raw sludge is dried naturally by spreading the sludge in thin layer. The bed consists of sand and block layers, through which water in the sludge is drained and collected through in underdrainage system. Supplementary addition of sand is necessary at regular intervals. Dried sludge is either collected by belt-conveyor or mini-shovel etc. to trucks for disposal outside the treatment plant.

CHAPTER 10

PROPOSED SANITATION SYSTEM

10 PROPOSED SANITATION SYSTEM

10.1 SANITATION DEVELOPMENT PLAN

To improve environmental conditions, wastewater generated should be collected and treated before discharge to water bodies. The developed parts of the Study Area in which wastewater generated cannot be collected by a gravity sewerage system will be provided with sanitation facilities. The procedure adopted to decide the area to be covered by the sanitation system is described below.

- Using the UNICEF survey as a basis, the characteristics of colonies/settlements were further studied during field visits and discussions with EMPAGUA officials.

- Colonies located within a ravine would be difficult to connect to the proposed sewerage system. These colonies have poor accessibility and so are identified for the provision of a sanitation system.

- The colonies/settlements selected from the above criteria were further studied with respect to the availability of water supply and land ownership. Colonies having a water supply and proper land ownership were selected to be covered by a sanitation system.

- Besides the above mentioned colonies, in North 2 and East 2 Regions a sanitation system is required as the topography is such that it would be difficult to construct a gravity sewerage system.

The majority of the colonies/settlements to be served by a sanitation system are described as high or medium risk settlements by the UNICEF survey which means that they lack most amenities. The Urban Development Department of Guatemala Municipality advised that the Government plans to reduce the population of these settlements however according to population growth trends, the population may be increasing. EMPAGUA therefore asked that the population of these communities to be served by the sanitation system in the year 2015 is considered to be the same as the present population. For Regions North 2 and East 2 which will only be served by a sanitation system, the population projection was taken into consideration.

The population to be served by a sanitation system in each Region in 2015 is shown below.

Table 10 - 1 Population to be Served by a Sanitation System in 2015

Region	Population in each Region to be covered by sanitation
Central	109,600
North 1	12,900
North 2	150,000
South 1	2,500
South 2	8,000
South 3	2,900
East 1	20,200
East 2	40,000
Total	346,100

Source : Study Team

In the sanitation development plan, only sanitation facilities at a community level are considered, as individual facilities are difficult to control from an O/M point of view.

10.2 WASTEWATER COLLECTION SYSTEM

A conventional gravity system is proposed for collecting and transporting the wastewater to the community sanitation treatment facility. The design criteria have already been described in the previous chapter. The size of sewer required for a colony of 1,000 people is less than 200 mm however a minimum size of 200 mm is assumed. The length of sewer required in each Region is shown in Table 10-2.

Table 10 - 2 Length of Sewers Required for Sanitation

Region	Length (km)
Central	177
North 1	10
North 2	111
South 1	2
South 2	17
South 3	10
East 1	53
East 2	324
Total	704

Source : Study Team

10.3 WASTEWATER TREATMENT SYSTEM AND SLUDGE MANAGEMENT

10.3.1 Treatment System

The sanitation treatment system proposed consists of a septic tank followed by soil absorption well or upflow anaerobic filter. A two compartment septic tank is proposed to limit discharge of solids with the effluent. The septic tank was designed with a detention time of 3 days at start-up, and the adequacy of the storage volume available for sludge was checked. In cases where the effluent is to be disposed using a soil absorption well, two wells are recommended to provide a sufficient resting period for the soil strata. In the case of a septic tank with an upflow anaerobic filter, the media to be adopted is broken stones of size 19-25 mm.

For Master Plan, the number of septic tanks required in each Region is shown in Table 10 - 3 and was estimated assuming that each community has a population of 1,000.

Table 10 - 3 Number of Septic Tanks Required

Region	Number of Units Required
Central	110
North 1	13
North 2	150
South 1	3
South 2	8
South 3	3
East 1	21
East 2	40
Total	348

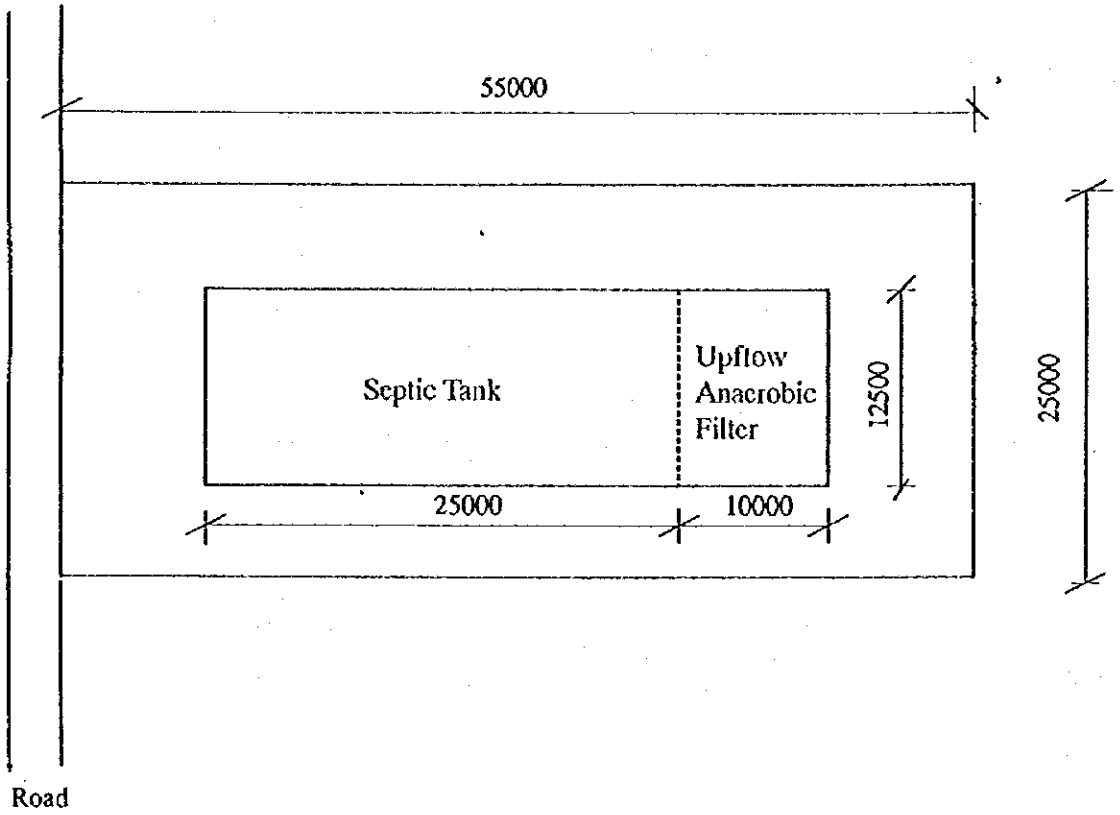
Source : Study Team

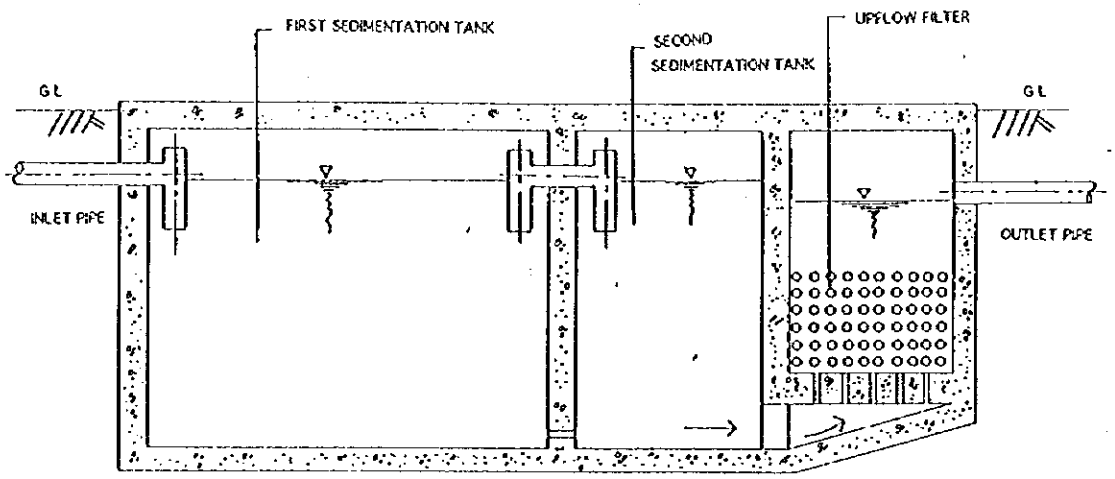
Dimensions of a septic tank and upflow anaerobic filter for a community having a population of 1,000 are given below as an example. Detailed design calculations are included in Supporting Report N.

Septic Tank: = 23.0 m x 12.0 m x 2.0 m
Upflow Anaerobic Filter: = 10.0 m x 12.0 m x 1.2 m

A typical layout of a community sanitation plant for a community having a populaiton of 1,000 is shown in Fig 10 - 1. Area required is about 0.14 ha.

Fig. 10 - 1





SEPTIC TANK WITH UPFLOW ANAEROBIC FILTER

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE TYPICAL LAYOUT OF A COMMUNITY SANITATION PLANT

10.3.2 Sludge Management of Sanitation System

The quantity of septage is calculated based on a sludge accumulation rate of 0.04m^3/capita/year. Septage containing 7 % solids content is assumed to be desludged once a year. At present, septage is being dumped without treatment, however in the future it should be properly treated before disposal.

It is proposed that septage be treated at the sludge treatment facility of the wastewater treatment plant to be constructed in the respective Region. It is proposed that sludge from North 2 and East 2 Regions be treated at the sludge treatment facility of the wastewater treatment plants in North 1 and East 1 Regions respectively. The volume of septage to be desludged from the sanitation system in the year 2015 for each Region is shown in Table 10 - 4.

Table 10 - 4 Quantity of Septage to be Desludged in the Year 2015

Region	Quantity of Septage to be Desludged from Septic Tanks (m^3/year)	Location of Treatment Plants for Treating Septage
Central	4,384	Central
North 1	516	North 1
North 2	6,000	North 1
South 1	100	South 1
South 2	320	South 2
South 3	116	South 3
East 1	808	East 1
East 2	1,600	East 1
Total	13,844	-

Source : Study Team

10.4 COST ESTIMATION

10.4.1 Basis of Cost Estimation

The same approach was adopted to estimate costs for implementing the proposed sanitation system as was used for the gravity sewerage system as described in Section 9.3 and Supporting Report O, Volume IV.

The required land area for the community plants for each Region, is shown in Table 10 - 5.

Unit cost of them are described in Table O3-3 in Supporting Report O, Volume IV.

Table 10 - 5 Land Area Required for Community Plant for Sanitation System

Region	Unit Land Area Required (ha/Plant)	Number of Community Plants	Required Land Area (ha)
Central	0.14	110	15.4
North 1	0.14	13	1.8
North 2	0.14	150	21.0
South 1	0.14	3	0.4
South 2	0.14	8	1.1
South 3	0.14	3	0.4
East 1	0.14	21	2.9
East 2	0.14	40	5.6
Total	_	349	48.7

Source: Study Team

10.4.2 Investment Cost

The investment cost required to construct sewer pipelines and community plants for each Region, is summarized in Table 10 - 6. The direct construction and land acquisition costs are further broken down in Tables O1-6, O1 - 7 and O1 - 8 in Supporting Report O.

Table 10 - 6 Summary of Total Investment Cost for Sanitation System

(Unit: Million Quetzal)

Region	Direct Construction	Land Acquisition	Engineering Fee	Admin Fee	Contingency	Total
Central	74.6	6.2	4.5	2.2	7.5	94.9
North 1	6.8	0.6	0.4	0.2	0.7	8.7
North 2	68.7	4.2	4.1	2.1	6.9	85.9
South 1	1.5	0.3	0.1	0.0	0.2	2.0
South 2	6.2	0.7	0.4	0.2	0.6	8.0
South 3	3.0	0.3	0.2	0.1	0.3	3.8
East 1	17.8	1.8	1.1	0.5	1.8	23.0
East 2	71.4	3.4	4.3	2.1	7.1	88.3
Total	249.9	17.3	15.0	7.5	25.0	314.7

Note: 1. Engineering Fee = Direct Construction Cost x 0.06
2. Administration Fee = Direct Construction Cost x 0.03
3. Contingency = Direct Construction Cost x 0.10
4. Costs are as of September 1995.

Source : Study Team

10.4.3 Operation and Maintenance Costs

The O/M cost of the sanitation system consists of annual costs for both community plants and sewer pipelines. The O/M cost of community plants is composed of personnel expenses, disposal/transportation cost of sludge generated and repair costs. Costs for sewer pipelines are composed of personnel expenses and repair costs.

The conditions assumed for O/M costs estimation are described below.

a) Required Staff

Community Plant : The frequency of maintenance of community plants is considered to be once a month and two (2) persons are assigned for this job.

Sewer Pipelines : Major works include cleaning and surveying the sewer pipelines. The staff required for cleaning is estimated as 10 man days per year per kilometer of sewer and for survey work 2 man days per year per kilometer.

b) Cost of Disposal/Transportation Sludge Generated in Community Plants

The water content of sludge (septage) is estimated to be 93% after digestion in the septic tank. Septage will be transferred to the regional wastewater treatment plant for further treatment.

c) Repair Work

The annual cost of repair is assumed to be 0.5 % of the direct construction cost. This should be adequate since facilities such as septic tanks, upflow anaerobic filters and soil absorption wells will be built of concrete.

The summary of required annual O/M costs are shown below in the Table 10 - 7 and a further break down is described in O1 - 13 to O1 -15 in Supporting Report O.

Table 10 - 7 Summary of O/M Cost for Sanitation System

(Unit: Thousand Quetzal/Year)

Item	Region							
	Central	North 1	North 2	South 1	South 2	South 3	East 1	East 2
1. Community Plant								
- Personnel Cost	220	30	300	30	30	30	42	80
- Transportation Cost of Sludge	140	17	192	3	10	4	26	51
- Repair Cost	208	24	284	6	15	5	39	75
Sub-total	568	71	776	39	55	39	107	206
2. Sewerage								
- Personnel Cost	175	30	109	30	30	30	52	320
- Repair Cost	165	10	60	2	16	10	50	282
Sub-total	340	40	169	32	46	40	102	602
Total O/M Cost	908	111	945	71	101	79	209	808

Note: Costs are as September 1995.
Source : Study Team

10.5 OPERATION AND MAINTENANCE PLAN

Septic tanks should be desludged annually and the septage should be transported to a wastewater treatment plant for treatment. An upflow anaerobic filter is expected to operate satisfactorily without maintenance for 18 to 24 months. However recommended cleaning of the filter media is once a year. Both desludging of septic tanks and cleaning of filter media can be done at the same time. In the case when effluent is disposed of by soil absorption well, each well should be operated for 6 months so as to provide a 6 month resting period. The resting period should help the soil to recover its infiltration capacity and so clogging of the soil absorption well can be avoided. O/M required for sewers is cleaning.

CHAPTER 11

SELECTION OF PRIORITY REGIONS

11 SELECTION OF PRIORITY REGIONS

11.1 INTRODUCTION

11.1.1 Objectives

The provision of a complete sewerage and sanitation system for the Guatemala Metropolitan Area, with its large and expanding population, is a task of tremendous magnitude. In order to construct and finance the Project, large capital funds will be required; however, it is not necessary to implement the complete plan at once. Many currently undeveloped areas will not require facilities until a later date.

Obviously, it is prudent to build the required facilities in stages, according to the urgency of need and benefit to be derived. Staged construction will spread capital expenditure over an extended period of years, and in so saving will save interest on borrowed capital and reduce initial costs.

This study has therefore been made to determine the desirable priority for sewerage/sanitation system construction, taking into account the various important elements which affect environmental and sanitary conditions in the eight Regions of the Study Area, based on reasonable assumptions and a rating procedure.

11.1.2 Procedure for Selection

The procedure for selecting Priority Regions is as shown in Figure 11-1. There are two steps;

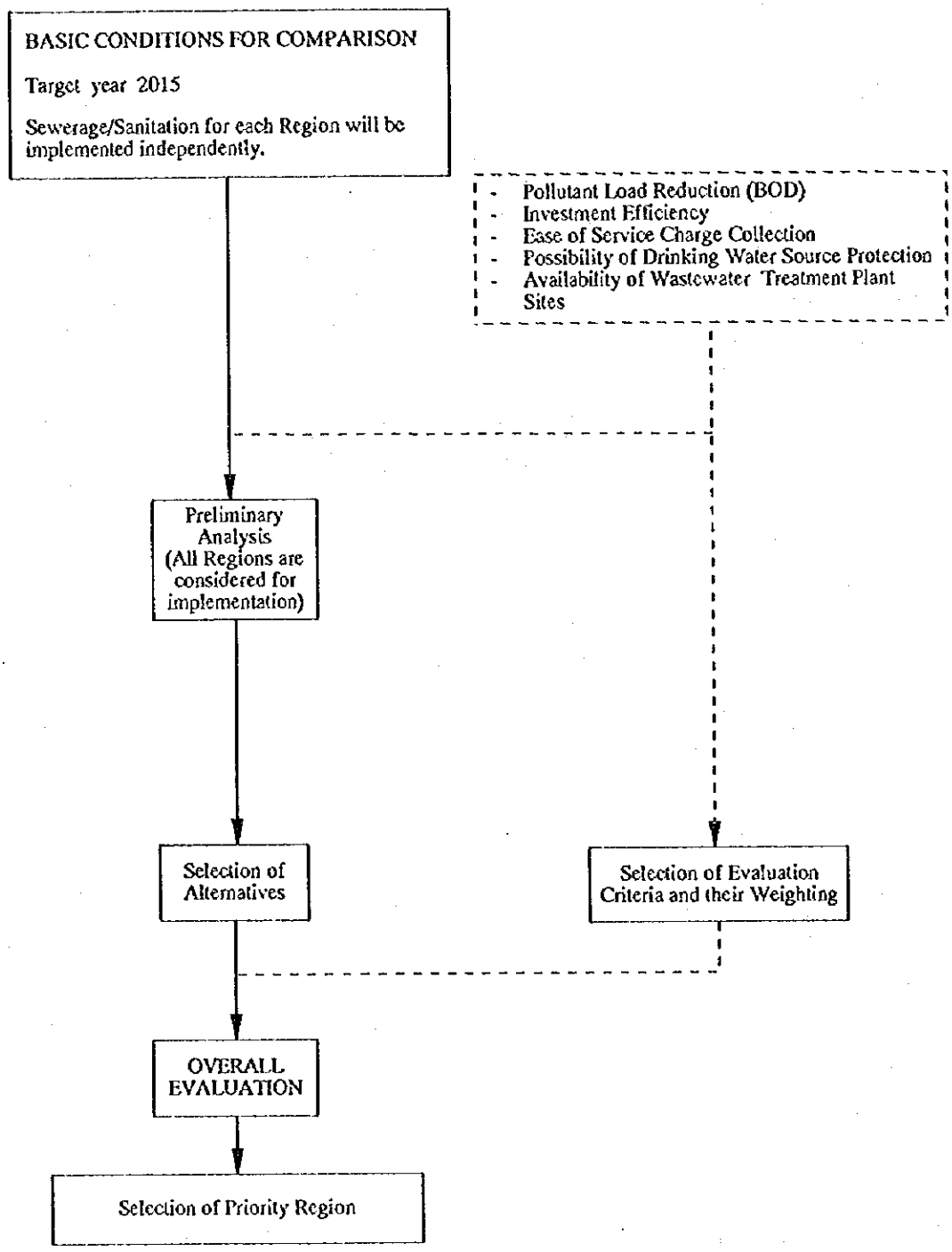
First Step : Selection of Alternatives
Second Step : Selection of Priority Regions

In the first step, on the assumption that sewerage/sanitation projects in each Region are implemented independently, a preliminary analysis was conducted to select alternative priority Regions.

The analysis examined the following parameters for the sewerage/sanitation projects of each Region :

- Level of pollutant load reduction,
- Investment efficiency,
- Willingness to pay,
- Contribution to drinking water source protection,

Fig. 11 - 1



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE FLOWCHART FOR SELECTION OF PRIORITY REGION

- Availability of wastewater treatment plant sites.

In the second step, Priority Regions were selected from the alternatives through an overall evaluation which examined the alternatives with respect to the parameters selected in the preliminary analysis and other factors.

11.2 PRELIMINARY ANALYSIS FOR SELECTION OF ALTERNATIVES

11.2.1 Summary of Sewerage/Sanitation Project for each Region

The principal data for sewerage/sanitation projects in each Region is summarized in Table 11-1.

11.2.2 Parameters for Preliminary Analysis

The parameters used for selecting alternatives were classified into five (5) quantitative and qualitative elements.

a) Quantitative Parameters

Pollutant Load Reduction (BOD): The expected reduction of pollutant discharge to water bodies, by the provision of sewerage/sanitation facilities, is estimated based on BOD removal efficiencies of 80 % and 75% for wastewater treatment plants and community level sanitation plants, respectively.

Investment Efficiency: Cost effectiveness was examined by considering two indices, "cost per unit pollutant load reduction" and "cost per capita served". The unit cost per pollutant load reduction was estimated by dividing the required total investment by the total waste load reduction. In the same manner, the cost efficiency for the population served was estimated. Because the calculated values of the two indices have no meaning in themselves, they are expressed for each Region relative to Central Region, which is taken as 100 for each parameters.

b) Qualitative Parameters

Willingness to Pay: Willingness to pay for sewerage/sanitation services, in terms of Q/household/month, for each of the Regions is based on the results obtained from the survey by the JICA Study Team.

Table 11-1 Summary of Principal Data for Project in each Region

Principal Data	Regions of Motagua River Basin					Regions of Lake Amatitlan			Total
	Central	North 1	North 2	East 1	East 2	South 1	South 2	South 3	
1. Population (Capita)									
Present Population (as of 1994)	505,000	180,000	70,000	251,000	31,700	40,000	83,000	139,000	1,299,700
Planned Population (2015)									
Sewerage	751,800	379,100	0	500,800	0	277,500	183,600	276,100	2,368,900
Sanitation	109,600	12,900	150,000	20,200	40,000	2,500	8,000	2,900	346,100
Total	861,400	392,000	150,000	521,000	40,000	280,000	191,600	279,000	2,715,000
2. Planned Area (ha)	7,227	2,232	740	3,935	1,155	1,648	2,293	2,414	21,644
3. Design Wastewater Flow Rate (m3/day)									
Sewerage System									
Daily Average Flow	237,757	88,899	0	120,382	0	63,983	50,969	65,734	627,724
Daily Maximum Flow	260,311	96,481	0	130,398	0	69,533	54,641	71,256	682,620
Hourly Maximum Flow	389,057	143,679	0	195,692	0	102,991	85,414	106,619	1,023,452
Sanitation System									
Daily Average Flow	18,084	2,129	24,750	3,333	6,600	413	1,320	479	57,108
Daily Maximum Flow	19,892	2,341	27,225	3,666	7,260	454	1,452	526	62,816
Hourly Maximum Flow	54,252	6,386	74,250	9,999	19,800	1,238	3,960	1,436	171,321
4. Estimated Pollutant Load Generation (BOD t/day)									
Sewerage	66.57	24.89	0.00	33.71	0.00	17.92	14.27	18.40	175.76
Sanitation	5.97	0.70	8.17	1.10	2.18	0.14	0.44	0.16	18.86
Total	72.54	25.59	8.17	34.81	2.18	18.06	14.71	18.56	194.62
Pollutant Load by Drainage Basin (BOD t/day)									
River Motagua Basin	72.54	25.59	8.17	34.81	2.18				143.29
Lake Amatitlan Basin						18.06	14.71	18.56	51.33
5. Cost Estimates									
Sewerage									
Construction (Million Quetzales)									
Sewers	136.4	172.3	0.0	200.2	0.0	112.5	95.4	183.4	900.2
Treatment Plant Secondary Treatment Level	232.3	93.7	0.0	116.8	0.0	59.1	47.6	70.7	620.2
Sub Total	368.7	266.0	0.0	317.0	0.0	171.6	143.0	254.1	1,520.4
Others	96.8	60.2	0.0	81.1	0.0	44.0	36.5	60.7	379.3
Total	465.5	326.2	0.0	398.1	0.0	215.6	179.5	314.8	1,899.7
Sanitation Facility									
Construction									
Sewers	33.0	1.9	12.0	9.9	56.3	0.4	3.2	1.9	118.6
Septic Tank Facility	41.6	4.9	56.7	7.9	15.1	1.1	3.0	1.1	131.4
Sub Total	74.6	6.8	68.7	17.8	71.4	1.5	6.2	3.0	250.0
Others	20.3	1.9	17.2	5.2	16.9	0.5	1.8	0.8	64.6
Total	94.9	8.7	85.9	23.0	88.3	2.0	8.0	3.8	314.6
Grand Total	560.4	334.9	85.9	421.1	88.3	217.6	187.5	318.6	2,214.3

Source : Study Team

Contribution to Drinking Water Source Protection: The likely beneficial effect of the sewerage/sanitation system on surface and underground water quality has been examined. The number of ground water wells and surface water intake facilities likely to be affected, and their respective flow rates, were investigated for each Region.

Availability of Wastewater Treatment Plant Sites: All of the Regions are classified into one of three ranks; i) A - good, ii) B - average, and iii) C - difficult, on the basis of the availability of suitable wastewater treatment plant sites.

11.2.3 Results of Preliminary Analysis

Results of the preliminary analysis are described below and summarized in Table 11-2.

a) Pollutant Loads Reduction

The total BOD_5 load generation in the M/P Area in 2015 is estimated to be 194.6 t/day, of which 143.3 t/day, (or 74%) and 51.3 t/day, (or 26%) will be generated in the Montagua River Basin and the Lake Amatitlan Basin respectively. The percentages shown in Figures 11-2 and 11-3 are as explained below:

All Regions: After the sewerage/sanitation facilities are fully implemented in all Regions, 80% of the total pollutant load generated will be removed prior to discharge to public water bodies. Higher pollutant load reduction is expected in Central, East 1, and North 1 Regions, where pollutant load generation is also high. Through implementing schemes in these Regions pollutant load reductions are estimated to be 30%, 14%, and 11% of the total generated pollutant load, and 37%, 18%, and 13% of the overall pollutant load reduction, respectively.

Motagua River Basin: Pollutant loads removed by implementation in Central and East 1 Regions are high compared with other Regions and are estimated to be 41% and 19% in the Motagua River Basin, and implementation of priority project in these Regions will achieve reductions of 51% and 24% of the overall pollutant load reduction for implementing all scmes in all the basin, respectively.

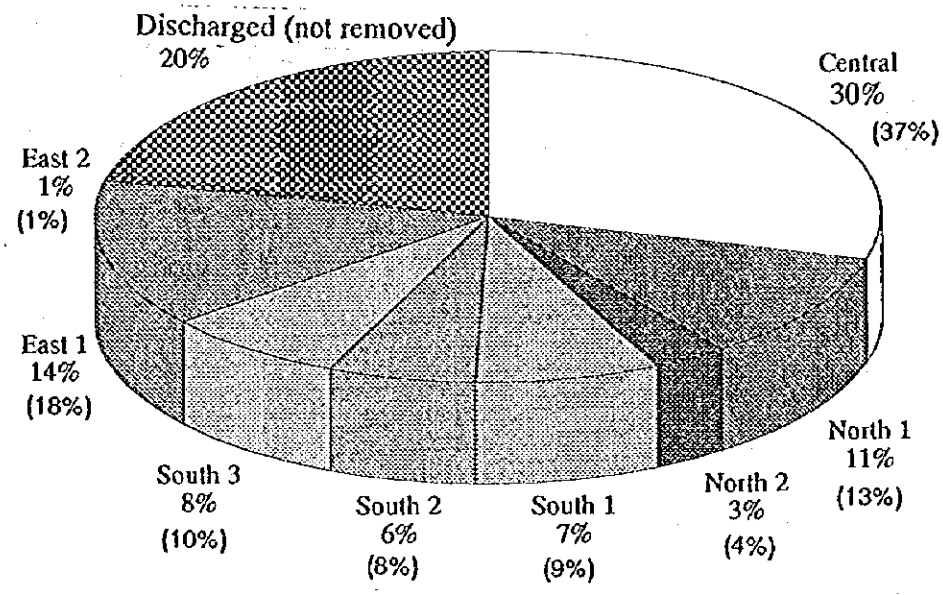
Lake Amatitlan Basin: Pollutant load reduction achieved by implementing schemes in South 3 and South 1 Regions are high compared with South 1 Region, and are estimated to contribute 29% and 28% of the total removable pollutant load, and implementation of priority project in these Regions can achieve reductions of 36% and 35% of the total removable pollutant load in the basin, respectively.

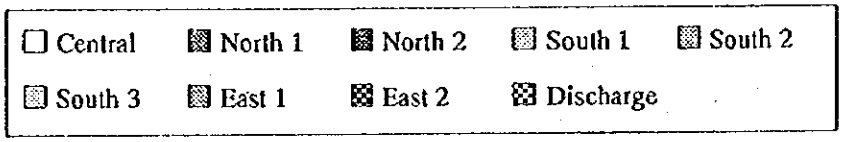
Table 11-2 Preliminary Analysis of Regions

Parameters	Regions of Motagua River Basin					Regions of Lake Amatitlan			Total
	Central	North 1	North 2	East 1	East 2	South 1	South 2	South 3	
Quantitative Parameters									
(a) Projected Pollutant Load Reduction (BOD t/day)									
Sewerage	53.26	19.91	0.00	26.97	0.00	14.34	11.42	14.72	140.58
Sanitation	4.48	0.53	6.13	0.83	1.64	0.11	0.33	0.12	14.18
Total	57.73	20.44	6.13	27.79	1.64	14.44	11.75	14.84	154.76
Pollutant Load Reduction by Drainage Basin (BOD t/day)									
River Motagua Basin	57.73	20.44	6.13	27.79	1.64				113.73
Lake Amatitlan Basin						14.44	11.75	14.84	41.03
(b) Investment Efficiency (in Case of Secondary Treatment)									
per Unit Pollutant Load Reduction (Central Region =100)	100	167	141	156	548	152	163	219	
per Capita Served (Central Region=100)	100	131	88	125	340	120	150	175	
Qualitative Parameters									
(c) Ease of Service Charge Collection									
Average Willingness to Pay (WTP : Quetzales/Household/Month)	11.3	9.8	10.1	13.2	11.2	12.0	17.4	16.0	
(d) Contribution to Drinking Water Source Protection									
Surface Water									
Number of Intake Facilities	-	1	-	1	-	-	-	2	
Intake Flow Rate (m3/day)		6,700		22,400				17,000	
Groundwater									
Number of Wells run by EMPAGUA	21	62	5	15	0	7	1	12	
Total Withdrawal Rate (m3/day)	49,272	45,069	5,156	31,122	-	6,677	1,526	98,658	
(e) Availability of Wastewater Treatment Plant Sites									
Ranking (A : Good, B : Average, C : Difficult)	B	A	B	B	B	B	B	C	

Source:Study Team

Fig. 11 - 2



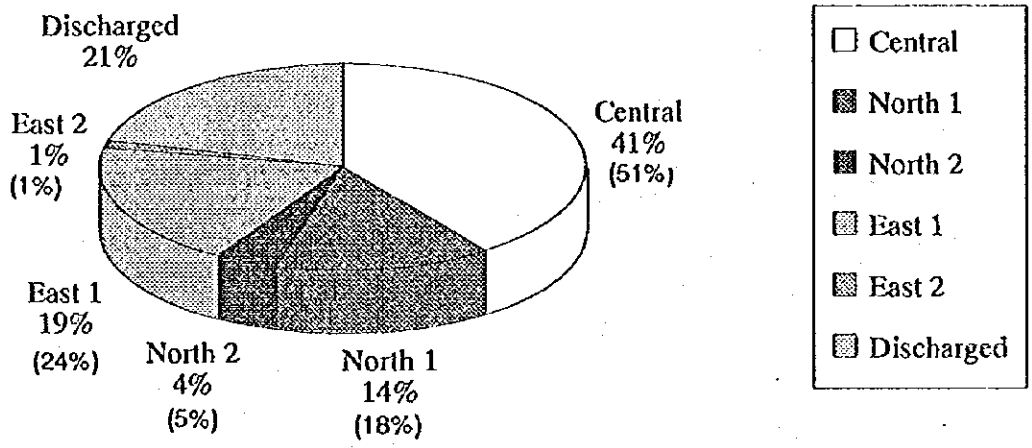


Figures in ( ) is the percentage of overall pollutant load reduction

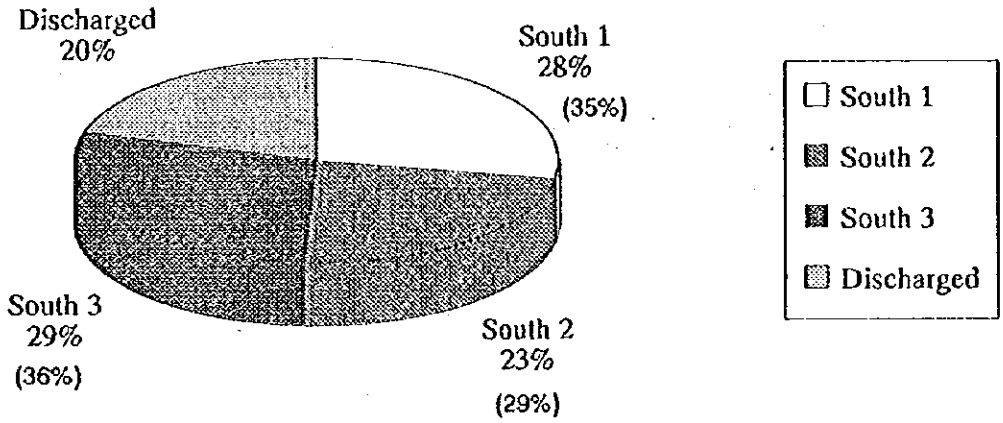
THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE ESTIMATED PERCENTAGE BOD LOAD REMOVAL AFTER FULL IMPLEMENTATION (1/2)

Fig. 11 - 3

River Motagua Basin



Lake Amatitlan Basin



Figures in ( ) is the percentage of overall pollutant load reduction

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE ESTIMATED PERCENTAGE BOD LOAD REMOVAL AFTER FULL IMPLEMENTATION (2/2)

b) Investment Efficiency

Two indices expressing investment efficiencies are compared for the sewerage/sanitation project of each Region. The results are shown in Table 11-2. For both indices, a lower value indicates a higher investment efficiency. It should be noted that Central and North 2 Regions, have relatively high investment efficiencies.

The reasons for higher investment efficiencies in Central and North 2 Regions are as follows:
Although Central Region has the disadvantage that the volume of wastewater and the pollutant load generation are higher than in other Regions, and the total amount of investment in sanitation facilities is the highest, it has the advantage that a significant proportion of the area is sewered, thus after the completion of construction of main sewerage facilities, sewerage services can be provided.

North 2 Region has the advantages that population density is high, sewers length required is shorter per capita and unit land acquisition cost is lower.

c) Ease of Service Charge Collection

The average level for "Willingness to Pay" for sewerage/sanitation services found from the survey by the JICA Study Team was 13.3 Q/household/month. From a comparison of the estimated average Willingness to Pay in each Region with the overall average, consumers in in South 2 and South 3 were willing to pay more for the services.

d) Contribution to Drinking Water Source Protection

In case of surface water, East 1 Region followed by South 3 Region is given high priority. While, in the case of groundwater, South 3 Region is the highest priority followed by Central and North 1 Regions.

e) Availability of Wastewater Treatment Plant Sites

The selected wastewater treatment plant sites were examined and ranked, taking into account required land area, present land use, number of land owners, and level of land acquisition cost.
North 1 Region was ranked A, South 3 Region C, while other Regions were ranked B.

11.2.4 Selection of Alternatives for Priority Regions

For selection of alternatives, the following parameters are taken into account.

- Pollutant load reduction,
- Investment efficiency,
- Protection of Lake Amatitlan
- Protection of water sources

From the results of the preceding preliminary analysis, ranking of the top three Regions is summarized in Table 11-3.

Table 11-3 Summary of Preliminary Analysis of Regions

Policy and Consytraints	Regions		
	Priority 1	Priority 2	Priority 3
A. Pollutant Load reduction			
Overall Priority	Central	East 1	North 1
Priority in Motagua Basin	Central	East 1	North 1
Priority in Lake Amatitlan Basin	South 3	South 1	South 2
B. Investment Efficiency			
(a) Unit Investment per Pollutant Load Reduced			
Priority in Motagua Basin	Central	North 2	East 1
Priority in Lake Amatitlan Basin	South 1	South 2	South 3
(a) Unit Investment per Served Population			
Priority in Motagua Basin	North 2	Central	East 1
Priority in Lake Amatitlan Basin	South 1	South 2	South 3
C. Protection of Lake Amatitlan			
Proximity of Discharge to Lake	South 3	South 2	South 1
D. Protectionn of Water Sources			
Overall Priority	South 3	Central	North 1
Priority in River Motagua Basin	Central	North 1	East 1
Priority in Lake Amatitlan Basin	South 3	South 1	South 2

Source : Study Team

The three combinations of Regions shown in Table 11-4 have been selected for further evaluation to select the Priority Regions.

Table 11-4 Selected Alternative Combinations of Regions

Alternative	Regions
B-1	Central + South 1
B-2	Central + South 2
B-3	Central + South 3

Source : Study Team

The reasons for selecting the alternatives are:

- For parameters a), b), and d) in the preliminary analysis Central Region is identified as being the highest priority Region
- Taking into account the importance of Government policy with respect to protection of Lake Amatitlan, the possible Regions to be combined with Central Region should be situated within the Lake Amatitlan (Pacific Drainage) Basin.

11.3 PRIORITY REGIONS

11.3.1 Criteria for Prioritization

In order to finalize selection of the Priority Regions, each of the three combination of Regions selected from the preliminary study, namely Central Region with South 1, South 2 or South 3, has been further evaluated to assess the investment efficiency and water quality improvement. For each parameter considered, a relative score of 1 to 5 is allocated which is further multiplied by a weighting to obtain a total. Other non-quantifiable factors such as the level of subsidy required, the level of likely public profile of the project to promote the government's efforts in environmental protection, impact of implementation of sewerage, etc. have also been evaluated.

11.3.2 Results of Evaluation

As shown in Table 11-5, each of the Regions was examined and graded for each parameter representing the degree of adequacy or shortage from a sewerage implementation priority viewpoints based on the evaluation criteria. The evaluation led to the following conclusions:

a) There are no significant distinctions between the alternatives. Alternative 3 has the highest scores followed by Alternative 2, and either could be included as priority Regions.

Table 11-5 Priority Evaluation of Regions

Evaluation Parameters	Weight	Alternative 1		Alternative 2		Alternative 3		Evaluation Basis	Points	
		Score	Total	Score	Total	Score	Total		High	Low
INVESTMENT EFFICIENCY										
- per unit poilutant load reduction	4	5	20	4	16	3	12		low	high
- per capita served	2	5	10	4	8	3	6		low	high
WATER QUALITY IMPROVEMENT										
Protection of water resources	4	2	8	1	4	5	20	Many / few water sources	many	few
Protection of Lake Amatitlan	3	4	12	3	9	5	15	Load reduction is high / low	many	few
APPEAL TO PUBLIC OF ENVIRONMENTAL PROTECTION MEASURES	3	3	9	4	12	5	15	Level of appeal is high /low	high	low
IMPACT OF IMPLEMENTATION OF PROJECTS (Return Rate of Results)	3	3	9	5	15	5	15	Speed is high / low	high	low
TOTAL SCORE			68		64		83			

Source : Study Team

b) Alternative 3 would contribute significantly to improving the water quality of Lake Amatitlan and will have high public appeal and demonstrate the governments eagerness for environmental improvement.

c) Alternative 3 covers many municipalities and has a high population thus, the provision of sewerage/sanitation would have a significant impact on the largest number of residents who would as a result better understand and appreciate the public administration's efforts for environmental protection.

The above analysis and discussion has led to the conclusion that Alternative 3 (Region South 3 Region has the highest score, representing the combined rating for all seven parameters, followed by Alternatives 2 (South 2 Region) and 1 (South 1 Region).

11.3.3 Recommended Priority Regions

It is concluded that while the rating system adopted above was in some respects, nevertheless it reasonably reflects and quantifies both present and future conditions in the Guatemala Metropolitan Area with respect to the need for sewerage/sanitation provision. The result is considered to be a good indication of the overall relative needs of the various Regions and should be used in determining the priority of the sewerage/sanitation system construction program.

Construction of sewerage/sanitation system in Central and South 3 Regions is recommended as the Priority Regions in the Wastewater Management Master Plan.

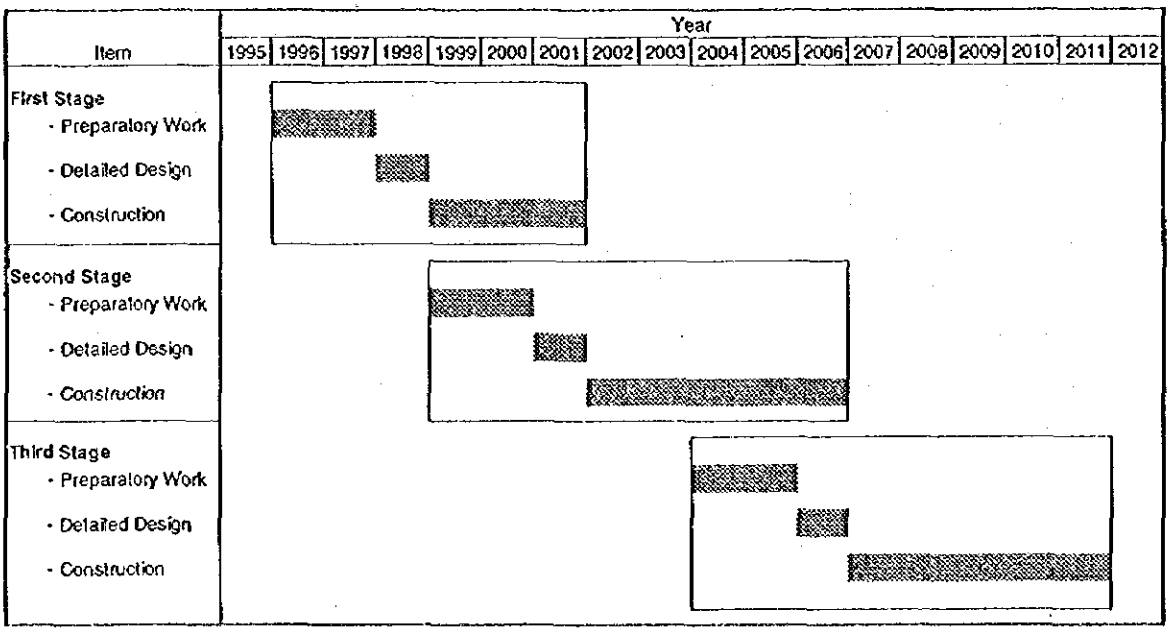
11.4 Development Plan of Priority Regions

11.4.1 Implementation Schedule

For determining the staging of the sewerage and sanitation construction program, components of the construction process and necessary preparatory work are taken into consideration.

It is assumed that the construction program to build the sewerage / sanitation system will start in 1999 for the priority Regions of Central and South 3. The whole program period is divided into three consecutive stages; the first stage program being from 1999 to 2001, the second stage from 2002 to 2006, and the third stage from 2007 to 2011. The schedule is summarized in Fig.11-4. This phasing, with its inherent flexibility, will permit periodic re-evaluation as required.

Fig. 11 - 4



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE CONSTRUCTION PROGRAM FOR SEWERAGE / SANITATION SYSTEM

11.4.2 Staged Implementation

The sewerage and sanitation construction program will consist of two interrelated components; the wastewater collection and treatment facilities. Each component has its place in the construction program recommendations, based on estimated requirements for the particular period.

The basic facilities of the wastewater system to be constructed first are the main collector sewers and wastewater treatment plants. After completion of these common facilities, it is possible to be flexible in progressing to serve the various areas within the sewerage Regions by connecting the existing and new sewer reticulations to these interceptors or collectors.

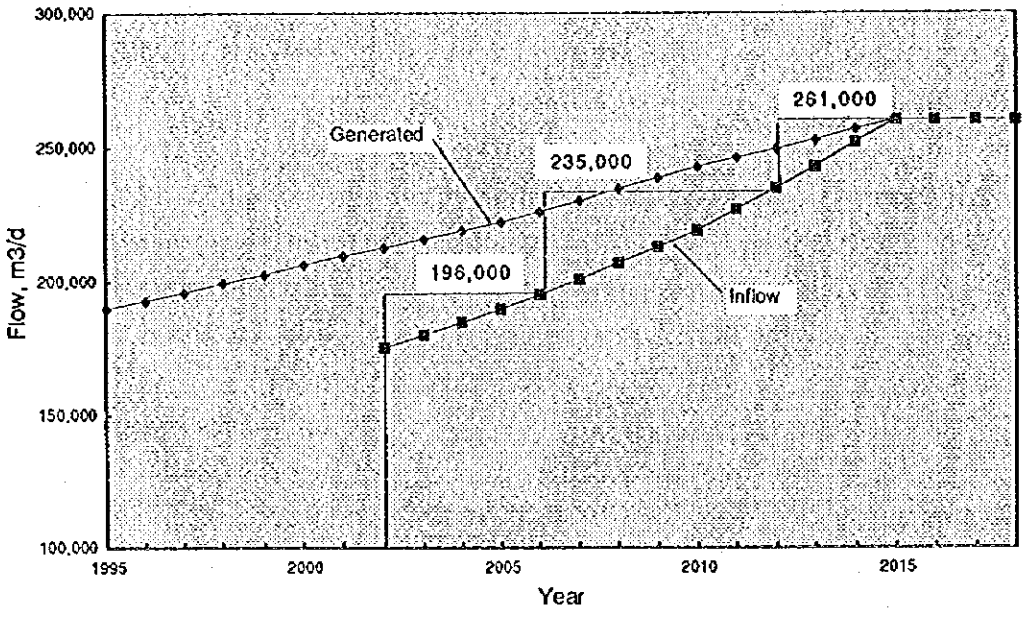
The development of treatment capacity for wastewater treatment plants is determined to be increased in stages to suit projected inflow. The stages of increasing treatment capacity for plants for Central and South 3 Regions, are shown in Fig.11-5. The program for the sanitation system comprises construction of branch and lateral sewers, and community treatment plants.

a) First Stage Construction Program (1999 to 2001)

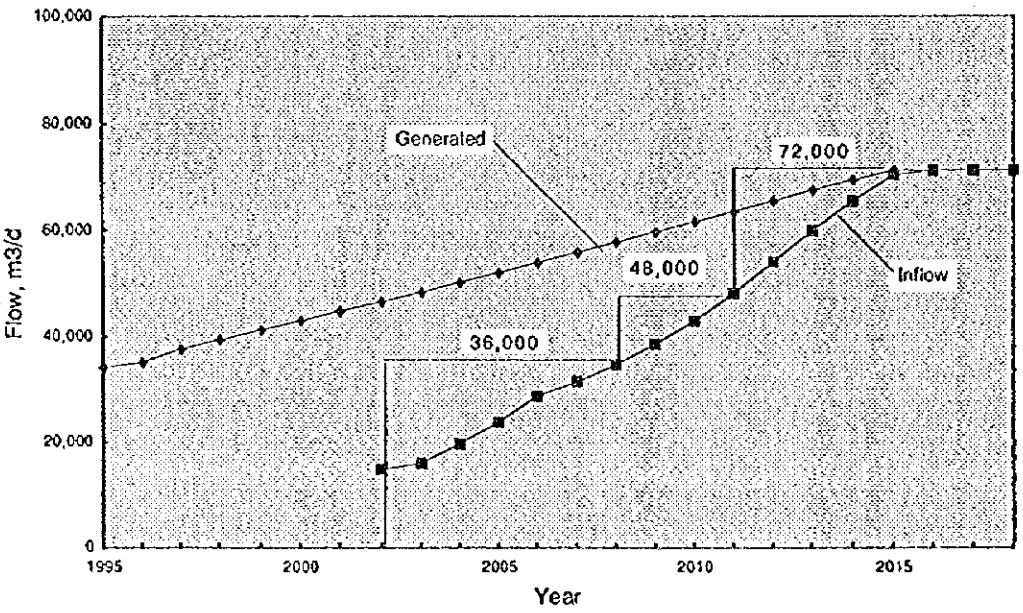
It is recommended that implementation of the first stage start by 1999 and end by 2001. The components of sewerage works including main collector sewers of about 25 km, branch lateral sewers, primary treatment and common facilities, (such as the control room, access road etc), with daily maximum treatment capacities of 195,800 m^3/day for Central Region, and secondary treatment and common facilities with daily maximum treatment capacities of 35,600 m^3/day for South 3 Region. The sanitation system program will comprise the construction of 35 community treatment plants in Central Region and 3 in South 3 Region, each rated at 1,000 persons capacity, with small sewer reticulations to transport the wastewater to the plants. The components of the first stage construction program are summarized in Table 11-6.

Fig. 11 - 5

Projected Total Amount of Wastewater Generated and Projected Inflow to Wastewater Treatment Plant - Central Region



Projected Total Amount of Wastewater Generated and Projected Inflow to Wastewater Treatment Plant - South 3 Region



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE STAGES FOR INCREASING TREATMENT CAPACITY IN CENTRAL AND SOUTH 3 REGIONS

Table 11-6 Proposed First Stage Construction Program

Component Facilities	Central Region	South 3 Region
1. Sewerage System		
Main Collector Sewers	3,000 mm dia. x 10.1 km	300 to 1,500 mm dia. x 15.5 km
Branch & Lateral Sewers	—	Reticulations to Main Collector Sewers
Wastewater Treatment Plants	Land Acquisition	Land Acquisition
"	Common Facilities	Common Facilities
"	Primary Treatment, 15 trains	Secondary Treatment, 3 trains
2. Sanitation System		
Branch and Lateral Sewers	Approximately 56 km	Approximately 10km
Community Treatment Plants	Land Acquisition for 35 plants	Land Acquisition for 3 plants
	Construction of 35 plants	Construction of 3 plants

Source : Study Team

b) Second Stage Construction Program (2002 to 2006)

With completion of the wastewater collection and disposal systems scheduled for the first stage, it is proposed that the second stage construction program from 2004 to 2006 be based on the current projection of development. During this construction stage, main collector sewers, part of the secondary treatment facilities and additional primary treatment facilities will be provided in Central Region and an additional train in South 3 Region. For the sanitation system, 35 community treatment plants in Central Region and connecting small sewer reticulations will be built. The components to be built are summarized in Table 11-7.

Table 11-7 Proposed Second Stage Construction Program

Component Facilities	Central Region	South 3 Region
1. Sewerage System		
Main Collector Sewers		200 to 1,500 mm dia. x 21.48 km
Branch & Lateral Sewers	Connection to Main Collector Sewers	Reticulations to Main Collector Sewers
Wastewater Treatment Plant	Primary Treatment 3 trains	Primary Treatment 1 train
"	Secondary Treatment 10 trains	Secondary Treatment 1 train
2. Sanitation System		
Branch and Lateral Sewers	Approximately 56 km	—
Community Treatment Plants	Land Acquisition for 35 plants	—
"	Construction of 35 plants	—

Source : Study Team

c) Third Stage Construction Program (From 2007 to 2011)

Following completion of the second stage construction, it is scheduled that the third stage start in 2007 and end by 2011. During this stage, the remaining main, branch and lateral sewers, and wastewater treatment plant trains will be constructed. When these are completed, a total of 1,140,400 people within the Central and South 3 Regions will have easy access to the sewerage and sanitation system by the year 2015. The wastewater system components to be provided under this stage are summarized in Table 11-8.

Table 11-8 Proposed Third Stage Construction Program

Component Facilities	Central Region	South 3 Region
1. Sewerage System		
Main Collector Sewers	—	—
Branch & Lateral Sewers	Reticulations to Main Collector Sewers	Reticulations to Main Collector Sewers
Wastewater Treatment Plant	Primary Treatment 2 trains	Primary Treatment 2 trains
"	Secondary Treatment 10 trains	Secondary Treatment 2 trains
2. Sanitation System		
Branch and Lateral Sewers	Approximately 65 km	—
Community Treatment Plants	Land Acquisition for 40 plants	—
"	Construction of 40 plants	—

Source : Study Team

11.4.3 Investment Program

The recommended plan for implementing sewerage and sanitation systems calls for construction, operation and maintenance in three construction stages. Table 11-9 shows the construction cost for each period, including both local and foreign currency portions. Operation and maintenance costs by stage are also summarized in Table 11-10.

a) Construction Costs

Total construction cost of the sewerage and sanitation facilities for the three stages is estimated to be Q 879.0 million at mid-1995 prices in Guatemala, but no cost escalation is considered. All construction costs include allowances for physical contingencies of 10 percent, administration fees of 3 percent, and engineering fees of 6 percent. Rates for construction of each size of sewer were derived from unit costs which correspond to the size and depth. Costs for the treatment plants were derived from unit costs developed for both civil works and equipment, assuming that most materials for civil works will be available in Guatemala whereas some equipment will be imported.

Table 11-9 Construction Costs by Stage

(Units: Million Quetzal)

Components	First Stage (1999 - 2001)	Second Stage (2002 - 2006)	Third Stage (2007 - 2011)	Total
1. Sewerage System				
Central Region	162.3	154.0	149.2	465.5
South 3 Region	103.5	97.7	113.6	314.8
Sub-Total	265.8	251.7	262.8	780.3
2. Sanitation System				
Central Region	30.1	30.1	34.7	94.9
South 3 Region	3.8	0.0	0.0	3.8
Sub-total	33.9	30.1	34.7	98.7
3. Grand Total	299.7	281.8	297.5	879.0

Source : Study Team

b) Operation and Maintenance Costs

Operation and maintenance costs for sewers and treatment plants are estimated on the basis of labor required, the cost of transportation of sludge and of call-out repairs of the facilities.

The labor and transportation costs are assumed to be proportional to the level of facility development and the projected inflow rate to treatment plants. Repair costs are estimated to

be 0.5% of direct construction cost of the facilities.

The annual Operation and Maintenance costs for sewerage and sanitation systems are estimated and summarized in Table 11-10.

Table 11-10 Annual O/M Costs by Region

(Units: Thousand Quetzal)

Year	Central Region			South 3 Region			Grand Total
	Sewerage	Sanitation	Total	Sewerage	Sanitation	Total	
2002	3,736	151	3,887	996	79	1,075	4,962
2003	3,850	200	4,050	1,113	79	1,192	5,242
2004	3,969	266	4,235	1,241	79	1,320	5,555
2005	4,088	333	4,421	1,372	79	1,451	5,872
2006	4,212	399	4,611	1,506	79	1,585	6,196
2007	5,158	462	5,620	1,749	79	1,828	7,448
2008	5,282	528	5,810	1,909	79	1,988	7,798
2009	5,404	587	5,991	2,104	79	2,183	8,174
2010	5,527	653	6,180	2,270	79	2,349	8,529
2011	5,660	724	6,384	2,441	79	2,520	8,904
2012	6,536	776	7,312	2,728	79	2,807	10,119
2013	6,582	818	7,400	2,782	79	2,861	10,261
2014	6,628	849	7,477	2,806	79	2,885	10,362
2015	6,668	880	7,548	2,856	79	2,935	10,483
2016	6,672	897	7,569	2,859	79	2,938	10,507
2017	6,674	903	7,577	2,859	79	2,938	10,515
2018	6,675	908	7,583	2,859	79	2,938	10,521

Source : Study Team

11.5 EVALUATION OF PROJECTS IN PRIORITY REGIONS

11.5.1 Technical Evaluation

The technical soundness of the proposed wastewater management facilities is examined with respect to the following points of view;

- Appropriate technology level,
- Likely ease of project implementation given the local technical level,
- Soundness of operation and maintenance required to run the proposed system.

a) Wastewater Collection Facilities

The proposed wastewater collection system is a gravity system, which requires no mechanical and electrical equipment and no power supply. The Operation and Maintenance is easy and low cost.

Large collector sewers bigger than 1,500 mm diameter, and manholes, (vertical shafts), will be constructed by tunneling.

The existing collectors in the Central Region were constructed by the tunneling method. EMPAGUA has experience and confidence in tunnel construction. Thus, it is appropriate to apply tunneling technology to construct the proposed collectors.

b) Wastewater Treatment Facilities

The wastewater treatment process applied to sewerage and sanitation systems are trickling filter and septic tank with adsorption well / anaerobic filter, respectively. Small scale of trickling filter installations and septic tanks exist and operate in Guatemala.

The proposed systems are easy to construct with locally available materials, and do not require imported mechanical and electrical equipment. The O/M of the proposed systems is easy, and low cost, and there is local practical experience and knowledge accumulated from the existing facilities. Thus, it can be evaluated that the proposed wastewater treatment facilities are technically sound.

c) Sludge Treatment Facility

It is proposed that sludge from the sanitation system be transferred to the proposed wastewater treatment plants for further treatment. The sludge treatment process proposed consists of anaerobic digesters, without covers or heating, and sludge drying beds.

This process is being used in existing facilities, and operational experience and knowledge has been accumulated. The O/M of the process is easy and low in cost. Thus, it can be evaluated that the proposed sludge treatment facilities are technically sound.

11.5.2 Financial Evaluation

a) Charges for Sewage Service

The charge for sewage service is estimated on the basis of water service charge as surcharge. According to the present tariff, the surcharge is 20% of water service charge.

In order to know an average unit charge for water and sewage services, typical users are classified into, i.e., domestic, commercial and industrial users. Since planned unit wastewater generation (daily average) is as 200 lpcd and an average family size is calculated as 5.3 persons, a monthly wastewater generation volume of a household is estimated at 32 m^3/month on average. This value of 32 m^3/month/household is used as wastewater discharge from a typical household, i.e. average water consumption. Based on this volume, the EMPAGUA's tariff expected to be effective in January 1995 says that unit water service charge is Q0.80/m^3, so unit sewage service charge is calculated at Q0.16/m^3 (20% of Q0.80/m^3). For commercial and industrial users, the estimated unit sewage service charge is Q0.40/m^3 and Q0.50/m^3, respectively.

The annual revenue is estimated as a product of annual wastewater discharge volume of individual consumers and the unit sewage service charge for the corresponding consumers. Table 11-11 shows the annual revenue accruing from both Central and South 3 Regions in the years 2002 and 2015.

Table 11-11 Basic Information of Sewage Service Revenue under Present Tariff

User Category	Average Discharge (m^3/Conn./month)	Unit Charge*1 (Q/m^3)	In-flow Volume (10^5 m3/year) 2002	In-flow Volume (10^5 m3/year) 2015	Revenue (Q million/year) 2002	Revenue (Q million/year) 2015
Central Region						
Domestic*2	32	0.16	36.6	61.2	5.9	9.8
Commercial*2	70	0.40	17.4	26.1	6.9	10.4
Industrial	200	0.50	1.7	1.7	0.8	0.8
Total	-	-	55.7	89.0	13.6	21.0
South 3 Region						
Domestic*2	32	0.16	3.7	18.5	0.6	3.0
Commercial*2	70	0.40	0.4	1.8	0.2	0.7
Industrial	200	0.50	0.8	0.8	0.4	0.4
Total	-	-	4.9	19.3	1.2	4.1

Note: *1 Applying the tariff of EMPAGUA
*2 Wastewater discharges balance between domestic and commercial establishments was assumed to be the same as the present one.
Source : Study Team

According to the results of the "Public Attitude Survey", the average monthly charge that a household could pay for sewage service was calculated at Q13.3. The monthly water consumption volume was calculated at 27 m^3 on average, thus, the estimated unit sewage service charge that a household could pay is Q0.49/m^3. Applying this unit charge instead of that based on the present tariff (Q0.16/m^3), the revenue would be around three (3) times than that at present.

Mark-up of service charges would be indispensable for implementation of the newly proposed project. Although the range of the mark-up will be discussed more specifically and realistically in the following section, two sewage service charge options are set up as follows to examine the viability of the proposed project.

The two sewage service charge options are set up based on connection basis, because of limited information. Under the tariff revised in January 1995, an average sewage service charge is estimated at around Q10 per connection per month, according to the analysis of EMPAGUA's income statements in 1994 which was discussed in Supporting Report H, Volume III.

- Charge I: Two times of the present average charge i.e., Q20 per connection per month on average.
  It is to be noted that in Central Region, a half of the charge, goes for the maintenance work of existing sewer network by EMPAGUA, and the rest half (Q10/connection/month) of the charges applied for the management of the proposed project. While in the South 3 Region, since the sewerage system is almost new all sewage service charges accruing from the beneficiaries are appropriated for the proposed project.
- Charge II: three (3) times of the present charge, i.e., Q30 per connection per month on average.
  In Central Region, Q10/connection/month, is used for the maintenance of the existing piping network, the remaining Q20/ connection/month is appropriated for the proposed project.
  In South 3 Region, all sewage service charge, Q30/connection/month is appropriated for the proposed project.

b) Financial Viability of Proposed Project for Priority Regions

The project proposed is examined in terms of its viability from the financial point of view in this section. Its financial construction costs were estimated in detail in Section 9.3 and Section 10.4. Operation and maintenance costs were also estimated in those Sections. The costs were estimated on the basis of unit prices as of September 1995. Their investment program was explained in the pervious Section 11.4 in this Chapter.

The financial revenues is estimated as a total of a product of (i) wastewater volume from each connection category and (ii) unit sewage service charge for the corresponding connection category. The wastewater volume by connection category such as domestic and industrial users are summarized in Supporting Report A, Volume III. The unit service charge is based on Charge I and II, mentioned in the above section.

Comparing the revenue with the above costs, the financial internal rate of return (FIRR) for gross capital is calculated as shown in Table 11-12 for Charge I option and Table 11-13 for Charge II option, respectively. The evaluation period was set within an economic life of the facilities, which was assumed to be 30 years after the completion of construction work. As shown in Table 11-12, FIRR under Charge I is negative, -1.1%. This means that the total revenue expected for the project life is smaller than the total costs of construction and O/M expenses for the project life.

On the other hand, although FIRR under Charge II is not so large, FIRR is positive, 4.1%, as shown in Table 11-13. This value is smaller than the interest rates of IBRD (7.72%) and IDB (8.1%) which were listed in Table 5-17. Therefore, even if the beneficiaries would accept the service charges based on the analysis of the "Public Attitude Survey", the proposed project could not be viable from the financial point of view.

In order that the proposed project reaches the financially viable level of around 8%, one of the most effective countermeasures is receipt of subsidy or grant. The difficulty of the project implementation is caused by the financial burden of South 3 Region schemes. When 40% of the total construction costs was granted to mitigate this burden, FIRR would be 8.4%. In this case, the total of subsidy or grant amounted to around Q350 million, which corresponds to 1.1 times of the total sewerage system construction costs (Q315 million) of South 3 Region schemes. The financial stream of this case is shown in Table 11-14.

Table 11-12 Financial Expenditure and Revenue Stream of Proposed Project Under Charge I

(Unit:Q1000)

Serial No.	Year	Expenditure			Revenue			Balance
		Construction	O/M	Total	Domestic	Industrial	Total	
1	1999	99,900	0	99,900	0	0	0	-99,900
2	2000	99,900	0	99,900	0	0	0	-99,900
3	2001	99,900	0	99,900	0	0	0	-99,900
4	2002	56,300	4,962	61,262	14,371	1,672	16,042	-45,220
5	2003	56,300	5,242	61,542	14,939	1,672	16,610	-44,932
6	2004	56,300	5,555	61,855	15,833	1,672	17,504	-44,351
7	2005	56,300	5,872	62,172	16,781	1,672	18,453	-43,719
8	2006	56,600	6,196	62,796	17,888	1,672	19,560	-43,236
9	2007	59,500	7,448	66,948	18,735	1,672	20,407	-46,541
10	2008	59,500	7,798	67,298	19,652	1,672	21,324	-45,974
11	2009	59,500	8,174	67,674	20,626	1,672	22,298	-45,376
12	2010	59,500	8,529	68,029	21,684	1,672	23,355	-44,674
13	2011	59,500	8,904	68,404	22,975	1,672	24,647	-43,757
14	2012		10,119	10,119	24,370	1,672	26,042	15,923
15	2013		10,261	10,261	25,759	1,672	27,431	17,170
16	2014		10,362	10,362	27,169	1,672	28,841	18,479
17	2015		10,483	10,483	28,381	1,672	30,053	19,570
18	2016		10,507	10,507	28,521	1,672	30,192	19,685
19	2017		10,515	10,515	28,533	1,672	30,205	19,690
20	2018		10,521	10,521	28,546	1,672	30,217	19,696
21	2019		10,521	10,521	28,546	1,672	30,217	19,696
22	2020		10,521	10,521	28,546	1,672	30,217	19,696
23	2021		10,521	10,521	28,546	1,672	30,217	19,696
24	2022		10,521	10,521	28,546	1,672	30,217	19,696
25	2023		10,521	10,521	28,546	1,672	30,217	19,696
26	2024		10,521	10,521	28,546	1,672	30,217	19,696
27	2025		10,521	10,521	28,546	1,672	30,217	19,696
28	2026		10,521	10,521	28,546	1,672	30,217	19,696
29	2027		10,521	10,521	28,546	1,672	30,217	19,696
30	2028		10,521	10,521	28,546	1,672	30,217	19,696
31	2029		10,521	10,521	28,546	1,672	30,217	19,696
32	2030		10,521	10,521	28,546	1,672	30,217	19,696
33	2031		10,521	10,521	28,546	1,672	30,217	19,696
34	2032		10,521	10,521	28,546	1,672	30,217	19,696
35	2033		10,521	10,521	28,546	1,672	30,217	19,696
36	2034		10,521	10,521	28,546	1,672	30,217	19,696
37	2035		10,521	10,521	28,546	1,672	30,217	19,696
38	2036		10,521	10,521	28,546	1,672	30,217	19,696
39	2037		10,521	10,521	28,546	1,672	30,217	19,696
40	2038		10,521	10,521	28,546	1,672	30,217	19,696
41	2039		10,521	10,521	28,546	1,672	30,217	19,696
42	2040		10,521	10,521	28,546	1,672	30,217	19,696
43	2041		10,521	10,521	28,546	1,672	30,217	19,696

FIRR : -1.1%

Table 11-13 Financial Expenditure and Revenue Stream of Proposed Project Under Charge II

(Unit:Q1000)

Serial No.	Year	Expenditure			Revenue			Balance
		Construction	O/M	Total	Domestic	Industrial	Total	
1	1999	99,900	0	99,900	0	0	0	-99,900
2	2000	99,900	0	99,900	0	0	0	-99,900
3	2001	99,900	0	99,900	0	0	0	-99,900
4	2002	56,300	4,962	61,262	28,116	2,936	31,052	-30,210
5	2003	56,300	5,242	61,542	29,251	2,936	32,187	-29,355
6	2004	56,300	5,555	61,855	30,934	2,936	33,870	-27,985
7	2005	56,300	5,872	62,172	32,696	2,936	35,632	-26,540
8	2006	56,600	6,196	62,796	34,727	2,936	37,663	-25,133
9	2007	59,500	7,548	67,048	36,346	2,936	39,282	-27,766
10	2008	59,500	7,798	67,298	38,077	2,936	41,014	-26,284
11	2009	59,500	8,174	67,674	39,875	2,936	42,811	-24,863
12	2010	59,500	8,529	68,029	41,820	2,936	44,756	-23,273
13	2011	59,500	8,904	68,404	44,186	2,936	47,123	-21,281
14	2012		10,119	10,119	46,714	2,936	49,650	39,531
15	2013		10,261	10,261	49,240	2,936	52,176	41,915
16	2014		10,362	10,362	51,792	2,936	54,729	44,367
17	2015		10,483	10,483	53,994	2,936	56,930	46,447
18	2016		10,507	10,507	54,259	2,936	57,196	46,689
19	2017		10,515	10,515	54,296	2,936	57,233	46,718
20	2018		10,521	10,521	54,334	2,936	57,270	46,749
21	2019		10,521	10,521	54,334	2,936	57,270	46,749
22	2020		10,521	10,521	54,334	2,936	57,270	46,749
23	2021		10,521	10,521	54,334	2,936	57,270	46,749
24	2022		10,521	10,521	54,334	2,936	57,270	46,749
25	2023		10,521	10,521	54,334	2,936	57,270	46,749
26	2024		10,521	10,521	54,334	2,936	57,270	46,749
27	2025		10,521	10,521	54,334	2,936	57,270	46,749
28	2026		10,521	10,521	54,334	2,936	57,270	46,749
29	2027		10,521	10,521	54,334	2,936	57,270	46,749
30	2028		10,521	10,521	54,334	2,936	57,270	46,749
31	2029		10,521	10,521	54,334	2,936	57,270	46,749
32	2030		10,521	10,521	54,334	2,936	57,270	46,749
33	2031		10,521	10,521	54,334	2,936	57,270	46,749
34	2032		10,521	10,521	54,334	2,936	57,270	46,749
35	2033		10,521	10,521	54,334	2,936	57,270	46,749
36	2034		10,521	10,521	54,334	2,936	57,270	46,749
37	2035		10,521	10,521	54,334	2,936	57,270	46,749
38	2036		10,521	10,521	54,334	2,936	57,270	46,749
39	2037		10,521	10,521	54,334	2,936	57,270	46,749
40	2038		10,521	10,521	54,334	2,936	57,270	46,749
41	2039		10,521	10,521	54,334	2,936	57,270	46,749
42	2040		10,521	10,521	54,334	2,936	57,270	46,749
43	2041		10,521	10,521	54,334	2,936	57,270	46,749

FIRR : 4.1%

Table 11-14 Financial Expenditure and Revenue Stream of Proposed Project Under Charge II with Subsidy of 40% Construction Cost

(Unit:Q1000)

Serial No.	Year	Expenditure			Revenue			Balance
		Construction	O/M	Total	Domestic	Industrial	Total	
1	1999	59,940	0	59,940	0	0	0	-59,940
2	2000	59,940	0	59,940	0	0	0	-59,940
3	2001	59,940	0	59,940	0	0	0	-59,940
4	2002	33,780	4,962	38,742	28,116	2,936	31,052	-7,690
5	2003	33,780	5,242	39,022	29,251	2,936	32,187	-6,835
6	2004	33,780	5,555	39,335	30,934	2,936	33,870	-5,465
7	2005	33,780	5,872	39,652	32,696	2,936	35,632	-4,020
8	2006	33,960	6,196	40,156	34,727	2,936	37,663	-2,493
9	2007	35,700	7,548	43,248	36,346	2,936	39,282	-3,966
10	2008	35,700	7,798	43,498	38,077	2,936	41,014	-2,484
11	2009	35,700	8,174	43,874	39,875	2,936	42,811	-1,063
12	2010	35,700	8,529	44,229	41,820	2,936	44,756	527
13	2011	35,700	8,904	44,604	44,186	2,936	47,123	2,519
14	2012		10,119	10,119	46,714	2,936	49,650	39,531
15	2013		10,261	10,261	49,240	2,936	52,176	41,915
16	2014		10,362	10,362	51,792	2,936	54,729	44,367
17	2015		10,483	10,483	53,994	2,936	56,930	46,447
18	2016		10,507	10,507	54,259	2,936	57,196	46,689
19	2017		10,515	10,515	54,296	2,936	57,233	46,718
20	2018		10,521	10,521	54,334	2,936	57,270	46,749
21	2019		10,521	10,521	54,334	2,936	57,270	46,749
22	2020		10,521	10,521	54,334	2,936	57,270	46,749
23	2021		10,521	10,521	54,334	2,936	57,270	46,749
24	2022		10,521	10,521	54,334	2,936	57,270	46,749
25	2023		10,521	10,521	54,334	2,936	57,270	46,749
26	2024		10,521	10,521	54,334	2,936	57,270	46,749
27	2025		10,521	10,521	54,334	2,936	57,270	46,749
28	2026		10,521	10,521	54,334	2,936	57,270	46,749
29	2027		10,521	10,521	54,334	2,936	57,270	46,749
30	2028		10,521	10,521	54,334	2,936	57,270	46,749
31	2029		10,521	10,521	54,334	2,936	57,270	46,749
32	2030		10,521	10,521	54,334	2,936	57,270	46,749
33	2031		10,521	10,521	54,334	2,936	57,270	46,749
34	2032		10,521	10,521	54,334	2,936	57,270	46,749
35	2033		10,521	10,521	54,334	2,936	57,270	46,749
36	2034		10,521	10,521	54,334	2,936	57,270	46,749
37	2035		10,521	10,521	54,334	2,936	57,270	46,749
38	2036		10,521	10,521	54,334	2,936	57,270	46,749
39	2037		10,521	10,521	54,334	2,936	57,270	46,749
40	2038		10,521	10,521	54,334	2,936	57,270	46,749
41	2039		10,521	10,521	54,334	2,936	57,270	46,749
42	2040		10,521	10,521	54,334	2,936	57,270	46,749
43	2041		10,521	10,521	54,334	2,936	57,270	46,749

FIRR : 8.4%

c) Financial Soundness of Undertaker

As discussed in the previous section, the proposed project would be viable if the sewage service charges Charge II, was applied and 40% of the total investment cost was subsidized or granted by the governments. To manage the project soundly, a short-term loan is also considered to cover an annual financial shortage. Hence, the terms of loans are assumed as follows:

(1) Long-term foreign loan: interest rate of 8.1% per annum and repayment period of 20 years including grace period of 5 years.

(2) Short-term loan: interest rate of 10% per annum as working fund, in case of covering short-time financial shortage.

The cash balance for the proposed project is shown in Table 11-15. It reveals that for the undertaker EMPAGUA to accomplish the proposed project financially sound for the economic life, 66% of the interest of the long-term loan has to be subsidized by the governments. Otherwise, the interest of short-time loan might lead a heavy burden to the management of the project in the future. As seen in the table, it would become the maximum Q264 million in the year 2026, 28 years after the embarkation of the project. However, once EMPAGUA get subsidy to cover the interest, it can get some cash surplus (Q40 million) at the end of the project life, as shown in the Table.

d) Household Budget of Domestic Users

In the "Public Attitude Survey", the monthly income of households were classified into the following three levels: high income class, (of more than Q5,000); middle income class, (of between Q2,001 and Q5,000); and low income class, (of less than Q2,000). In the survey, the average volume of water consumption (wastewater discharge) was analyzed as follows: 43 m^3/month for high income class; 25 m^3/month for middle income class; and 23 m^3/month for low income class. Table 11-16 shows the level of sewage service charges as a percentage of household income by income class. Hence, each family is assumed to discharge the aforesaid volume of wastewater.

Table 11-15 Financial Stream of Income and Expenditure of Proposed Project
Under Charge II with Subsidy of 40% Construction Cost and Long-Term Loan of 60% Construction Cost

(Unit: ¥ Million)

Serial No.	Year	Capital Balance							Revenue Balance										Working Fund (W/F)		Cash Balance *1	Balance Carried Forward
		Revenue			Expenditure			Balance	Revenue				Expenditure					Balance				
		Foreign Loan*4	Subsidy (40%)	Total	Construction Cost	Repayment of Principal	Total		Domestic Sewage	Industry Sewage	Subsidy *2	Total	O/M Expenses	Depreciation	Interest of Loan	Interest of W/F*3	Total		Procurement	Repayment		
1	1999	60	40	100	100	0	100	0	0	0	3	3	0	0	5	0	5	-2	2	0	0	0
2	2000	60	40	100	100	0	100	0	0	0	6	6	0	0	10	1	10	-4	6	2	0	0
3	2001	60	40	100	100	0	100	0	0	0	10	10	0	0	15	1	16	-6	12	6	0	0
4	2002	34	23	56	56	0	56	0	28	3	11	42	5	5	17	0	28	15	0	12	3	3
5	2003	34	23	56	56	0	56	0	30	3	13	46	5	5	20	0	31	15	0	0	15	18
6	2004	34	23	56	56	12	68	-12	31	3	14	49	6	5	22	0	33	16	0	0	4	22
7	2005	34	23	56	56	12	68	-12	33	3	16	51	6	5	24	0	35	17	0	0	5	27
8	2006	34	23	57	57	12	69	-12	35	3	17	54	6	5	25	0	37	17	0	0	5	32
9	2007	36	24	60	60	23	83	-23	36	3	17	57	7	10	26	0	44	12	0	0	-11	21
10	2008	36	24	60	60	23	83	-23	38	3	18	59	8	10	27	0	46	13	0	0	-10	12
11	2009	36	24	60	60	23	83	-23	40	3	19	62	8	10	28	0	47	15	0	0	-9	3
12	2010	36	24	60	60	23	83	-23	42	3	19	64	9	10	29	1	49	15	5	0	-3	0
13	2011	36	24	60	60	23	83	-23	44	3	20	67	9	10	30	1	51	16	13	5	0	0
14	2012					35	35	-35	46	3	18	67	10	16	28	4	57	10	38	13	0	0
15	2013					35	35	-35	48	3	16	68	10	16	25	6	57	11	63	38	0	0
16	2014					35	35	-35	51	3	14	68	10	16	22	9	57	12	86	63	0	0
17	2015					35	35	-35	53	3	13	69	10	16	19	11	56	12	109	86	0	0
18	2016					35	35	-35	54	3	11	67	11	16	16	13	56	12	133	109	0	0
19	2017					35	35	-35	54	3	9	66	11	16	13	16	55	11	157	133	0	0
20	2018					35	35	-35	54	3	7	64	11	16	10	18	55	9	183	157	0	0
21	2019					23	23	-23	54	3	6	63	11	16	9	20	55	8	198	183	0	0
22	2020					23	23	-23	54	3	4	62	11	16	7	21	54	7	214	198	0	0
23	2021					23	23	-23	54	3	3	60	11	16	5	23	54	6	231	214	0	0
24	2022					12	12	-12	54	3	3	60	11	16	4	24	54	6	237	231	0	0
25	2023					12	12	-12	54	3	2	59	11	16	3	24	54	6	243	237	0	0
26	2024					12	12	-12	54	3	1	59	11	16	2	25	53	5	250	243	0	0
27	2025					12	12	-12	54	3	1	58	11	16	1	26	53	5	257	250	0	0
28	2026					12	12	-12	54	3	0	57	11	16	0	26	53	4	264	257	0	0
29	2027					0	0	0	54	3	0	57	11	16	0	26	52	5	260	264	0	0
30	2028					0	0	0	54	3	0	57	11	16	0	25	52	6	254	260	0	0
31	2029					0	0	0	54	3	0	57	11	16	0	25	51	6	248	254	0	0
32	2030					0	0	0	54	3	0	57	11	16	0	24	50	7	241	248	0	0
33	2031					0	0	0	54	3	0	57	11	16	0	23	50	8	233	241	0	0
34	2032					0	0	0	54	3	0	57	11	10	0	22	43	14	219	233	0	0
35	2033					0	0	0	54	3	0	57	11	10	0	20	41	16	203	219	0	0
36	2034					0	0	0	54	3	0	57	11	10	0	19	39	18	185	203	0	0
37	2035					0	0	0	54	3	0	57	11	10	0	17	37	20	165	185	0	0
38	2036					0	0	0	54	3	0	57	11	10	0	14	35	22	143	165	0	0
39	2037					0	0	0	54	3	0	57	11	5	0	11	27	30	113	143	0	0
40	2038					0	0	0	54	3	0	57	11	5	0	8	24	33	80	113	0	0
41	2039					0	0	0	54	3	0	57	11	5	0	4	20	37	43	80	0	0
42	2040					0	0	0	54	3	0	57	11	5	0	0	16	41	1	43	0	0
43	2041					0	0	0	54	3	0	57	11	5	0	0	16	41	0	1	40	40
	Total	527	352	879	879	527	1,406		1,967	117	292	2,376	383	475	442	509	1,809					

Note: *1 (Capital Balance)+(Revenue Balance)+(Depreciation)
*2 66% of Interest Portion of Long-term Loan
*3 Interest rate of working fund: 10% p.a.
*4 Terms of Foreign Loan Interest: 8.1% p.a.
Repayment Period: 20 years (including 5 years of grace period)

At present the sewage service charge accounts for less than 0.13% of household income for high income class; 0.08% to 0.20% for middle income class; and more than 0.18% for low income class. If Charge II was reflected in the sewage service tariff, the charges will increase to less than 0.38% of household income for high income class; 0.24% to 0.60% for middle income class; and more than 0.55% for low income class. Those percentages are still small when compared to the referential figure of 3%. However, it can be said that the tariff structure would be more burdensome for low and middle income households than for high income households.

Table 11-16 Level of Sewage Service Charge as Percentage of Household Income

Item	Low Income	Middle Income	High Income
Monthly Income (Quetzal)	Less than 2,000	2,001 to 5,000	More than 5,001
Water Consumption (m^3/month)	23	25	43
Sewage Service Charge			
Present Tariff	3.68	4.00	6.40
Charges based on Charge II*1	11.04	12.00	19.20
Percentage of Income			
Present Tariff	More than 0.18%	0.08% to 0.20%	Less than 0.13%
Charge II*1	More than 0.55%	0.24% to 0.60%	Less than 0.38%
Referential Rate*2	Maximum 3%	Maximum 3%	Maximum 3%

Note: *1 Charge II, i.e., three times of the present tariff.
*2 Low Cost Sanitation, World Bank Economic Development Institute
Source : Study Team

In order to mitigate the impact of mark-up on the lower-income households, certain type of cross subsidy could be considered. For example, if EMPAGUA employs a two-step progressive tariff with the cutoff consumption volume being 40 m^3 per month, a cross subsidiary effect can be expected from the high-income households whose average monthly consumption is over 40 m^3, to the low and middle-income households. Another example is a district tariff system. If EMPAGUA sets up a higher tariff for zones and areas where higher-income households live, other areas' residents will become beneficiaries of the cross subsidy.

Allotment to beneficiaries can also be levied, which will be another source of capital investment so that the level of mark-up as a whole will be lowered. Such a special allotment charge is considered collectible from the following group of people whose profiles are not necessarily the same:

- Direct users connected to the sewer installed under the proposed project, who receive general benefits of health protection and nuisance elimination;
- Owners of properties in the project area who can anticipate an increase of market value

of the properties; and

- Residents of whole Metropolitan Area who can enjoy esthetic enjoyment of environment and will benefit in the future, from cleaner and less expensive water sources.

When introducing the allotment to beneficiaries, it should be especially noted that:

- Details such as total amount of allotment, contributors and the sharing method among them, and collection period are determined clearly and fairly;
- Contributors are informed well of the allotment from the preparation stage of the project ;
- Contributors are convinced enough to pay the allotment after understanding the project.

11.5.3 Economic Evaluation

a) Basic Conditions and Assumptions

In estimating economic cost and benefit, economic values are converted or quantified applying the following conditions and assumptions to the financial costs of the proposed project estimated in the former Chapters.

1) Opportunity cost of capital represents the permissible economic rate of return for development projects. In Guatemala, 10% of this opportunity cost of capital is applied as a discount rate for assessing economic viability of the proposed project.
2) In economic analysis, all goods and services related to the project costs and benefits have to be estimated on the basis of real economic value. In terms of goods and services in the local market, the following points must be considered in the case of converting their financial values into economic ones: (a) internal transfer payment and (b) shadow wage of unskilled labor in particular because of taking unemployment and under-employment conditions into account. In this study, the economic values of these local portions are converted as 90% of the financial values. Hence, this 90% figure is called as standard conversion factor (SCF) in general. On the other hand, the imported goods and services are estimated based on international market prices, so their values reflect real economic ones.
3) Land acquisition costs were eliminated because (i) it is difficult to determine the economic value of land and (ii) the economic value of land in "without project" condition will be sufficiently offset by the incremental economic value of land in "with project" condition. However, in the case that a part of lands acquired for sites

of sewage treatment plants is used for economic activity such as agricultural production, the activity could be accounted as negative benefit.

4) The economic life of the projects is taken as 30 years after the completion of construction works. The benefits accruing from the project are assumed to continue in proportion to increasing service population during the economic life of the projects.

b) Economic Costs

The construction and O/M costs of the proposed project were summarized in Table 11-17 in financial terms, which were described in Section 11.4. Considering the aforesaid conditions and assumptions for converting from the financial costs, the economic costs of the respective items were estimated applying SCF of 90%, as shown in Table 11-17.

Table 11-17 Financial Costs and Economic Costs

(Unit: Q Million)

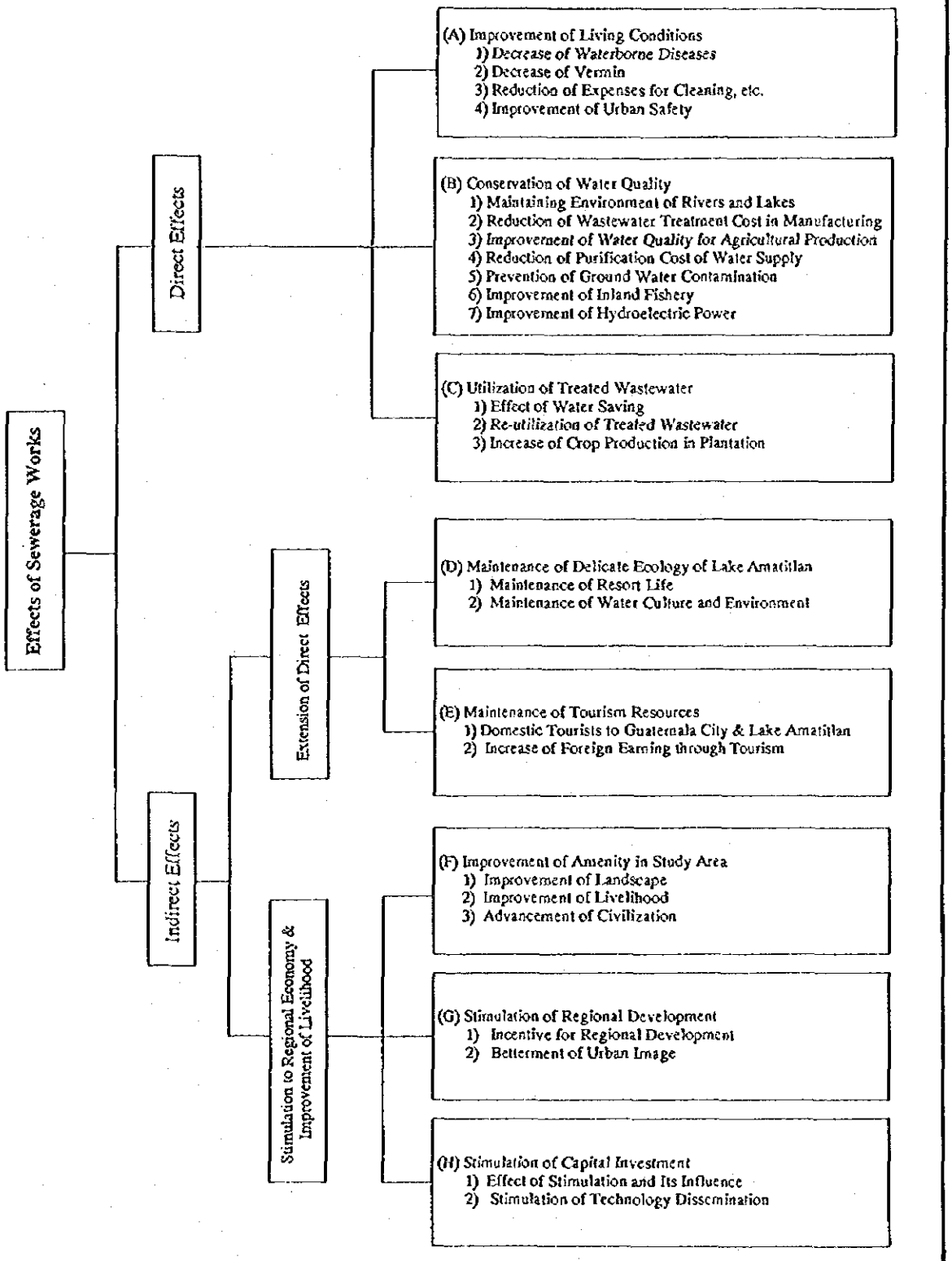
	Local Portion	Foreign Portion	Total
I. Financial Costs			
Construction Cost	847.5	31.5	879.0
•Construction Works	801.8	31.5	833.3
•Land Acquisition	45.7	0.0	45.7
Annual O&M Cost*1	10.5	0.0	10.5
II. Economic costs			
Construction Cost	721.6	31.5	753.1
•Construction Works	721.6	31.5	753.1
•Land Acquisition	0.0	0.0	0.0
Annual O&M Cost*1	9.5	0.0	9.5

Note: *1 In the matured year, 2015
Source : Study Team

c) Economic Benefits

Figure 11-6 illustrates the structure of benefits accruing from sewerage projects in Guatemala metropolitan areas. Among various benefits shown in the figure, the following important and tangible benefits are quantified taking account of data availability: (i) decrease of water-borne diseases, and (ii) reduction of future purification cost for water supply.

Fig. 11 - 6



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER *MANAGEMENT IN THE GUATEMALA* METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE STRUCTURE OF ECONOMIC BENEFIT

1) Decrease of Water-borne Diseases

Project benefit regarding decrease of water-borne diseases consists of three components: (i) reduction of deaths due to water-borne diseases, (ii) reduction of inpatients and (iii) reduction of outpatients. According to a public health report, "Medical Environment and Public Health for Metropolitan Development Plan (El Sancamiento del Medio y las Metas de Salud, Propuesta para el Plan de Desarrollo Metropolitano), 1972, Dr. Raúl Paredez López", public health in the metropolitan areas was exacerbated in accordance with development expansion. It gave a warning of increasing medical expenses because of exacerbating health conditions. This analysis is useful to quantify economic benefit of countermeasures to water contamination, although the data in the report was old. In this evaluation, thus, the data revised applying economic indices to the results of the report are used to quantify this benefit in the project areas, because of data availability.

Table 11-18 shows the number of avoidable medical losses owing to sewerage and sanitation system in the project areas by Region until the target year 2015. The number of deaths due to water-borne diseases under "without project" for eliminating water contamination was estimated on the basis of past mortality, which was analyzed in the above report. Once the project was implemented, the mortality rate would be reduced to 2.16 per 1000 population at the first year and finally to 0.48 per 1,000 population in the area of implementation in the target year. In the original report, it was planned the project would start in 1982 and finish in 1991. In this study, these conditions were translated as for starting in 2001 and finishing in 2015. As a result, 17,782 and 5,236 people could avoid death from water-borne diseases in Central and South 3 Regions, respectively. The details of this estimate were enumerated in Table P-1 to P-3 in Supporting Report P.

Table 11-18 Number of Medical Losses Avoidable by Implementation of Sewerage and Sanitation System during 1999 to 2015

	Deaths	Inpatients	Outpatients
Central Region	17,782	42,124	73,652
South 3 Region	5,236	12,426	21,726

Note: Details of these figures are shown in Supporting Report P.
Source : Study Team

In the same manner, the number of patients suffering from water-borne diseases is also estimated in Table 11-18. As seen in the table, patients were classified into two categories: inpatients and outpatients. According to the estimates, the number of inpatients due to water-borne diseases would be reduced by 42,124 in Central Region and 12,426 in South 3 Region within 14 years till 2015. The number of outpatients would be reduced by 73,652 in Central Region and 21,726 in South 3 Region.

In the report, the average medical care period for an inpatient in hospital was recorded as 12.7 days. A national hospital expensed Q8.00 per day for a inpatient on average in 1976. This value was re-evaluated as being around Q88.00 per day for a patient in 1995, applying a price index of 1,100, which was estimated through the consumer price index. Incidentally, the consumer price indices are shown in Table P-4 in Supporting Report P. An inpatient also has to suspend his business during his medical care period. An average income was assumed to be Q1,500 per month. This loss could also be avoided and appropriated as an economic benefit.

The medical care for a hospital outpatient cost Q4.25 per outpatient on average in 1976. This value was re-evaluated as around Q46.75 per day for a patient in 1995. An outpatient also has to suspend his business for medical care, although the period might be short as compared with an inpatient case.

Reduction benefit of deaths due to water-borne diseases was quantified based on the annual income which the casualties could have during the rest of their life. The benefit was estimated as a product of the number of deaths, an average annual income which was assumed at Q18,000, and a labor participation rate which was estimated at 36% of the total population in the target areas (Table P-5 of Supporting Report P, Volume IV).

Yet, people in existing sewered areas have already enjoy some environmental effects of public health, even if no wastewater treatment plant is constructed in the areas. Morbidity and mortality rates in existing sewered areas are considered to be lower than those in no sewered areas. Thus, the medical losses in the existing sewered areas such as Central Region are assumed to be a half of those in no sewered areas in the current study. On the other hand, South 3 Region has few existing sewerage systems, so it is assumed to be able to enjoy the full reduction benefit of water-borne diseases.

2) Reduction of Future Purification Cost for Water Supply

Security of water supply sources is an issue of burning concern for the project areas, considering the present water contamination circumstances and expanding urbanization in Guatemala metropolitan areas. If this present conditions were left without any improvement measures taken for water contamination, the surface water and groundwater in the project areas could not be utilized for water supply sources. In this context, water purification would be indispensable as countermeasures against water contamination. Wastewater treatment is one of the most effective countermeasures for this situation.

The water supply sources will be extracted from surface and underground sources. As of 2002, they will reach at least to 662 L /s in Central Region and 1,240 L/s in South 3 Region, as shown in Table 11-19. Beyond 2002, thus, this volume need to be purified because of water contamination.

Table 11-19 Water Resource Exploitation in Central and South 3 Regions

Category	Type of Water Resource	Capacity, L/s Central Region	South 3 Region
Existing (As of 1996)	Ground Water	548	1,142
	Surface Water	34	98
Planned (Fulfilled by 2002)	Ground Water	80	0
	Surface Water	0	0
Total		662	1,240

Note : Refer Supporting Report B, Volume III for details.
Source : Study Team and EMPAGUA

Reduction of purification cost for water supply sources is quantified as follows. Under "without project" conditions, it is assumed that the water supply sources in the project areas need to be purified by means of upgrading and strengthening water treatment processing after the year 2001, the completion year of the first stage. The water supply undertaker could not help purifying the intake water in the areas after 2001 because of the serious water contamination.

According to EMPAGUA's experience and the analysis by Study Team, the reduction of unit purification costs for water supply with project are estimated at about Q0.5 per m^3 in 1995. However, contribution of wastewater treatment in the respective regions to water resources protection was assumed at 50% of total. Consequently, the annual reduction of purification costs with project are estimated at Q5.22 million in Central Region and Q9.78 million in South 3 Region in financial terms. In economic terms, they are converted to Q4.70 million and Q8.80 million, respectively. These costs would be eliminated under the "with-project" conditions in the respective regions.

3) Negative Benefit

The undertaker of the sewerage project has to expropriate some areas for the wastewater treatment plant. These sites include some agricultural crop lands partially. Then, crop production can not be carried on after beginning construction works. This production activity has to be considered as negative benefit of the project. The crops cultivated at the sites are assumed to be maize and beans as representative products, referring to the site inspection results. This negative benefits are summarized as shown in Table 11-20. The details of the respective crops' information are listed in Supporting Report P.

Table 11-20 Economic Losses of Agricultural Production at Plant Sites

Item		Total	Maize	Beans
Crop Production Data				
Yield	(ton/ha)	-	4.24	1.04
Production Value	(Q/ton)	-	1,323	3,858
	(Q/ha)	-	5,611	4,029
Production Cost	(Q/ha)	-	3,142	2,951
Value Added (VA)	(Q/ha)	-	2,469	1,078
VA in Economic Term*1	(Q/ha)	-	2,220	970
Plant Site of Central Region	(ha)	90.0		
Crop Lands	(ha)	34.0	11.3	22.7
Loss of Crop Cultivation	(Q 1000)	47.1	25.1	22.0
Plant Site of South 3 Region	(ha)	30.0		
Crop Lands	(ha)	18.0	6.0	12.0
Loss of Crop Cultivation	(Q 1000)	24.9	13.3	11.6
Total Losses of Crop Cultivation	(Q 1000)	72.0	38.4	33.6

Note: SCF of 0.9 was applied to the financial value.
Source : Study Team and EMPAGUA

As seen in the table, value added (VA) of Maize and Beans is estimated at Q2,220/ha and Q970/ha, respectively. Then, the economic losses of crop cultivation are aggregated to Q72,000 per annum in the both plant sites.

d) Economic Evaluation

The economic benefit consists of (i) the reduction of death and patients due to water-borne diseases, (ii) the reduction of future purification cost for water supply, and (iii) the negative benefit of eliminating crop production at the wastewater treatment plant sites. Table 11-21 shows an annual stream of the benefits which was quantified on the basis of the above discussion, as well as economic costs.

The economic evaluation for the proposed project should be examined in terms of economic efficiency by consideration of net present value (NPV), benefit-cost ratio (B/C) and economic internal rate of return (EIRR). The results of these factors are shown in Tables 11-21. EIRR and B/C was 7.9% and 0.79. EIRR was lower than the opportunity cost of capital and B/C was below 1.0. Thus, the proposed project might not be feasible, from the economic point of view. However, the sewage projects are scarcely exceed the opportunity cost of capital, in general. The calculated indices seems to be high, as compared with the same kind of projects in other areas. Moreover, this kind of project would rather be considered in terms of fulfilling basic human needs with regard to environmental conditions. From this context, the proposed project would rather be recommendable, even from the economic point of view.

Table 11-21 Economic Cost and Benefit Stream of Proposed Project

(Unit:Q1000)

Serial No.	Year	Cost			Benefit						Balance
		Const-ruction	O/M	Total	Decrease of Diseases			Purification for W/S	Negative	Total	
					Death	Inpatient	Outpatient				
1	1999	85,594	0	85,594	0	0	0	0	72	-72	-85,666
2	2000	85,594	0	85,594	0	0	0	0	72	-72	-85,666
3	2001	85,594	0	85,594	0	0	0	0	72	-72	-85,666
4	2002	48,237	4,466	52,703	1,414	195	23	13,496	72	15,056	-37,647
5	2003	48,237	4,718	52,955	2,967	295	35	13,496	72	16,720	-36,235
6	2004	48,237	5,000	53,237	5,236	411	49	13,496	72	19,120	-34,117
7	2005	48,237	5,285	53,522	8,326	543	64	13,496	72	22,357	-31,165
8	2006	48,494	5,576	54,071	12,337	691	81	13,496	72	26,533	-27,538
9	2007	50,979	6,703	57,682	17,432	857	101	13,496	72	31,814	-25,869
10	2008	50,979	7,018	57,997	23,652	1,037	121	13,496	72	38,235	-19,763
11	2009	50,979	7,357	58,336	31,076	1,232	144	13,496	72	45,876	-12,460
12	2010	50,979	7,676	58,655	39,777	1,440	168	13,496	72	54,809	-3,846
13	2011	50,979	8,014	58,993	49,825	1,661	193	13,496	72	65,103	6,110
14	2012		9,107	9,107	57,397	1,774	206	13,496	72	72,801	63,694
15	2013		9,235	9,235	65,361	1,884	218	13,496	72	80,887	71,652
16	2014		9,326	9,326	73,697	1,991	230	13,496	72	89,341	80,016
17	2015		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
18	2016		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
19	2017		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
20	2018		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
21	2019		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
22	2020		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
23	2021		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
24	2022		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
25	2023		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
26	2024		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
27	2025		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
28	2026		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
29	2027		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
30	2028		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
31	2029		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
32	2030		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
33	2031		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
34	2032		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
35	2033		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
36	2034		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
37	2035		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
38	2036		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
39	2037		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
40	2038		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
41	2039		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
42	2040		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715
43	2041		9,435	9,435	82,389	2,096	241	13,496	72	98,149	88,715

Present Value (Discounted at 10%)

Cost (Q1000) :	493,129	NPV (Q1000):	-102,079
Benefit(Q1000):	391,050	B/C :	0.79
		EIRR :	7.9%

11.6 ORGANIZATIONAL REFORM

11.6.1 Organizational Arrangement

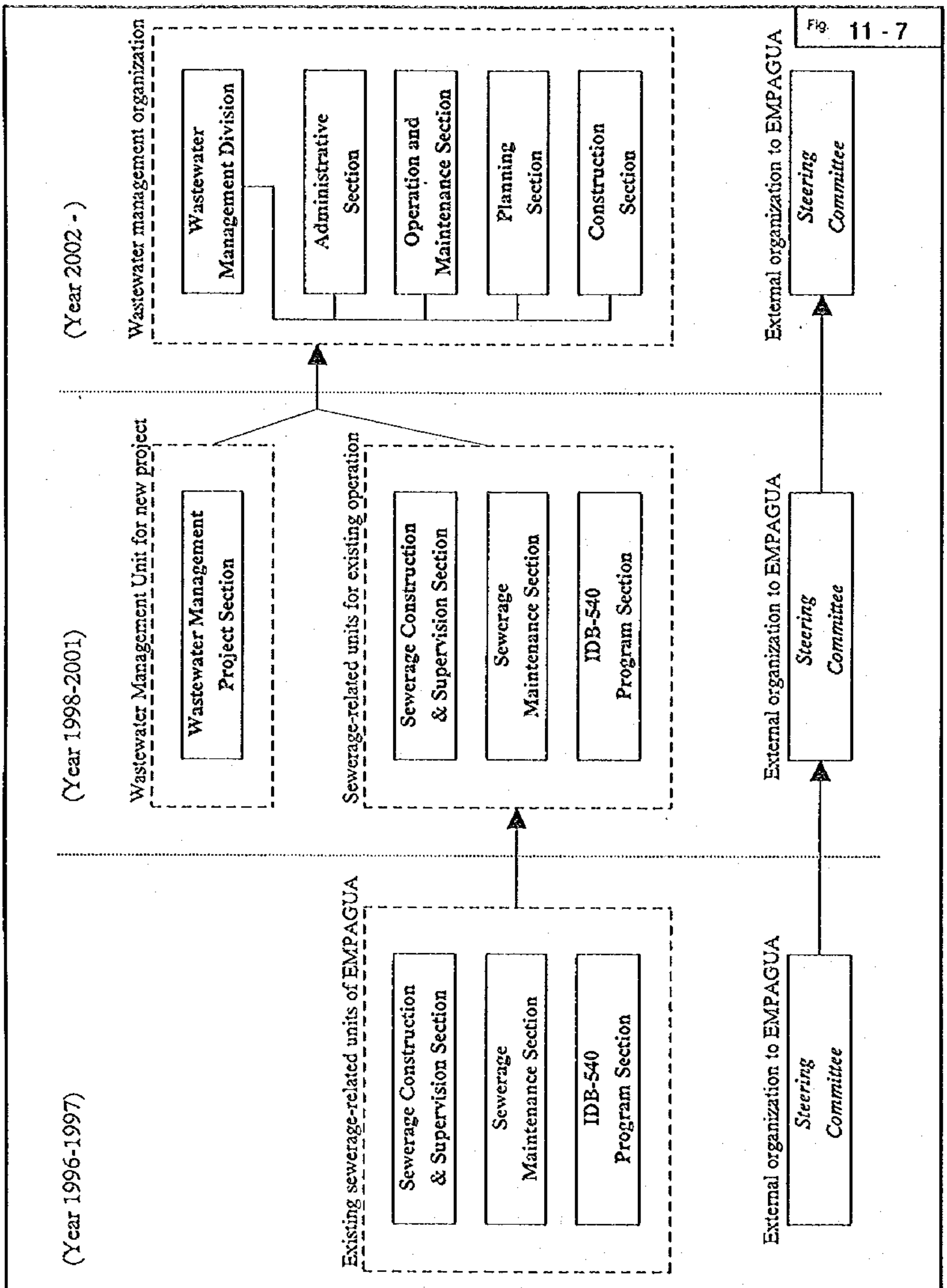
The current organization of EMPAGUA is formed by a typical functional grouping where most of the units are established on the basis of function for water supply services. Although there are some units which are charged with a wastewater management role (*i.e.* Sewerage Construction & Supervision Section, Sewerage Maintenance Section, and IDB-540 Program Section), these units are almost indiscernible amongst many other water supply related units.

If water supply services and wastewater management are regarded as two different products, one way of designing a suitable organization would be based on product grouping by which most of the administrative and financial units of the existing water supply divisions are duplicated in a wastewater management division. Nevertheless, given that the proposed project will be implemented in stages and that the scale is not sizable compared with the present water supply operation, complete departmentation by product is not recommended from the initiation of the project.

Instead, in order to minimize difficulties of personnel recruitment and administrative expenses, it is desirable to establish the Wastewater Management Project Section at an early stage. Thereby organizational arrangement will aim at mobilization of the existing water supply functions. A radical shuffle of the existing organization is avoidable since it causes many difficulties such as personnel relocations and dismissals to be followed by lengthy legal procedures.

At a later stage, the Wastewater Management Project Section should assume responsibility for operation and maintenance of the newly constructed treatment facilities. Also the existing wastewater related units such as Sewerage Construction and Supervision Section, and Sewerage Maintenance Section, should be integrated into the Wastewater Management Division.

Fig. 11-7 illustrates the aforementioned evolution of the wastewater management unit in accordance with the schedule of the proposed project. The assumption is that (i) the system construction of the first stage project initiates from 1999 after the detailed designing in 1998: (ii) the facilities designed for the first stage of proposed project starts the full operation from 2002 after the completion in 2001: (iii) between 1998 and 2001, the existing units exclusively related to sewerage continue their own activities while the newly created Wastewater Management Project Section executes the proposed project: and (iii) the four



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE PROPOSED WASTEWATER MANAGEMENT ORGANIZATION

sections coexistent between 1998 and 2001 are merged into the Wastewater Management Division in 2002 when integrated wastewater management activities start.

11.6.2 Required Functions

The functions considered necessary for the proposed wastewater management project are described in subsequent paragraphs in order to present the guideline based on which the practical organizational arrangement can be made. These functions can be either (i) performed by the proposed wastewater management unit, (ii) entrusted to existing water supply related units or (iii) contracted out to external suppliers. Table 11-22 summarizes an alternative allocation of these functions to each section. The wastewater management units shown in Fig. 11-7, and Table 11-22 are defined to cover the smallest number of these dissimilar functions. However, if any of these functional units turns out inadequate or understaffed according to then existing situation of the proposed project, it should be considered to modify the allocation of fucntions or to add other derivative units.

Table 11-22 Functions of Wastewater Management Division

Section	Funtion (Area to Be Covered)
Administrative Section	• finance and accounting • procurement and inventory control • community participation • coordination and public relations
O/M Section	• operation and maintenance • monitoring
Planning Section	• planning and design
Construction Section	• construction management
Other units of EMPAGUA or outsourcing	• legal administration • loan administration • recruitment and evaluation • training • customer services

Source : Study Team

a) Finance and Accounting

Although at present, the revenues of EMPAGUA are separately recognized for the sewerage and for the water supply, regarding the expenses, no separate accounting is made. It will be required therefore, to distinguish the wastewater management accounting from the water supply accounting. It is necessary to have a financial and accounting function exclusive for wastewater management operation in order to maintain the financial records of the sewerage system including budgeting, payroll, billing and collection. Such self autonomous accounting system will provide adequate information for evaluating and controlling wastewater management operation and would serve as a rational cost basis for planning future expansions of the wastewater management works. If the proposed project is financed

by an external lending agency, this function is especially important to provide the lending agency with accurate operating results of the wastewater management operation.

b) Procurement and Inventory Control

The objective of procurement is to ensure that only necessary materials and supplies are procured and that these are obtained at prices most advantageous to Wastewater Managment Division, consistent with the quality of the goods being procured. The inventory control system should provide for management controls over the receipt and delivery of materials and supplies. A provision of periodic reports will assist to plan and control the supplementary purchases on the based of inventory of materials and supplies. Procurement and inventory control are, like many other functions, required to be handled in internal coordination with construction and O/M activities.

c) Community Participation

According to the two field surveys conducted separately in May 1995 and in March 1996, it is noted that residents are aware of the benefits derived from a wastewater management project and willing to pay for the environmental improvement. These attitudes may be the fruits of efforts made by the Guatemala Municipality to encourage community participation projects. It is, therefore, possible to take advantage of the favorable attitude and continue the participatory development. When promoting the community participation in the proposed project, it is recommended:

- to designate Administrative Section to be charged with the coordination of participatory program in the Wastewater Management Division;
- to tailor "Assistance to Citizen" scheme to meet the requirements of the proposed project according to such factor as the technical manageability of residents and resource availability of EMPAGUA. Those which are to be clarified are, for example, (i) technical level and requirement of each sewerage sub project (ii) participatory stage such as planning, construction, O/M, and/or monitoring; and (iii) type of contribution and amount of input represented by labor, goods, and/or money;
- to avoid "Food for Work" program. Because in principle, a community participation program should be driven by residents' eagerness to have a particular infrastructure. In case of "Food for Work" program, the value of allowance in kind which residents may receive has substantial effect. Such allowance not only raises the total project cost but also spoils the residents' voluntarism; and

- to enhance residents' attitude towards improvement of wastewater treatment by informing them of the importance of wastewater management with the financial and other situations of EMPAGUA. An efficient vehicle to realize the enhancement is public relations which include use of mass media such as publications, radios and televisions.

d) Coordination and Public Relations

It is important to have coordinator and communicator functions in order to carry forward the wastewater management operation which is yet to be recognized widely. Coordination and public relation works are oriented outward EMPAGUA. The function will be comprised of (i) negotiation of service conditions with other municipalities than Guatemala City, and (ii) augmenting public awareness and recognition on necessity and benefits of wastewater management operation including the tariff structure and community participation program.

To reinforce the coordinator function, it is advisable to make use of the Steering Committee created for the Wastewater Management Project. Since EMPAGUA will be responsible for the wastewater management in other municipalities included in the project area, it is likely that some problems regarding administrative and legislative procedures with other municipalities may arise, which will be a great burden in the initial period of the proposed project. For smooth materialization of the proposed project, with mutual understanding or agreements among agencies concerned, it is proposed that the Steering Committee should continue and contribute to the project. The committee shall consist of existing members and if necessary, other representatives involved in the proposed project. It is expected that the committee members will meet periodically and discuss the problems and actions to be taken.

e) Operation and Maintenance

The operating function will include operation of wastewater management facilities in order to achieve desired quality of wastewater effluent and proper disposal of plant effluent. The maintenance function consists of cleaning, maintenance and repair of the sewerage system such as equipment, treatment facilities, plant premises structures, pipes, manholes and street inlets.

f) Monitoring

This function will include monitoring and surveillance on flow rate and water quality of wastewater and effluents of treatment facilities with necessary laboratory test and analysis.

It should be also required to conduct routine inspection for physical damage and obstruction in the sewer and treatment facilities.

Another important task will be control of illegal discharge of industrial wastewater. For this end, EMPAGUA should be empowered to enter premises of factories and commercial undertakings, and examine the compliance with pollution standards and regulations established by external organizations such as CONAMA. In case that any disobedience is found, no permit should be given for the factory in question.

g) Planning and Design

This function will consist of development of wastewater management plan, preparation of engineering design and specification necessary to receive tenders for all construction works of the proposed project. Cost estimation, drawings and reproduction of engineering plans are also included.

h) Construction Management

This function is not only for constructing the facilities required by the proposed project but also includes supervision of all construction works to assure compliance with regulation and required specification. Based on the recorded costs, periodical reports with the costs incurred to that date by the project in contrast with the corresponding budgeted costs, will be conveyed to the head of Wastewater Management Division. This will enable the Division Head to control and take necessary actions, accordingly to adjust further expenditure within allotted budgetary provision.

i) Legal Administration

Various legal administrations will be required before and after during the proposed project. This legal function is to arrange necessary proceedings for legal settlements for any conceivable disputes related to wastewater management operation. Those included in legal settlements will be easements and rights of way, acquisition and expropriation of lands, definition of service area, contracting, levying and collection of sewerage charge, penalty and punishment.

j) Loan Administration

The loan administration will deal primarily with the basic reporting. Several separate reports should be prepared in order to inform major items of both financial and technical matters as

required by the lending institutions. It is recommended that Administrative Section should compile such reports in collaboration with relevant sections. Loan amortization scheduling and foreign currency operation should be centralized in Finance Division where all liabilities of EMPAGUA are controlled.

k) Recruitment and Evaluation

Most of positions may be filled internally. The key personnel to be assigned particularly for the proposed project are especially important and they should be qualified as well as experienced. It is thus, recommended that Personnel Section should open the recruitment information to the public so that chances to have better staff will increase.

In considering the creation of a new wastewater management organization, the present EMPAGUA's salary structure may be maintained. Nevertheless, it should have certain flexibility or incentive to attract new applicants as well as encourage employees to be transferred from EMPAGUA's old wastewater management related units. For these ends, establishing the job evaluation standard based on job performance should be required.

l) Training

The proposed project requires qualified and experienced staff in order to handle the expanded functions for the wastewater management activities. Under the present circumstances where such experienced and qualified staff are not readily available, proper training should be necessary for the staff, especially key personnel, to be assigned for the new jobs. It is desirable for those key staff to acquire necessary skills and knowledge in a manner exemplified in subsequent paragraphs.

- O/M staff - The basic knowledge about O/M such as (i) role required for plant operator, (ii) processes involved in wastewater treatment and sanitation (iii) equipment used in wastewater treatment and sanitation (iv) routine operation procedures, (v) preventive maintenance procedures and (vi) safety can be transferred to key staff by a foreign expert through the training course provided normally by bilateral technical assistance program. The actual operation skills are, however, more important and such skills can be provided through direct contact with a personnel sufficiently experienced in the operation of wastewater management. The dispatch of such capable engineers or technicians to the proposed project for a certain period is considered most realistic for such objective.

- Planner, designer and construction supervisor - Training to acquire these skills can be achieved through the transfer of knowledge from foreign consultants directly participating in the planning and designing as well as construction supervision works at the designing and construction phase of the proposed project.

- Administration staff - Acquaintance with management accounting, personnel management and public relations is necessary. If not, it is advisable to attend some course for management and finance which can be provided by certain internal or external experts at the initial stage of the proposed project.

- Having limited in-house facilities and staff for training, Training Section of EMPAGUA counts on external agencies to provide training programs for new skill and technology. It is recommended the services of these external organizations should be utilized to supplement in-house training.

m) Customer Services

This function includes receipt of applications for house extension, billing, handling of customer complaints, control of arrears, etc. (Fig. 5-5). Billing and collection are particularly important because it affects directly to the security of fund for the proposed project.

Special attention is needed for other municipalities than Guatemala City, where EMPAGUA will start new sewerage services by the proposed project. EMPAGUA is not necessarily bound to bill to and collect from those new customers. Instead, the municipalities may be entrusted by EMPAGUA to bill and collect sewerage charges, after which the collected charges will be remitted to EMPAGUA. The objective of the entrustment is to save EMPAGUA's operating expenses. However, not all municipalities may be eligible to be entrusted the task. At least the following conditions should be satisfied:

- Process of billing and collecting charges of potable water has been already completed; and
- Satisfactory administration is established.

Furthermore, many other details should be agreed between EMPAGUA and other municipalities in order to materialize the entrustment. Those details include:

- Meter reading

- Tariff applied to the municipalities
- Remittance timing of collected charges
- Handling of arrears and recognition of bad debts
- Payment of additional costs incurred by other municipalities as a result of new sewerage services

11.6.3 Staffing Plan

Wastewater management requires many engineers, technicians, administrators and operators who can do planning, designing, construction, and O/M. It goes without saying that those people should be better qualified as well as experienced. The strengthening of the wastewater management by having such staff is an important requisite in arranging the organization for the proposed project.

As described in the Section 11.6.1, although the wastewater management unit is trying to be financially independent, securing full supports of existing staff related to water is vital to reduce difficulties of personnel recruitment and save administrative costs. In fact, EMPAGUA has a large number of unskilled workers who could contribute to the proposed project by filling newly generated functions. Nevertheless, when it comes to qualified and experienced engineers of sewerage and sanitation specialty, the procurement is considered fairly difficult due to the scarcity of such engineers both in EMPAGUA and in the general Guatemalan labor market.

Another factor to influence the staff requirement is outsourcing, which is currently operative at EMPAGUA in some areas. If such tasks as topographic survey, soil survey, boring, design, construction work and even operation and maintenance are contracted out, the proposed organization will be less staffed. Because those who are employed as a proper staff could spare more time for other jobs such as supervision, budgeting, and legal procedure. The necessary number of staff therefore, varies according to how much the organization uses outsourcing.

Table 11-23 shows the staffing plan in accordance with the organizational arrangement for the proposed project, taking into account the factors explained in preceding paragraphs. Since there is no accepted standard as to the number of staff for a wastewater management organization of particular area and population, the figures in Table 11-23 are based on EMPAGUA's staffing for other projects and present availability of sewerage related staff. The units presented in Table 11-23 are classified by job category and visualized in Fig. 11-8.

Table 11-23 Staffing Plan for Wastewater Management Organization

Position and Category	1996-1997	1998	1999-2001
Wastewater Management Project Section*1			
Project delegate (senior management)		1	1
Admin.& Financial officer (administrative)		1	2
Civil or Sanitary engineer (technical)		2	2
Assistant engineer (technical)			3
Secretary (administrative)		1	3
Unskilled worker		2	4
Total		7	15
Sewerage Construction & Supervision Sec.*2			
Administrative staff	9	9	9
Technical staff (+ Skilled specialist)	10	10	10
Unskilled worker	112	112	112
Total	131	131	131
Sewerage Maintenance Section *2			
Administrative staff	4	4	4
Technical staff (+ Skilled specialist)	12	12	12
Unskilled worker	68	68	68
Total	84	84	84
IDB-540 Program Section			
Unskilled worker	17	17	17
Total	17	17	17
All sewerage-related units			
Senior management		1	1
Administrative staff	13	15	18
Technical staff (+ Skilled specialist)	22	24	27
Unskilled worker	197	199	201
Total	232	239	247

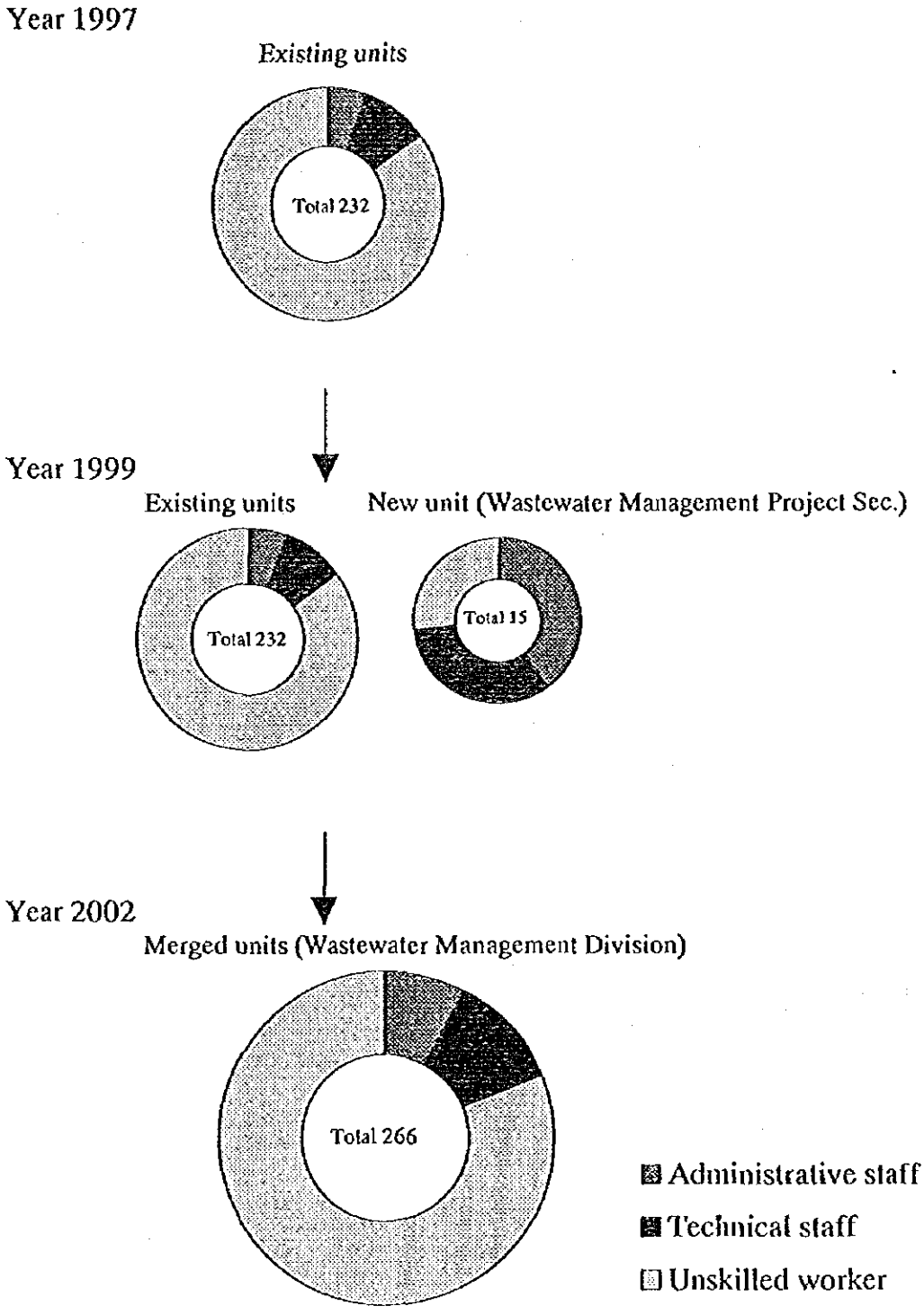
2002 -		(Recruiting source)
Wastewater Management Division		
Administrative Section*3		
Senior management	1	(Project delegate of Wastewater Management Project Section)
Administrative staff	4	(2 admin.& financial officers and 2 secretaries from WMP Sec.)
Unskilled worker	2	(2 from Wastewater Management Project Section)
Total	7	
O/M Section		
Administrative staff	6	(4 from Sewerage Maintenance Section + 2 newly recruited)
Technical staff	14	(12 from Sewerage Maintenance Section + 2 newly recruited)
Unskilled worker	100	(68 from Sewerage Mainte. Sec. + 17 from IDB-540 Sec. + 15 newly recruited)
Total	120	
Planning Section		
Administrative staff	1	(1 secretary from Wastewater Management Project Section)
Technical staff	5	(5 technical staff from Wastewater Management Project Section)
Unskilled worker	2	(2 from Wastewater Management Project Section)
Total	8	
Construction Section		
Administrative staff	9	(9 from Sewerage Construction & Supervision Section)
Technical staff	10	(10 from Sewerage Construction & Supervision Section)
Unskilled worker	112	(112 from Sewerage Construction & Supervision Section)
Total	131	
Total		
Senior management	1	
Administrative staff	20	
Technical staff	29	
Unskilled worker	216	
Total	266	

*1: Staff of Wastewater Management Project (WMP) Section will be recruited either internally or externally.

*2: Existing sections are assumed to maintain the same size of staff until 2002, ignoring natural abatement.

*3: Including Division head (Senior management).

Fig. 11 - 8



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE CHANGE IN DISTRIBUTION OF JOB CATEGORY

Effective staff planning can be achieved with necessary modification in compliance with then existing situation.

Table 11-24 shows suggested job duties of each position in the merged Wastewater Management Division (Table 11-23). It is recommended to establish and decree the proper job qualification and job description of each position so that the staff can surely understand their duties and avoid unnecessary confusion.

Table 11-24 Job Classification of Wastewater Management Division

Position	Job duties
Wastewater Management Division	
Division head (Senior management)	• Organize, manage, check and evaluate the overall technical and administrative work of the wastewater management activities • Coordinate each section and give proper orders to section heads • Report the development and progress of activities to other senior management of EMPAGUA
Administrative Section	
Section head	• Take responsibility of overall administrative, financial, commercial, and participatory activities related to wastewater management.
Finance and accounting specialist	• Support Section head in financial and accounting jobs • make financial and accounting reports of wastewater management operation
Procurement staff	• Support Section head in procurement, supply and inventory control of materials used for construction and O/M of wastewater management operation
Coordination and public relation staff	• Support Section head in coordination with external organizations and in public relation about wastewater management operation
Clerk	• Assist the above mentioned staff • Do various administrative works
Secretary	• Do various secretarial works
Unskilled worker	• Perform miscellaneous tasks pertinent to administration • Drive vehicles and transport people and materials
Operation and Maintenance Section	
Section head	• Take charge of O/M and monitoring of wastewater management facilities • Possible to be held concurrently by the civil or sanitary engineer below mentioned
Civil or sanitary engineer	• Assist Section head • Take charge of direct control and supervision of routine O/M of wastewater management facilities
Assistant engineer	• Assist civil or sanitary engineer
Operator	• Station at wastewater treatment plant and take charge of its O/M • Make the circuit of sanitation facilities and take charges of their maintenance • Carry out on site wastewater quality tests and sampling for laboratory tests
Secretary	• Do various secretarial works
Unskilled worker	• Undertake the cleaning activities of sewers, various equipment in wastewater treatment plant and septic tanks under direction of engineer and operator • Watch over and guard facilities and equipment • Drive vehicles and transport people and materials
Planning Section	
Section head	• Take charge of overall planning and designing of wastewater management works • Possible to be held concurrently by the civil or sanitary engineer below mentioned
Civil or sanitary engineer	• Assist Section head • Take charge of the development of wastewater management system
Assistant engineer	• Assist civil or sanitary engineer
Draftperson	• Undertake the drawing of every systems, facilities and accessories
Secretary	• Do various secretarial works
Unskilled worker	• Perform miscellaneous tasks pertinent to planning and designing • Drive vehicles and transport people and materials
Construction Section	
Section head	• Supervise overall construction works for wastewater management operation
Assistant section head	• Assist Section head • Control personnel involved in construction works
Secretary	• Perform various secretarial jobs
Chief worker	• Supervise labors working in the field
Unskilled worker	• Perform miscellaneous tasks in construction works • Drive vehicles and transport people and materials

Source : Study Team