Design Item	Design Criteria for Modified Activated Sludge Process	Design Values in Urgent Project
F/M Ratio	1.5~5.0	3.23
BOD Volumetric Load	1.2~2.4 BOD kg/m^3.d	1.95 BOD kg/m^3.d
Retention Time	1.5~3.0 hr.	2.7 hr.
MLSS	200~1,000 mg/l	805 mg/l
Sludge Recirculation Ratio	5 ~ 25 %	10 %

Crest elevation of overflow weir is proposed at a level of 2,234.73 m with overflow depth of 0.19 m. Water level of aeration tank is 2,234.92 m. Bottom elevation of aeration tank is at 2,228.92 m with an effective water depth of 6.0 m. Hydraulic retention time is calculated to be 2.7 hrs with a sludge recirculation ratio of 10%. MLSS in the aeration tank at the urgent stage is 805 mg/l.

Required number of blower with a capacity of 900 kW for one (1) unit of aeration tank are seven (7), for the Urgent Project stage. At the Final Project stage, required number of blower for one (1) unit of aeration tank is reduced to be four (4). Remaining three (3) blowers of one (1) unit will be removed and installed to newly constructed aeration tanks at the Final Project stage.

2.5 Secondary Sedimentation Tank

One (1) unit of secondary sedimentation tank consists of 64 number of channels. At the urgent stage two (2) units of secondary sedimentation tank are required. Surface loading at the urgent stage is calculated to be 87.5 m^3/m^2/d which is 3.5 times larger than that of the final stage. Required length of effluent trough with V-notch weir is calculated based on the overflow rate of 190 m^3/m^2/day. Effluent trough of 125 m is required in the each channel of secondary sedimentation tank. Total length of effluent trough of the secondary sedimentation tank at the Urgent Project is estimated to be 16,000 m.

2.6 Disinfection

Chlorine gas is used for disinfection. Required chlorine gas dosage ratio of 2.0 mg/l is estimated from coliform survival ratio and chlorine contact time. After dosage of chlorine, treated wastewater contact chlorine for 15 minutes in the contact tank and 2 minutes in the discharge channel before discharging Gran Canal.

3. Sludge Treatment Facilities

At the Urgent Project stage, only activated sludge is discharged. Hence sludge thickening is proposed to be done by centrifugal thickener. For liquid treatment system, required unit of treatment plant for the Urgent Project is one fourth of the Final Project stage. While the solid balance calculations, about half of the final sludge treatment capacity is required at the urgent stage (ref. Fig. 6.4). Two (2) units of sludge treatment plant are required to be constructed at the urgent stage.

3.1 Centrifugal Thickener

Activated sludge of 35,240 m^3/d, having solid content of 0.65%, is discharged from one (1) unit of wastewater treatment plant. Then total daily discharged activated sludge becomes 70,480 m^3/d. Required number of centrifugal thickener with a capacity of 170 m^3/hr are 11 sets, for one (1) unit of sludge treatment plant. Operation efficiency of centrifugal thickener is assumed to be 80 %. At the Final Project stage, required number of centrifugal thickener are six (6) sets, then remaining five (5) sets will be removed and installed in the newly constructed sludge treatment unit. Required power of one (1) set of centrifugal thickener is 200 kW.

Centrifugal thickener thickens the sludge with a solid content of 6.0%. Total daily thickened sludge per unit of 3,440 m^3/d with dry solid weight of 206.18 ton/d is produced from the raw sludge of 35,240 m^3/d.

3.2 Anaerobic Digester

Thickened sludge of 3,440 m^3/d per unit is stabilized by the anaerobic digester. Anaerobic digester of 10 tanks with 26 m diameter and 12.5 m depth are required for each unit at the urgent stage. Retention time of anaerobic digester is 19.3 days. In anaerobic digester, 33% of solids are removed as digestion gas. Blower with a capacity of 45 kW is installed to agitate sludge for each tank of anaerobic digester.

3.3 Belt Filter Press

Belt filter press dewater digested sludge of 1,950 m^3/d with a solid content of 6.0% for each one (1) unit. Polymer of 0.584 ton/d is added as coagulant. Belt filter press of 16 sets with 3 m belt width are installed for each unit of the sludge processing building. At the Final Project stage, required number of belt filter are

20 sets, hence four (4) sets will be newly installed at each unit of sludge dewatering house. Required power capacity of each belt filter is 5.5 kW.

3.4 Land Disposal

About 480 m^3/d (105.73 t/d) of dewatered sludge is obtained from one unit, hence amount of sludge to be disposed annually from the whole sludge treatment system is 154,366 tons. For the dedicated land disposal site, 370 tons/ha of annual application rate is recommended. Hence about 420 ha of area for land disposal is required.

3.5 Power Generation by Digestion Gas

Solid of 68.73 ton/d of the thickened sludge is digested and digestion gas is produced in the anaerobic digester. Digestion gas to be produced is assumed to be about 0.9 N m^3/kg of VSS. Thus digestion gas of 62,000 N m^3/d will be produced in the one (1) unit of sludge treatment plant in the urgent stage.

Digestion gas has a calorific value of about 5,500 kcal/N m^3. This energy is proposed for using the operation of power generator. About 4,500 kw/d of electric power is produced from one (1) unit of sludge treatment plant at the Urgent Project stage under the following conditions.

- Efficiency of engine : 30%
- Efficiency of generator : 90%
- Power factor of generator : 80%

This electric power is used for treatment plant operation. Required energy for heating the digestion tank is supplied by the waste heat of engine operation.

4. Electrical Design

Required capacity of electrical supply for each unit in the Urgent Project is estimated to be 12,854.0 kw and details are summarized below.

Facility	Required Power (kw)
Aeration tank	12.0
Secondary Sedimentation Tank	1,006.4
Disinfection	43.7
Blower for Aeration	6,401.6
Water Supply for Treatment	539.8
Sidestreams Reservoir	159.8
Centrifugal Thickener	2,797.8
Anaerobic Digester	855.1
Belt Filter Press	662.8
Others	375
Total	12,854.0

Required electrical power for the Urgent Project is 25,708 kw. While electrical generation of 9,000 kw by digestion gas can be achieved. Hence the total required electrical supply is estimated to be 16,708 kw.

5. Design of Foundation

As previously mentioned in Chapter 5, section 1, the existing soil condition of the proposed Texcoco treatment plant site is very weak. Proper foundation should be considered for the treatment facilities.

5.1 Design Considerations

5.1.1 Soil Conditions

Soil conditions of the proposed treatment plant site is described in Chapter 5, section 1.4. Characteristics of each soil layer is summarized below.

Layer	Depth (m)	Nature of soil	SPT (N value)	Cohesion (t/m^2)	Angle of Internal Friction (Ø)
(1)	0.0~G.L -9.0 m	Very soft clay	0 ~ 3	1.25~2.5	0
(2)	GL-9.0~-12.0 m	Silty sand	10	3.0	27°
(3)	GL-12.0~16.0 m	Soft clay	< 5	4.0	0
(4)	GL-16.0~19.0 m	Silty sand	10 ~ 50	0	27~42°
(5)	GL-19.0~28.0 m	Clay and sand	0 ~ 20	3.5~7.0	0~20°
(6)	GL-28.0~37.0 m	Silty sand	30 ~ 50	0	36~42°
(7)	GL-37.0~55.0 m	Soft clay and silty sand	10 ~ 50	-	-

Soil data deeper than 37.0 meter below ground surface is achieved from the previous relevant study.

Ground water table at the proposed site is found to be 7.3 meter below ground surface.

5.2 Design of Foundation

Keeping in view the poor subsurface soil conditions, following two (2) alternatives are considered for the foundation of the proposed treatment facilities.

- Improving Site Soil condition by preloading/sand drain method for Foundation construction
- Adopting Pile Foundation

Major purpose of the improving site soil is to accelerate the settlement and hence to improve the shear strength of the subsoil.

Based on the preliminary calculation, the present soil conditions require 15 years to complete the land settlement with the preload of 40 ton per m^2. Hence improving site soil by preloading and/or sand drain methods is not recommended for this project.

Hence Pile foundation is proposed and basic design is described below.

5.2.1 Pile Foundation

Cast insitu reinforced concrete piles with a diameter of 600 mm and 800 mm are proposed for the foundation of the facilities.

Proposed base layer is the silty sand layer located 28 m to 37 m below ground surface which has SPT of about 50.

With due consideration to the negative skin friction and horizontal load by earthquake, allowable design vertical load of pile foundation (Ra) is calculated as follows.

Ø600 : Ra = 70 ton/pile

Ø800 : Ra = 139 ton/pile

Based on the design unit load of each facility and allowable bearing capacity of pile foundation, pile alignment of each facility is designed as follows.

Structure	Unit Vertical Load (ton/m^2)	Pile Diameter (mm)	Pile Pitch (m)
Receiving Tank	12.3	Ø800	3.4
Aeration Tank	8.7	Ø600	2.8
Secondary Sedimentation Tank	6.0	Ø600	3.4
Anaerobic Digester	18.7	Ø800	2.7
Control Building	7.0	Ø600	3.2

6. Construction Plan, and Operation and Maintenance of Facilities

6.1 Construction Plan, and Operation and Maintenance

Open cut method is proposed for facility construction. The earth works will be done mainly by machines of backhoe, bulldozer and dragline. Reinforced concrete pile foundation is proposed for supporting all structures. Dewatering from the construction site is required during rainy season. All structures are to be constructed by reinforced concrete.

The operation and maintenance of the Texcoco wastewater treatment plant shall be the responsibility of DGCOH in D.F Mexico.

To achieve the expected effluent water quality, the treatment plant should be operated under appropriate conditions.

The following work items by each facility should be performed daily and/or intermittently.

(1) Aeration Tank

- Control of aeration time
- Control of aeration and mixing
- Control of MLSS

(2) Secondary Sedimentation Tank

- Control of sedimentation time
- Control of inflow gate
- Inspection of sludge scraper
- Control of return and excess sludge desludging
- Inspection of transparency

(3) Disinfection

- Inspection of effluent water quality and quantity
- Control of chlorine gas dosing rate

(4) Centrifugal Thickener

- Control of sludge feeding
- Inspection of rotation speed of dram and screw
- Control of water level

(5) Anaerobic Digester

- Inspection of mixing and other equipment
- Control of retention time
- Control of dewatering and collection of exhaust gas

(6) Belt Filter Press

- Inspection of belt filter (washing and/or replacement)
- Control of chemical dozing
- Control of mechanical devices
- Control of sludge scattering

(7) Connection Pipe

- Inspection of sludge accumulation and scum appearance
- Inspection of foaming
- Inspection of corrosion and settlement of conduit
- Inspection of gates

6.2 Mitigating Measures Against Potential Negative Impact

Environmental Impact Assessment study was conducted to identify negative impacts of the Wastewater Treatment Plant. Mitigating measures against identified negative impacts are described below.

A) Preparation of the site and Preconstruction stage

During this stage, historical assets around the site, flora and fauna present, need to be assessed. The flora present in the project site is negligible. The project site has practically negligible fauna species. The surrounding zones are inhabited by certain species represented mainly by migratory birds. The

human activities, machinery operation, sound generation will probably scare away few fauna species. However considering the minimum distance to the shallow water bodies, no important damage to the migratory fauna is expected.

B) Construction stage

During this stage, vibration and noise generated could affect the surrounding inhabitants. The minimum distance from the treatment plant site to the existing permanent building is 250 m. By employing pre boring method for pile construction and planning only daytime work, the negative impact of vibration and noise can be significantly reduced.

Dust nuisance to some extent is unavoidable during construction. However cleaning and water spraying of the roads in and/or around the construction site will be employed to minimize dust nuisance.

Transport of construction materials, equipments and heavy machinery will cause traffic problems specially on the Ave. Central where traffic is complicated due to slowness of the trucks and the buses. The part of Central Avenue should be fixed exactly in front of the main access to the treatment plant. This will consist basically the construction of additional lanes to use them as entrance and exit lanes to and from the plant. This measure must be complemented with the appropriate signals in both sides of the road. These measures could mitigate the traffic problems.

C) Operation stage

The vehicle traffic on the access roads to the treatment plant, specially on the Central Avenue will be significantly increased. At the main access to the plant, the road is narrow, with one lane in each way, so the problem will be worse by the time the plant operates. The mitigating measures are same as mentioned above. It is necessary to build a specific space on the road lanes to make easier and less troublesome the ascent and descent to and from the public transport, without interfering with the vehicles traffic.

Another potential negative impact could be the generation of odor due to operation of treatment plant. By properly maintaining the operation of treatment process and further by providing sufficient buffer zone of 50 m width, the impact of odor can be significantly reduced.

7. Cost Estimation

7.1 Project Cost

The total project cost, consisting of direct construction cost, land compensation, administration cost, engineering cost and physical contingency amounts to N$ 1,392.1 million at the price of 1994. Its breakdown is shown below.

	(Unit : N$ million)
(A) Direct Construction Cost	1,115.4
1) Wastewater Treatment	503.4
(1) Receiving Tank	15.0
(2) Distribution Tank	5.2
(3) Aeration Tank	262.4
(4) Secondary Sedimentation Tank	144.8
(5) Disinfection	14.9
(6) Discharge Channel	11.1
(7) Equipment for Reclaimed Wastewater	9.8
(8) Electrical Works	40.2
2) Sludge Treatment	481.9
(1) Centrifugal Thickener	93.8
(2) Anaerobic Digester	140.0
(3) Belt Filter Press	50.2
(4) Gas Generation System	131.4
(5) Electrical Works	66.5
3) Building Construction	95.2
4) Other Works	34.9
(B) Land Compensation	115.1
(C) Administration Cost	11.1
(D) Engineering Cost	39.0
(E) Physical Contingency	111.5
Total	1,392.1

The direct construction cost is further broken down as shown in Table 6.1.

7.2 O/M Cost

The annual O/M cost of the Urgent Project in 1997 is estimated at N$ 83.7 million with following breakdown.

	(Unit : N$ million /annum)
(1) Personal Expenditure	3.9
(2) Electrical Charge	21.4
(3) Chemical Cost	16.6
(4) Sludge Disposal Cost	11.7
(5) Repairing Cost	30.1
Total	83.7

Table 6.1 Break-down of Direct Construction Cost for the Urgent Project

(Unit = N$ million)

Description	Civil / Architecture			Mechanical / Electrical			Total
	Quantity	Unit Cost	Const. Cost	Quantity	Unit Cost	Const. Cost	
1) Wastewater Treatment							
(1) Receiving Tank	1 ls.	-	3.2	1 ls.	-	0.9	4.1
(2) Connecting Pipe (ø2,800mm)	1,040 m	0.0105	10.9	-	-	-	10.9
(3) Distribution Tank	2 unit	0.5	1.0	-	-	-	1.0
(4) Influent Channel	2 unit	2.1	4.2	-	-	-	4.2
(5) Aeration Tank	2 unit	67.1	134.2	2 unit	26.3	52.6	186.8
(6) Blower	-	-	-	14 set	5.4	75.6	75.6
(7) Secondary Sedimentation Tank	2 unit	43.9	87.8	2 unit	28.5	57.0	144.8
(8) Disinfection Tank	1 ls.	-	11.9	2 unit	1.5	3.0	14.9
(9) Discharge Channel	1 ls.	-	11.1	-	-	-	11.1
(10) Treated Water Reuse	-	-	-	2 unit	4.9	9.8	9.8
Sub-Total			264.3			198.9	463.2
(11) Electrical Work	-	-	-	1 ls.	-	40.2	40.2
Sub-Total of 1) Wastewater Treatment			264.3			239.1	503.4
2) Sludge Treatment							
(1) Sidestream Reservoir	2 tank	1.7	3.4	2 tank	2.3	4.6	8.0
(2) Centrifugal Thickener	-	-	-	22 set	3.9	85.8	85.8
(3) Anaerobic Digester	20 tank	5.7	114.0	20 tank	1.3	26.0	140.0
(4) Mechanical Dewatering (Belt Filter Press)	-	-	-	32 set	1.57	50.2	50.2
(5) Gas Holder	8 tank	0.12	1.0	8 tank	10.1	80.8	81.8
(6) Gas Generator	-	-	-	8 set	6.2	49.6	49.6
Sub-Total			118.4			297.0	415.4
(7) Electrical Work	-	-	-	1 ls.	-	66.5	66.5
Sub-Total of 2) Sludge Treatment			118.4			363.5	481.9
3) Building Construction							
(1) Blower House	2 house	6.3	12.6	-	-	-	12.6
(2) Centrifugal Thickener House	2 house	20.0	40.0	-	-	-	40.0
(3) Anaerobic Digester (Electrical Room)	2 house	1.2	2.4	-	-	-	2.4
(4) Mechanical Dewatering House (Belt Filter Press)	2 house	13.1	26.2	-	-	-	26.2
(5) Co-Generator House	2 house	1.6	3.2	-	-	-	3.2
(6) Control Building	1 house	7.2	7.2	-	-	-	7.2
(7) Sub-Control Building	1 house	3.6	3.6	-	-	-	3.6
Sub-Total of 3) Building Construction			95.2			-	95.2
4) Other Works							
(1) Preparatory Work	1 ls.	-	3.4	-	-	-	3.4
(2) Main Earth Work	1 ls.	-	13.0	-	-	-	13.0
(3) Site Preparation	1 ls.	-	18.5	-	-	-	18.5
Sub-Total of 4) Other Works			34.9			-	34.9
Grand Total			512.8			602.6	1,115.4

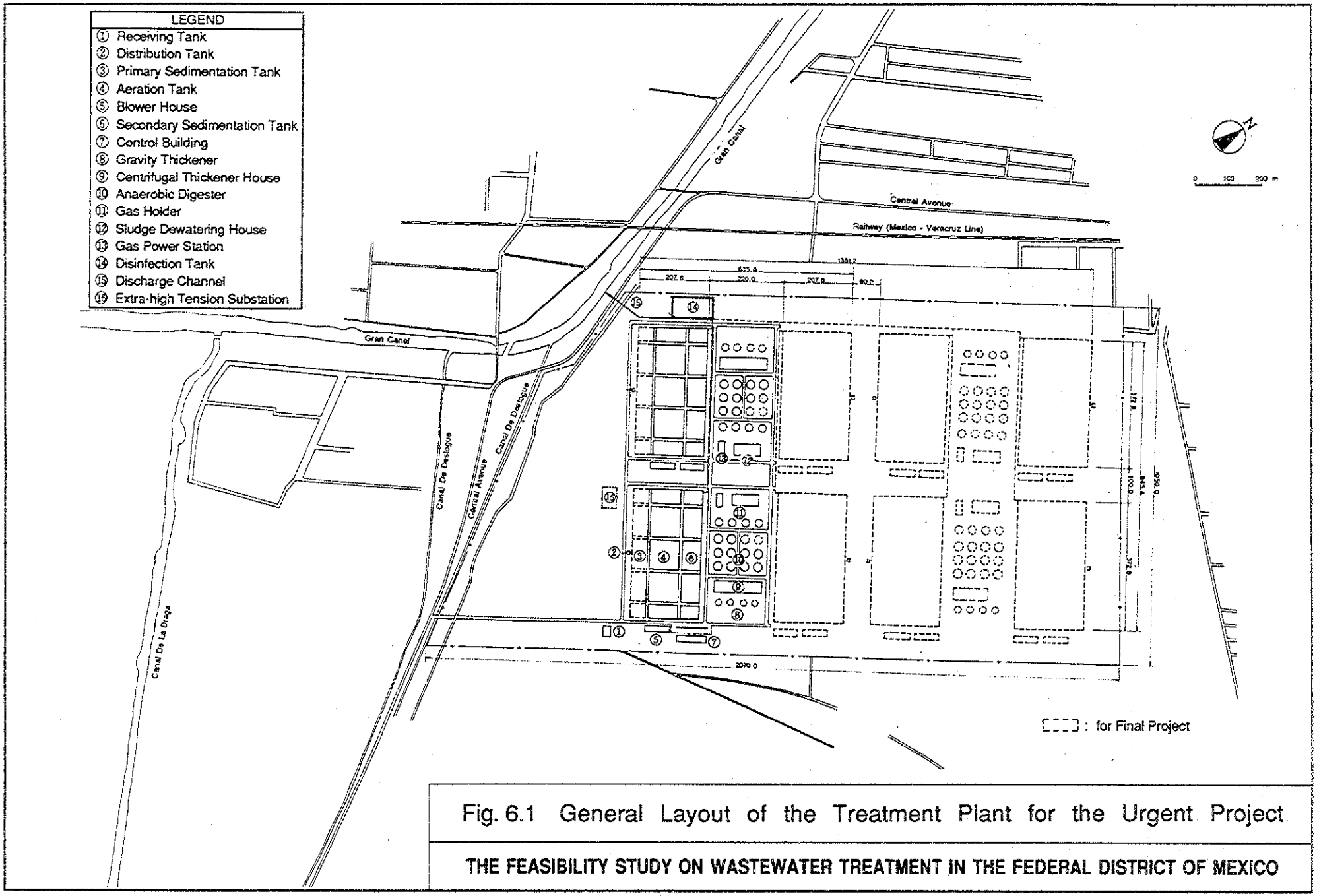

Fig. 6.1 General Layout of the Treatment Plant for the Urgent Project

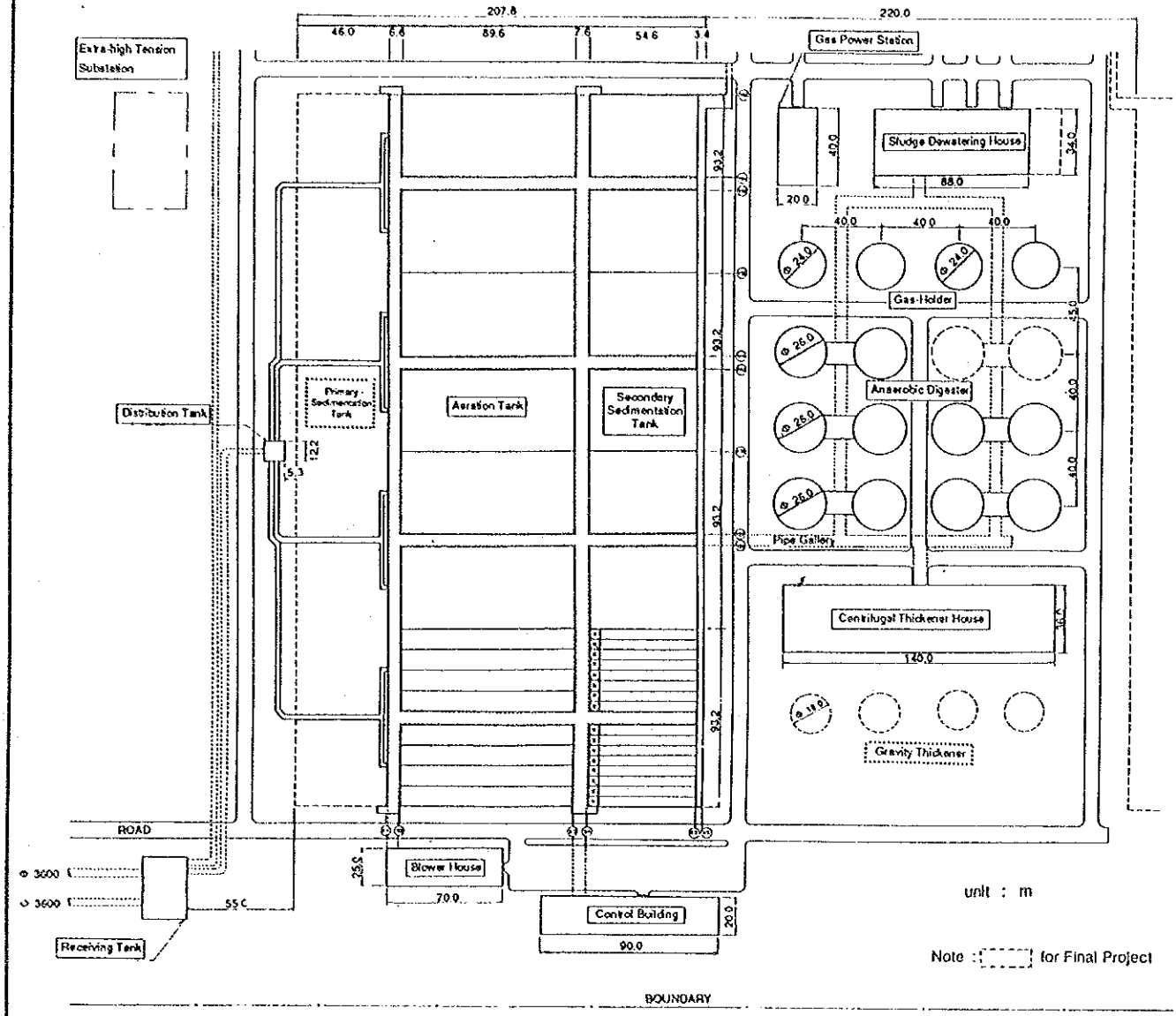

Fig. 6.2 Layout of One Unit of Proposed Treatment Plant for the Urgent Project

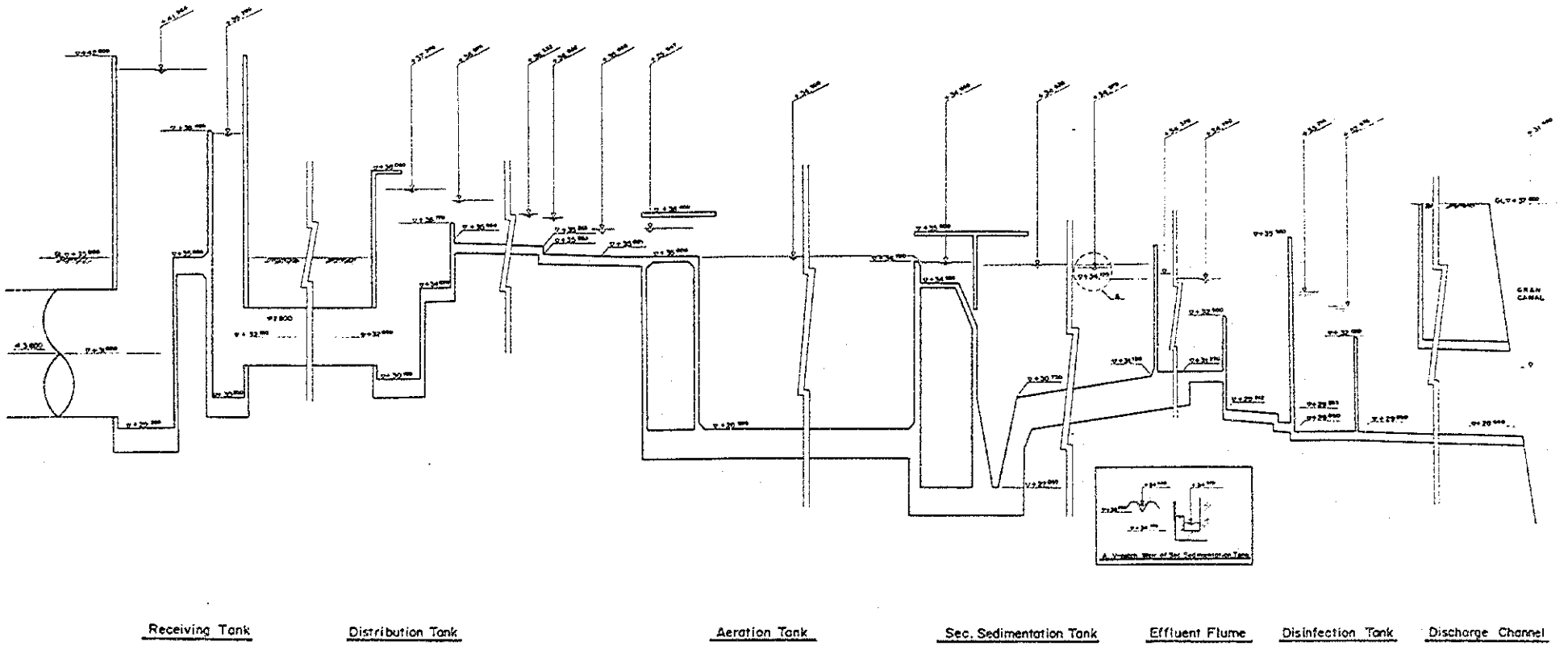

Fig. 6.3 Hydraulic Profile of the Proposed System for the Urgent Project

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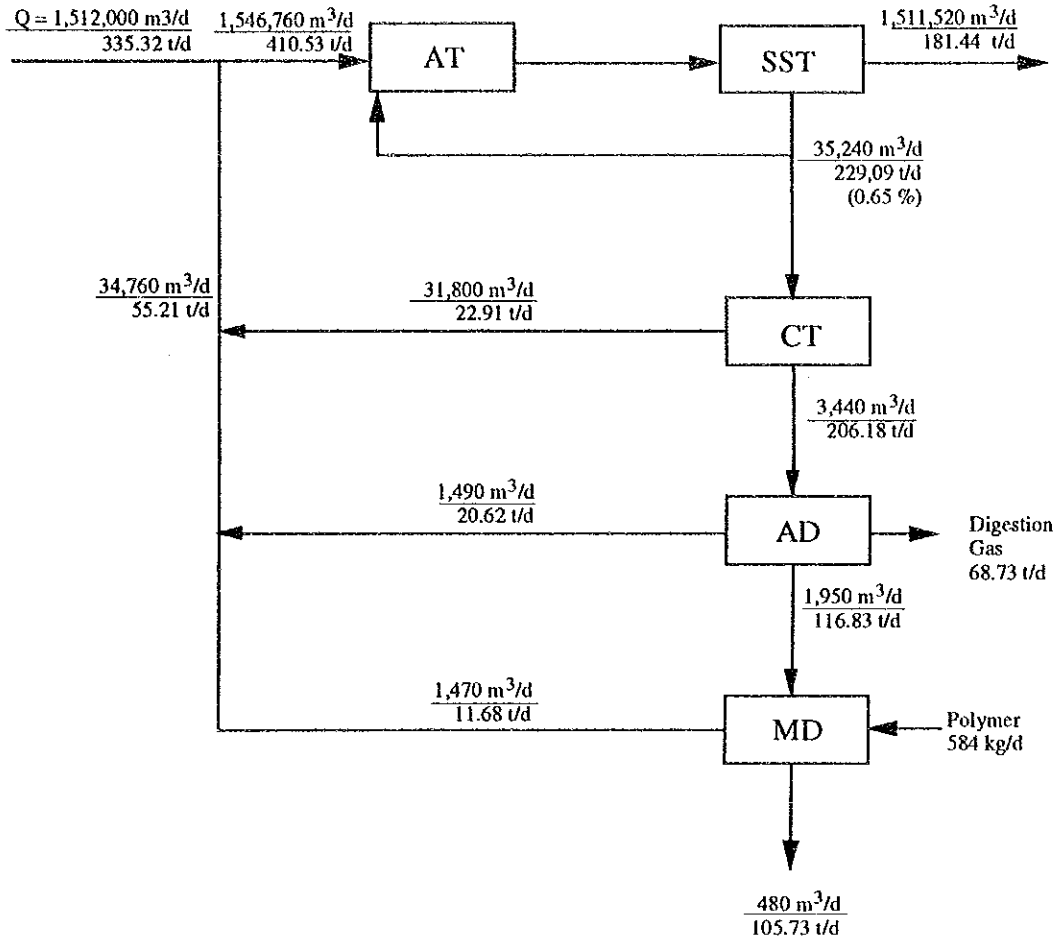


Note : 0,000 / 00.00 — Quantity of WW/sludge / Dry Solid

CT : Centrifugal Thickening
AD : Anaerobic Digester
MD : Mechanical Dewatering by Belt Filter Press

Fig. 6.4 Solid Balance of Each Unit for the Urgent Project

CHAPTER 7

CHAPTER 7 IMPLEMENTATION PROGRAM

1. Implementation Schedule

The Urgent Project will be completed until 1997 and the Final Project will be constructed within 9 years from 2007 to 2015. The construction works will be divided into four (4) stages as described below.

1st Stage — Urgent Project consists of preparatory work of construction site, construction of two (2) units of wastewater and sludge treatment facilities and construction of common facilities such as receiving tank, discharge channel and substation.

2nd stage — Primary sedimentation tanks of the wastewater treatment plant for the Urgent Project
Gravity thickener for two (2) units of sludge treatment plant for the Urgent Project
Additional four (4) anaerobic digesters for completion of two (2) units of sludge treatment plant
Additional two (2) units of wastewater treatment plant of conventional activated sludge process

3rd stage — Additional two (2) units of wastewater treatment plant of conventional activated sludge process
Additional one (1) complete unit of sludge treatment plant

4th stage — Additional two (2) units of wastewater treatment plant of conventional activated sludge process
Additional one (1) complete unit of sludge treatment plant

The inflow pumping station, which will convey wastewater to Texcoco treatment plant is designed by the Mexican side. And it is necessary to construct pumping station simultaneously with Texcoco treatment plant.

The proposed implementation schedule including the inflow pumping station is shown in Fig. 7.1.

2. Disbursement Schedule

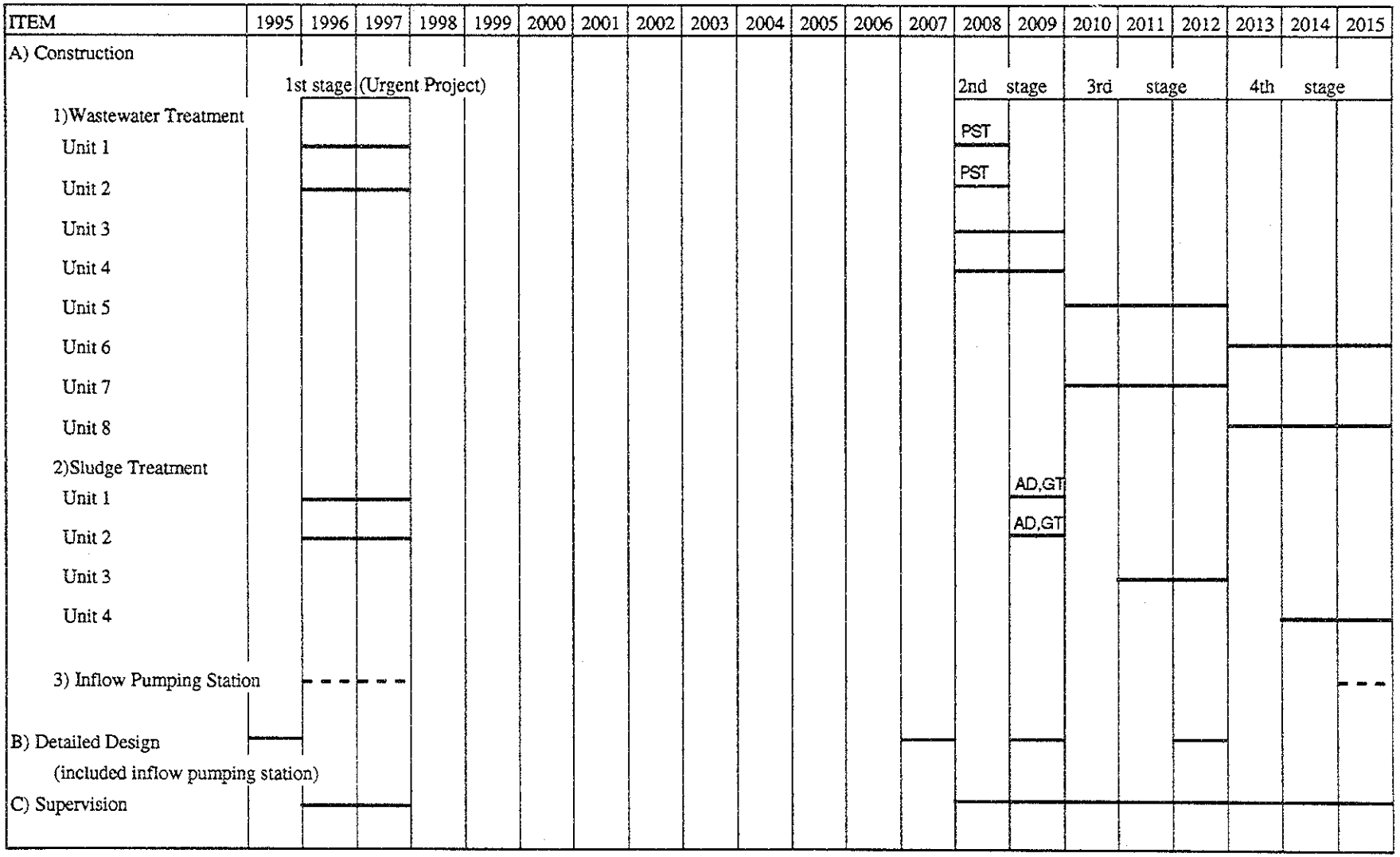
The proposed disbursement schedule is shown in Table 7.1.

Table 7.1 Disbursement Schedule

(Unit : Million N$)

Item \ Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Direct Construction Cost		557.7	557.7											375.5	375.3	285.4	285.4	285.5	285.4	285.4	285.5	3,578.8
(1) First Stage(Urg. Project)		557.7	557.7																			1,115.4
Wastewater Treatment		251.7	251.7																			503.4
Sludge Treatment		241.0	240.9																			481.9
Building Construction		47.6	47.6																			95.2
Other Works		17.4	17.5																			34.9
(2) Second Stage														375.5	375.3							750.8
Wastewater Treatment														326.4	326.4							652.8
Sludge Treatment														32.4	32.4							64.8
Building Construction														9.6	9.5							19.1
Other Works														7.1	7.0							14.1
(3) Third Stage																285.4	285.4	285.5				856.3
Wastewater Treatment																182.3	182.3	182.4				547.0
Sludge Treatment																78.4	78.3	78.3				235.0
Building Construction																17.6	17.7	17.7				53.0
Other Works																7.1	7.1	7.1				21.3
(4) Fourth Stage																			285.4	285.4	285.5	856.3
Wastewater Treatment																			182.3	182.3	182.4	547.0
Sludge Treatment																			78.4	78.3	78.3	235.0
Building Construction																			17.6	17.7	17.7	53.0
Other Works																			7.1	7.1	7.1	21.3
Land Compensation	115.1																					115.1
Administration Cost		5.6	5.5											3.8	3.7	2.9	2.9	2.8	2.9	2.9	2.8	35.8
Engineering Cost	26.6	6.2	6.2										16.3	5.0	20.0	5.0	5.0	20.0	5.0	5.0	5.0	125.3
Physical Contingency		56.0	55.5											37.6	37.6	28.5	28.5	28.6	28.5	28.5	28.6	357.9
Total	141.7	625.5	624.9										16.3	421.9	436.6	321.8	321.8	336.9	321.8	321.8	321.9	4,212.9

Fig. 7.1 Implementation Schedule



CHAPTER 8

CHAPTER 8 EVALUATION OF THE PROJECT

1. Economic, Social and Environment Evaluation

1.1 Reduction of Water-borne Disease

The proposed Texcoco wastewater treatment project will improve the river water quality of Tula river which is the irrigation canal for the Tula irrigation area in Hidalgo State. Consequently the environmental conditions of Tula irrigation area and sanitary environment of the farmers in Tula irrigation area will be improved.

The number of agricultural households using untreated wastewater for irrigation in 1990 in the Tula irrigation area, Alfajayucan irrigation area and irrigation area in Ecatepec Municipality are 14,939, 11,598 and 1,096 respectively. And the number of agricultural households in the above mentioned areas is assumed to be the same from 1990 onwards.

JICA Study Team conducted sampling questionnaire surveys to compare the incidence of water-borne diseases in the untreated wastewater irrigated area and in the treated wastewater irrigated area.

Irrigation areas of Tula and Ecatepec Municipality are selected as the area of untreated wastewater irrigation area, and Tlahuaqc and Xochimilco in D.F. Mexico are selected as the area of treated wastewater irrigation area.

The average annual incidence of water-borne diseases and water-related diseases is 1.2832 cases per household in the untreated wastewater irrigated area, while it is 0.1536 cases in the treated wastewater irrigated area. The difference is about 1.1296 cases per household (ref. Table 8.1).

An average medical cost of water-borne diseases and water related diseases are found out to be N$ 74.3 per case.

The proposed Texcoco wastewater treatment project will greatly contribute to the reduction of water-borne diseases and water related diseases. About N$ 2.3 million per annum of medical expenditure could be reduced due to the implementation of the project.

1.2 Increase of Agricultural Products

In the untreated wastewater irrigated area, vegetables as lettuce, carrot, onion and etc., which are eaten raw are not allowed to be cultivated.

The average annual agricultural income and the average cultivated area per household in the untreated wastewater irrigated area are estimated to be N$ 10,225 and 4.90 ha respectively, while in the treated wastewater irrigated area are estimated to be N$ 5,667 and 2.24 ha respectively.

Supposing the average cultivated area per household in the treated wastewater irrigated area were 4.9 ha, the average annual agricultural income would become N$ 12,397. It means that the agricultural household in the untreated wastewater irrigated area may earn that much when wastewater is treated in future. Then each household in the untreated wastewater irrigated area is assumed to earn an additional amount of N$ 2,172 per annum.

The annual incremental amount of agricultural income in the untreated wastewater irrigated area, after the completion of project, is expected to be N$ 60.0 million by multiplying agricultural household of 27,633 with an annual additional earning amount of N$ 2,172.

1.3 Economic Evaluation

After the completion of the project, benefits of N$ 2.3 million by the reduction of medical cost and N$ 60.0 million by increase of agricultural income, are expected. To convert the project benefits into economic values, the standard conversion ratio of 0.9633 is applied and N$ 60.0 million of benefit is achieved.

From the year 1998 to 2015, between the completion of Urgent Project and Final Project, annual economic benefits can be assumed to be a half of N$ 60.0 million, that is, N$ 30.0 million because of the low quality of treated wastewater.

The initial costs of Urgent and Final Projects are estimated to be N$ 1,392.1 million and N$ 2,820.8 million respectively, summing up to N$ 4,212.9 million. Annual operation and maintenance cost of Urgent and Final Projects are estimated to be N$ 83.7 million and N$ 200.4 million respectively.

The economical benefit can neither cover the initial cost nor the annual O/M cost. It is obvious that the benefits are limited because polluters and beneficiaries are not one and the same, and the number of beneficiaries are very small compared with that of polluters. A long term viewpoint is required to discuss the justification of the Project. The Project must be viewed in the context of the national environmental protection policy.

2. Financial Evaluation

2.1 Water Charge in the Study Area

Existing average monthly water consumption for domestic and non-domestic uses per household in the Study Area of D.F. Mexico and Mexico State are estimated as follows.

(Unit : m^3/household/month)

	Domestic Use	Non-domestic Use	Total
D.F. Mexico	26.0	12.1	38.1
Mexico State	20.5	9.1	29.6

Existing average unit water charge for domestic and integrated beneficiaries (which include domestic and non domestic beneficiaries) in the Study Area of D.F. Mexico and Mexico State are estimated as follows.

(Unit : N$/$m^3$)

	Domestic Use	Integrated Beneficiaries
D.F. Mexico	0.802	1.056
Mexico State	0.874	1.142

Existing annual O/M costs for water supply in D.F. Mexico and Mexico State are N$ 1,217 million and N$ 240 million in 1993 respectively.

Supposing that by the year 1998, the collection efficiency of water bills will be 85 % in both D.F. Mexico and Mexico State and also the O/M costs in Mexico State will go up by 50%, the price of water per unit m^3 fully covering the O/M costs will be N$ 1.837 in D.F. Mexico and N$ 1.310 in Mexico State.

2.2 People's Willingness to Pay

Based on the sampling questionnaire survey conducted by JICA Study Team, the average monthly amount which household is willing to pay for both water supply and sewerage services in D.F. Mexico and in Mexico State are shown below.

(Unit : N$/month)

	Water Supply	Sewerage	Total
D.F. Mexico	36.6	24.4	61.0
Mexico State	29.4	19.6	49.0

It means household's willingness to pay of unit water consumption of D.F. Mexico and Mexico State are N$ 1.435/m^3 and N$ 1.434/m^3 respectively. Based

on the existing water consumption ratio by domestic and non-domestic uses, the integrated beneficiaries willingness to pay is estimated to be N$ 1.890/m^3 in D.F. Mexico and N$ 1.874/m^3 in Mexico State respectively. These are greater than the required water charge of N$ 1.837 and N$ 1.310 to cover the existing O/M cost in D.F. Mexico and Mexico State.

Willingness to pay for sewerage service in D.F. Mexico and Mexico State are estimated shown below.

(Unit : N$/$m^3$ sewage)

	Domestic	Integrated Beneficiaries
D.F. Mexico	0.957	1.260
Mexico State	0.956	1.249

Existing average monthly household income is N$ 4,530 in D.F. Mexico and N$ 2,421 in Mexico State.

The average willingness to pay for water supply and sewerage services as percentage of household income in D.F. Mexico are 0.81% and 0.54%, adding up to 1.35%. In Mexico State, the average willingness to pay for water supply and sewerage services are 1.21% and 0.81%, summing up to 2.02%. While the ratio of average monthly water supply charge to average monthly household income in both D.F. Mexico and Mexico State are estimated at 0.46% and 0.74% respectively. Household's willingness to pay for water supply is greater than current water supply charge by 76% in D.F. Mexico and by 64% in Mexico State.

2.3 Proposed Sewerage Charge

The proposed sewerage service charge is estimated based on the following assumptions:

- Initial cost, O/M cost, repayment cost and replacement cost will be fully recovered by the revenue of sewerage charge.

- Sewerage service population ratio, in the year 1997, is assumed to be 98 % and 95 % for D.F. Mexico and Mexico State respectively. The ratio is assumed to be 100 % in D.F. Mexico and Mexico State for the year 2015.

- Bill collection efficiency is 85 %.

- 100 % of the initial costs of the project will be lended by external agency A. The details of financial conditions are described in subsequent sections.

The ultimate sewerage service charge per unit m^3 of sewage after the completion of the Final Project at 2016 in both D.F. Mexico and Mexico State are proposed to be N$ 0.605/m^3 and N$ 0.600/m^3 respectively. They are 48% of what beneficiaries are willing to pay.

The provisional sewerage charges from 1998, the year immediately following the completion of the Urgent Project up to 2015 when the Final Project will be completed in both D.F. Mexico and Mexico State are proposed to be N$ 0.378/m^3 and N$ 0.375/m^3 respectively.

The proposed combined water supply and sewerage service charge per unit m^3 in both D.F. Mexico and Mexico State are estimated as follows.

(Unit : N$/$m^3$)

	Water Supply	Sewerage	Total
From 1998 to 2015			
D.F. Mexico	1.837	0.378	2.215
Mexico State	1.310	0.375	1.685
From 2016 ~			
D.F. Mexico	1.837	0.605	2.442
Mexico State	1.310	0.600	1.910

2.4 Financial Analysis

Financial analysis for the proposed wastewater treatment plant in the form of the estimation of financial internal rate of return (FIRR), financial statement projections for the period of 30 years, etc. was performed.

The analysis was made for the proposed financial plan and three (3) alternative plans. In the proposed plan it is assumed that Mexico Government will ask 100 % of initial cost as the loan from external agency A. In alternative I it is assumed that external agency B will provide the loan for 60 % and remaining 40 % will be borrowed from external agency C. In Alternative II it is assumed that the external agency C will fully finance the project. Under Alternative III it is assumed that the financial resources will fully come from external agency D. Further details of the financial analysis are summarized in Table 8.2.

The results of the financial analysis are summarized below.

(1) Proposed Plan

Projected financial statement comprised of income statement and funds statement for 30 years from 1995 to 2024 is shown Table 8.3. Fig. 8.1 graphs some important aspects of the financial statement. As they show, the wastewater treatment plant will be financially sound and stable in terms of earnings as well as solvency during the project life period of 30 years.

Financial internal rate of return (FIRR) was calculated to be 13.3 % based on the cost benefit streams for 30 years from 1995 to 2024 as shown in Table 8.4. FIRR is greater than the annual interest rate of the loan plus the commission charge of BANOBRAS and, therefore, the proposed plan is financially feasible.

(2) Alternative Plans

Financial statement was also projected for the three (3) alternatives. The wastewater treatment plant under those alternatives will also be financially sound and stable in terms of earnings as well as solvency during the project period of 30 years. For their financial statements, see Appendix I, Table I.8, Table I.9 and Table I.10.

FIRR was also calculated for Alternatives I, II and III based on cost benefit streams. Their FIRR's are 8.3 %, 11.4% and 14.3% respectively. Their cost benefit streams are shown in Appendix I, Table I.12, Table I.13, and Table I.14 respectively.

It is to be reminded that one cannot compare FIRR's of the respective alternatives to determine the priority order among them. Because, in our circumstances costs concerned are the same for all the alternatives, a higher FIRR means a greater revenue and a greater revenue in turn means a higher sewerage service charge. Under such circumstances what is relevant and meaningful is to compare the FIRR with the annual interest rate of the loan plus the BANOBRAS commission charge regarding a particular alternative.

(3) Repayment Costs

The total amount of repayment including principal and interest for the four (4) alternatives was calculated at the present value. In calculating the present value of repayment, firstly the opportunity cost of capital (OCC) was assumed as 10 % (repayment costs at present value (1)). Secondly, in

addition to the above it was assumed that the exchange rate of yen against the dollar would appreciate at the annual rate of 5 % in future (repayment costs at present value (2)). The results are shown below:

(Unit : N$ Million)

Alternative	Initial Costs at 1994 Prices	Repayment Costs at Current Prices	Repayment Costs at Present Value (1)	Repayment Costs at Present Value (2)
Proposed Plan	4,212.9	6,954.6	3,402.8	3,402.8
Alternative I	4,212.9	9,745.7	3,299.2	4,729.9
Alternative II	4,212.9	10,352.3	3,991.3	3,991.3
Alternative III	4,212.9	8,104.2	3,965.2	4,549.2

It can be said from the above table that financially the Proposed Plan is the most feasible one.

As already mentioned, the value of FIRR is not appropriate in evaluating the alternatives.

(4) Sensitivity Analysis

Sensitivity analysis was performed for the proposed plan. Four cases were presupposed;

Case 1 - O/M cost would be higher by 20 %

Case 2 - Capital cost would be higher by 20 %

Case 3 - O/M and capital cost would be higher by 10 % and revenue would be lower by 10 %

Case 4 - Revenue would be lower by 20 %

The delay in project implementation was not considered in establishing cases because it does not constitute a negative factor for the project.

As a result of the analysis FIRR's were calculated to be 11.7 %, 9.5 %, 7.4 % and 6.7 % for Cases (1), (2), (3) and (4) respectively. They are all greater than the annual interest rate of the loan plus the commission charge of BANOBRAS. Thus, the proposed plan will be able to maintain its financial equilibrium under any conceivable adverse circumstances.

(5) Urgent Project

The financial analysis of the Urgent Project was conducted for the Proposed Plan.

The afore-mentioned financial source and preconditions/assumptions regarding the recovery of costs, depreciation period, period of projection, rate of tax on corporate income and collection efficiency of bills apply to the Urgent Project.

Supposing the Urgent Project is itself the final project, then the proposed sewerage service charge per cubic meter of sewage will be N$ 0.265 in the Federal District and N$ 0.262 in the Mexico State.

The projected Financial statement is shown in Table 8.5. The table shows that the wastewater treatment plant will be managed financially well from the long term perspective.

The cost benefit streams were prepared to estimate FIRR as shown in Table 8.6. Using the table, FIRR was calculated to be 10.6 %. It is greater than the annual interest rate plus the BANOBRAS commission charge.

The initial costs at 1994 prices, the repayment costs at current prices and the repayment costs at the present value discounted at the Opportunity Cost of Capital (OCC) of 10 % are 1.392.1, 2172.5, and 883.7 in N$ million respectively.

Sensitivity analysis was conducted for the afore-mentioned four cases. As a result, FIRR's were calculated to be 9.4 %, 8.5 %, 7.2 % and 6.8 % for Cases (1), (2), (3) and (4) respectively. They are all greater than the annual interest rate plus the BANOBRAS commission charge. Thus, the proposed Plan will be able to keep up its financial equilibrium under any conceivable adverse circumstances.

3. Institutional Aspect

3.1 Overview of Institutional Matters in Water Sector

3.1.1 Current Administration and Water Sector

The Current administration introduced the basic philosophy of economy (that is, efficient use of resources), economics (that is, generation of sufficient revenues

to meet costs) and environmental protection into the water sector. The administration stressed importance of the provision of water supply and sewerage services in raising people's living standards and health. In the urban centers, the reduction of demand, the expansion and improvement of service, the treatment and reuse of wastewater and the replacement of clean water with treated water in agriculture has been stressed.

The aim is that tariff will recover the costs of the investments, the operation, the maintenance and rehabilitation of the service systems. Simultaneously expansion of the proper resources of the sector, increase in the efficiency of the water usage and change in the notion about the value of water has been emphasized. For manufacturing industries replacement of clean water with treated water has been promoted so as to make it necessary for pollution generating industries to have treatment facilities.

3.1.2 Important Institutional Issues and Recommended Measures

The enforcement of various relevant laws including the Law of National Water and reinforcement/creation of organizations concerned including CNA reflected the policy of the current administration toward the water sector. What the administration aimed at, as mentioned above, are not fully realized yet and several items remain the urgent and major concerns of relevant government organizations.

The important institutional issues which are of major concern are listed below:

- Raising of water tariffs
- Introduction of sewerage charge
- Implementation and expansion of meter system
- Reduction of leakage
- Raising of water bill collection rate
- Introduction of strict financial management

JICA Study Team has studied such items and following measures are recommended.

1) Raising of water tariffs

Water tariffs in the study area will be revised so that the average charge per m^3 in D. F. Mexico and Mexico State will go up to N$ 1.837 and N$ 1.310 respectively. Under the new tariffs a household in the D.F. Mexico and Mexico State will pay monthly N$ 36.3 and N$ 20.5 respectively.

2) Introduction of sewerage service charge

It has been made clear by JICA Study Team that people of the study area can afford to fully shoulder such sewerage service charge. Sewerage service tariff will be introduced in the study area. Average charge (ultimate) per m^3 for D.F. Mexico and Mexico State will be N$ 0.605 and N$ 0.600 respectively. Under the tariffs a household in D. F. Mexico and Mexico State will pay monthly N$ 11.9 and N$ 9.4 respectively. The combined monthly water supply and sewerage service charge, for a household, in D.F. Mexico and Mexico State will be N$ 48.2 and N$ 29.9 respectively.

3) Implementation and expansion of meter system

If water meter is to be installed to every user as early as possible and if meter system is to succeed, it will be necessary institutionally to obligate every user to install it and to obligate every user to maintain the proper functioning of meter. On the side of water organizations it will be necessary to regularly dispatch men for the correct reading and recording of water consumption.

Authorities intend to realize the captioned objective in two year's time.

4) Reduction of leakage

The causes of leakage should be identified and proper measures should be taken toward the alleviation of the adverse effects of those causes.

To succeed in it, it will be necessary to provide those measures in the law and to enhance the relevant functions/activities in DGCOH, CEAS, etc. Also, the cooperation of the private and social sectors is indispensable.

Authorities are making effort to attain the captioned objective in two year's time.

5) Raising of water bill collection rate

The causes of the low rate of collection should be identified and measures should be taken to rectify the situation. Such measures will include reinforcement of legal provisions whereby violators of the provisions will be punished as well as reinforcement of water organizations in terms of functions and workforce.

6) Introduction of strict financial management

All the above mentioned items have one common objective of improving the financial status of water organizations toward self-financing. To achieve this objective strict financial management should be introduced to the water organizations.

For a strict financial management of a water organization, the three steps cycle of plan-do-see should be strictly observed.

Before the start of a particular financial year, the annual financial plan should be prepared and formulation of the expenditure and revenue budget should be done. Such a budget will be ultimately distributed over 12 months. This is the "plan" step.

Corporate activities such as the implementation of investment projects, production and distribution of water, transportation and treatment of sewage and collection of water bills should be done. This is the "do" step.

Corporate activities should be monthly recorded, compared with the budgeted ones. Finally, the annual comparison of the accomplishments and the budget should be done and the differences between them should be analyzed. This is the "see" step.

3.2 Required Activities for Sewerage Organization

At the present moment there is no independent sewerage organization either in the D.F. Mexico or Mexico State. The activities related to sewerage are now done in parallel with, or together with those related to hydraulics in the water organizations, namely, DGCOH and CEAS.

It may be worthwhile to list the required activities for a sewerage organization so that proper structure of such an organization may be worked out. These activities are listed below:

1) Corporate planning

Working out long and medium term plans on sewerage demands, construction and replacement of sewerage facilities, revenues and costs, financial requirements and sources, personnel and remuneration requirements, etc.

2) New works

Conducting the technical research, planning, designing and construction of sewerage facilities, and the implementation of contracts.

3) Water pollution control

Implementing wastewater discharge standards and monitoring effluents quality. Wastewater discharge standards should be implemented step by step and steadily. Monitoring of effluents quality should be done regularly and without fail.

4) Sewerage operation and maintenance

Carrying out the operation, maintenance and inspection of sewerage facilities, operation of workshop, and keeping of technical records. Technical records include records of construction plans, property connections, operations, maintenance, repair and replacement.

5) Administration and finance

Performing the functions such as personnel and general administration, financial management, accounting, public relations and internal audit.

3.3 Existing Organization

The existing functions/activities related to sewerage are performed by DGCOH for the D.F. Mexico and by CEAS for Mexico State. The structures of the two organizations are shown in Appendix D, Fig. D.6 and Fig. D.7.

Functions/activities in the two organizations can be divided into three categories, namely, those related to water supply, those related to sewerage and those related to both.

DGCOH is composed of 6 directorates, namely Technical Directorate, Directorate of Construction, Directorate of Operation, Directorate of Maintenance, Directorate of Hydraulics and User Services, and Directorate of Hydraulic Operation and Support Services. "Corporate planning" functions are performed under Technical Directorate, "new works" activities are carried out by Directorate of Construction, "water pollution control" functions are performed by Technical Directorate, "sewerage operations and maintenance" activities are carried out under Directorate of Operation and Directorate of Maintenance, and "administration and finance" functions are incorporated in Directorate of Hydraulics and User Services, and Directorate of Hydraulic Operation and Support Services.

It appears that the existing organizational structure of DGCOH satisfies the general requirements of a sewerage organization at least on the surface. However, observing the organizational structures at the "Unit" level, it is found that "corporate planning" and "administration and finance" functions might not be sufficiently institutionalized. In other words out of the plan-do-see steps of corporate activities, "plan" and "see" steps must be better improved and reinforced.

CEAS is composed of 5 directorates, namely, Directorate of Studies and Projects, Directorate of Construction, Directorate of Treatment Plants, Directorate of Operation and Directorate of Administration and Finance, and Internal Auditor. One observes that "corporate planning" functions are performed under Directorate of Studies and Projects, "new works" functions and activities are incorporated in Directorate of Construction, "water pollution control" functions are performed by Directorate of Treatment Plants, "sewerage operations and maintenance" activities are carried out under Directorate of Operation, and "administration and finance" functions are performed by Directorate of Administration and Finance, and Internal Auditor.

It appears that CEAS also satisfies all the requirements of a sewerage organization. Looking at the organizational structures at the "Department" level, it seems that "corporate planning" and "administration and finance" functions seem to be substantial. However, CEAS is financially in the red these years. It is hoped, therefore, that "plan" and "see" activities will be improved and reinforced more.

3.4 Alternatives of Sewerage Organization

JICA Study Team proposes that an independent sewerage organization be established in the course of time with the target year set at 2015. The recommended structure of the organization is shown in Fig. 8.2. It is a skeleton structure meeting minimum requirements. The outlines of the functions/activities for the directorate level and in some cases for the sub-directorate level have been presented in a preceding section.

This organization will have the total workforce of around 2,500 in 2015. In 1997, the concluding year of the Urgent Project it will have the personnel of around 700. This organization will be a semi-governmental organization with a mixture of governmental control and profit pursuing management because of the social nature of the "business".

The sewerage service charge will be incorporated in the water supply charge bills for the sake of economy and efficiency. Cooperation with the water supply organizations is required in various fields for the same reason.

An independent sewerage organization has several advantages compared with an organization having both water supply and sewerage service functions. They are listed below:

1) An independent corporate targets can be established

2) Self-discipline mentality will be nurtured

3) Lethargy and redundancy of a big organization will be reduced.

4) Conflicts with water supply personnel will be removed

5) Technological improvement can be expected

However, there are some disadvantages in the establishment of an independent sewerage organization.

There are many things that can be utilized and shared by both water supply and sewerage service personnel as shown below.

1) workforce

2) technology and know-how

3) equipment, vehicles and tools

4) facilities

This fact is a major reason behind the existence of the organization with both water supply and sewerage service functions. One has to part with such advantages in an independent sewerage organization. It leads to another alternative proposal that the existing organizations having both functions should continue to exist during and after the completion of the Project.

Under this proposal the sewerage service revenues deriving from the beneficiaries in the Federal District will belong to the Ministry of Federal District (DGCOH). Likewise, the sewerage service revenues deriving from the beneficiaries in the Mexico State will belong to the Government of Mexico State (CEAS, etc.).

Also, the Texcoco Sewage Treatment Plant will be operated and managed by the Ministry of Federal District, but the costs concerned will be divided between the Ministry and the Government of Mexico State.

Table 8.1 Annual Incidence of Water-Borne and Water Related Diseases

(Unit : Cases / Household)

Name of Diseases	Untreated Sewage Irrigated Areas (A)	Treated Sewage Irrigated Areas (B)	Difference (A - B)
I. Water-Borne Diseases			
1. Malaria	0.0430	0.0208	0.0222
2. Diarrhoea	0.5054	0.0417	0.4637
3. Dysentery	0.0251	0.0000	0.0251
4. Cholera	0.0143	0.0000	0.0143
5. Typhoid	0.0466	0.0000	0.0466
6. Para-Typhoid	0.0036	0.0000	0.0036
7. Gastro-Enteritis	0.0251	0.0000	0.0251
8. Dengue Fever	0.0287	0.0000	0.0287
9. Tuberculosis	0.0072	0.0000	0.0072
10. Diphtheria	0.0072	0.0000	0.0072
11. Measles	0.0143	0.0130	0.0013
12. Hepatitis A/B	0.0036	0.0000	0.0036
Sub-Total	0.7241	0.0755	0.6486
II. Water Related Diseases			
1. Parasitic Diseases	0.3871	0.0781	0.3090
2. Skin Diseases	0.1720	0.0000	0.1720
Sub-Total	0.5591	0.0781	0.4810
Total	1.2832	0.1536	1.1296

Note: 1. Untreated sewage irrigated areas = Irrigation areas of Tula and Alfajayucan, Hidalgo State and Municipality of Ecatepec, Mexico State
2. Treated sewage irrigated areas = Delegations of Tlahuac and Xochimilco, Federal District

Source: Sampling questionnaire surveys conducted by JICA

Table 8.2 Preconditions for Financial Analysis

1. Financial Sources and Lending Terms

External Agency	Annual Interest Rate	Repayment Period	Grace Period
A	5.25%	15 years (maximum)	construction period
B	5%	25 years	7 years
C	7.4%	20 years	5 years
D	7.3%	15 years	3 years

BANOBRAS will add 0.25% for the first five years of repayment and 0.125% from the sixth year onward to the above interest rate as commission charge when transferring the loan to DDF.

2. Full Recovery of Costs

Initial cost, O/M cost, repayment cost and replacement cost will be fully recovered by the revenue from sewerage service charge.

3. Depreciation Period

Facilities : 30 years
Electro-mechanical equipment : 15 years

4. Period of Project Life : 30 years

5. Rate of Tax on Corporate Income : 50%

6. Collection Efficiency of Bills : 85%

7. Relationship between Alternatives and Financial Sources

Alternative	External Agency			
	A	B	C	D
Proposed Plan	100%	-	-	-
Alternative I	-	60%	40%	-
Alternative II	-	-	100%	-
Alternative III	-	-	-	100%

Table 8.3 (1) Financial Statement - Proposed Plan

(Unit: N$ million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	0	0	0	338	342	346	350	355	359	363
Operation and Maintenance	0	0	0	84	84	84	84	84	84	84
Depreciation	0	24	49	49	49	49	49	49	49	49
Payment of Interest	0	0	0	84	79	75	70	64	57	52
Expenditure	0	24	49	216	212	207	202	197	190	184
Profit before Tax	0	-24	-49	122	131	139	149	158	169	179
Tax	0	0	0	61	65	70	74	79	85	89
Profit after Tax	0	-24	-49	61	65	70	74	79	85	89
Funds Statement										
Profit after Tax	0	-24	-49	61	65	70	74	79	85	89
Loans	142	626	625	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	0	24	49	49	49	49	49	49	49	49
Sources	142	626	625	110	114	118	123	127	133	138
Capital Works	142	626	625	0	0	0	0	0	0	0
Payment of Principal	0	0	0	82	86	91	95	100	106	111
Working Capital	0	0	0	28	28	28	28	27	28	27
Applications	142	626	625	110	114	118	123	127	133	138
Loan Liabilities	149	815	1,516	1,434	1,348	1,258	1,162	1,062	957	845
Cash Balance	0	0	0	28	56	84	111	138	166	193

Source: JICA

Table 8.3 (2) Financial Statement - Proposed Plan

(Unit: N$ million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	367	371	375	379	383	388	392	396	400	404
Operation and Maintenance	84	84	84	84	98	113	127	142	157	171
Depreciation	49	49	49	63	78	89	100	112	123	134
Payment of Interest	46	39	33	26	18	11	3	0	0	0
Expenditure	178	172	165	173	194	212	231	254	280	306
Profit before Tax	189	199	210	207	189	175	160	142	120	99
Tax	94	100	105	103	95	88	80	71	60	49
Profit after Tax	94	100	105	103	95	88	80	71	60	49
Funds Statement										
Profit after Tax	94	100	105	103	95	88	80	71	60	49
Loans	0	0	16	422	437	322	322	337	322	322
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	49	49	49	63	78	89	100	112	123	134
Sources	143	148	170	588	609	498	502	520	505	505
Capital Works	0	0	16	422	437	322	426	441	322	322
Payment of Principal	117	123	130	136	143	132	64	0	0	0
Working Capital	26	25	24	30	29	44	12	78	183	184
Applications	143	148	170	588	609	498	502	520	505	505
Loan Liabilities	729	605	493	802	1,142	1,398	1,743	2,189	2,643	3,120
Cash Balance	219	244	268	299	327	372	384	462	645	829

Source: JICA

Table 8.3 (3) Financial Statement - Proposed Plan

(Unit: N$ million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	408	653	653	653	653	653	653	653	653	653
Operation and Maintenance	186	200	200	200	200	200	200	200	200	200
Depreciation	146	146	146	146	146	146	146	146	146	146
Payment of Interest	0	202	185	167	148	128	104	83	60	43
Expenditure	331	548	531	513	494	474	450	429	406	389
Profit before Tax	77	105	122	140	159	179	203	225	247	264
Tax	38	53	61	70	80	89	102	112	123	132
Profit after Tax	38	53	61	70	80	89	102	112	123	132
Funds Statement										
Profit after Tax	38	53	61	70	80	89	102	112	123	132
Loans	322	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	146	146	146	146	146	146	146	146	146	146
Sources	506	198	207	216	225	235	247	258	269	278
Capital Works	322	0	0	0	0	0	0	0	21	21
Payment of Principal	0	307	323	340	358	376	396	412	323	242
Working Capital	184	-108	-116	-124	-132	-141	-149	-154	-75	15
Applications	506	198	207	216	225	235	247	258	269	278
Loan Liabilities	3,623	3,316	2,993	2,653	2,296	1,919	1,523	1,111	789	547
Cash Balance	1,013	904	788	664	532	390	241	88	13	28

Source: JICA

Table 8.4 Cost Benefit Streams - Proposed Plan

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:N$ Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	142	0	142	0	-142
2	1996	626	0	626	0	-626
3	1997	625	0	625	0	-625
4	1998	0	84	84	338	254
5	1999	0	84	84	342	258
6	2000	0	84	84	346	263
7	2001	0	84	84	350	267
8	2002	0	84	84	355	271
9	2003	0	84	84	359	275
10	2004	0	84	84	363	279
11	2005	0	84	84	367	283
12	2006	0	84	84	371	287
13	2007	16	84	100	375	275
14	2008	422	84	506	379	-126
15	2009	437	98	535	383	-151
16	2010	322	113	435	388	-47
17	2011	426	127	554	392	-162
18	2012	441	142	583	396	-188
19	2013	322	157	478	400	-78
20	2014	322	171	493	404	-89
21	2015	322	186	508	408	-100
22	2016	0	200	200	653	453
23	2017	0	200	200	653	453
24	2018	0	200	200	653	453
25	2019	0	200	200	653	453
26	2020	0	200	200	653	453
27	2021	0	200	200	653	453
28	2022	0	200	200	653	453
29	2023	21	200	221	653	432
30	2024	21	200	221	653	432

Table 8.5 (1) Financial Statement - Proposed Plan (Urgent Project)

(Unit: N$ million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	0	0	0	237	240	242	245	248	251	254
Operation and Maintenance	0	0	0	84	84	84	84	84	84	84
Depreciation	0	24	49	49	49	49	49	49	49	49
Payment of Interest	0	0	0	84	79	75	70	64	57	52
Expenditure	0	24	49	216	212	207	202	197	190	184
Profit before Tax	0	-24	-49	21	28	36	43	52	61	70
Tax	0	0	0	10	14	18	22	26	31	35
Profit after Tax	0	-24	-49	10	14	18	22	26	31	35
Funds Statement										
Profit after Tax	0	-24	-49	10	14	18	22	26	31	35
Loans	142	626	625	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	0	24	49	49	49	49	49	49	49	49
Sources	142	626	625	59	63	66	70	74	79	84
Capital Works	142	626	625	0	0	0	0	0	0	0
Payment of Principal	0	0	0	82	86	91	95	100	106	111
Working Capital	0	0	0	-23	-23	-24	-25	-26	-26	-27
Applications	142	626	625	59	63	66	70	74	79	84
Loan Liabilities	149	815	1,516	1,434	1,348	1,258	1,162	1,062	957	845

Source: JICA

Table 8.5 (2) Financial Statement - Proposed Plan (Urgent Project)

(Unit: N$ million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	257	260	263	266	268	271	274	277	280	283
Operation and Maintenance	84	84	84	84	84	84	84	84	84	84
Depreciation	49	49	49	49	49	49	49	49	49	49
Payment of Interest	46	39	33	26	18	11	3	0	0	0
Expenditure	178	172	165	158	151	143	136	132	132	132
Profit before Tax	79	88	98	108	118	128	138	145	148	151
Tax	39	44	49	54	59	64	69	72	74	75
Profit after Tax	39	44	49	54	59	64	69	72	74	75
Funds Statement										
Profit after Tax	39	44	49	54	59	64	69	72	74	75
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	49	49	49	49	49	49	49	49	49	49
Sources	88	93	97	102	107	113	118	121	122	124
Capital Works	0	0	0	0	0	0	104	104	0	0
Payment of Principal	117	123	130	136	143	132	64	0	0	0
Working Capital	-29	-30	-32	-34	-36	-19	-51	17	122	124
Applications	88	93	97	102	107	113	118	121	122	124
Loan Liabilities	729	605	476	340	196	64	0	0	0	0

Source: JICA

Table 8.5 (3) Financial Statement - Proposed Plan (Urgent Project)

(Unit: N$ million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	286	286	286	286	286	286	286	286	286	286
Operation and Maintenance	84	84	84	84	84	84	84	84	84	84
Depreciation	49	49	49	49	49	49	49	49	49	49
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	132	132	132	132	132	132	132	132	132	132
Profit before Tax	153	153	153	153	153	153	153	153	153	153
Tax	77	77	77	77	77	77	77	77	77	77
Profit after Tax	77	77	77	77	77	77	77	77	77	77
Funds Statement										
Profit after Tax	77	77	77	77	77	77	77	77	77	77
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	49	49	49	49	49	49	49	49	49	49
Sources	125	125	125	125	125	125	125	125	125	125
Capital Works	0	0	0	0	0	0	0	0	0	0
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	125	125	125	125	125	125	125	125	125	125
Applications	125	125	125	125	125	125	125	125	125	125
Loan Liabilities	0	0	0	0	0	0	0	0	0	0

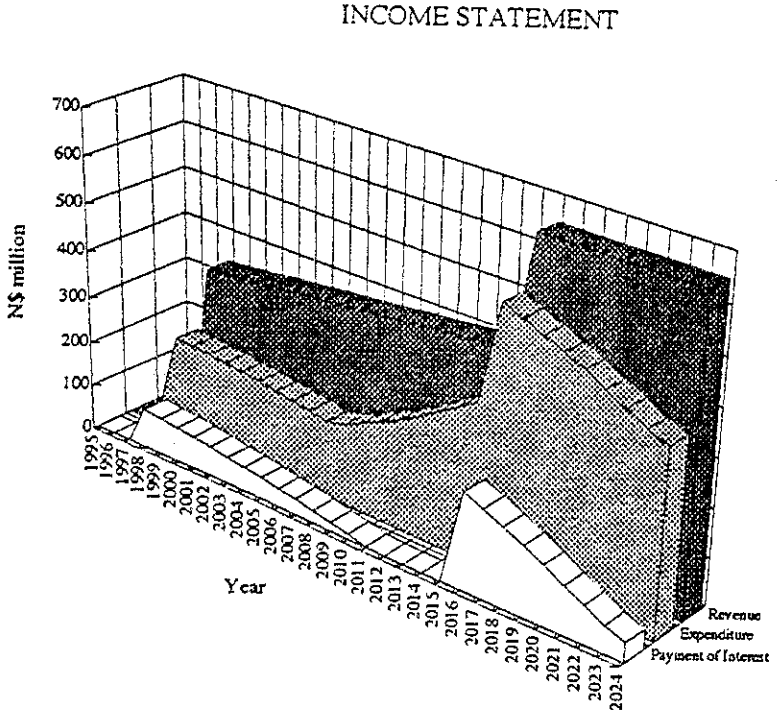
Source: JICA

Table 8.6 Cost Benefit Streams - Proposed Plan (Urgent Project)

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:N$ Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	170	0	170	0	-170
2	1996	751	0	751	0	-751
3	1997	750	0	750	0	-750
4	1998	0	84	84	237	153
5	1999	0	84	84	240	156
6	2000	0	84	84	242	159
7	2001	0	84	84	245	162
8	2002	0	84	84	248	164
9	2003	0	84	84	251	167
10	2004	0	84	84	254	170
11	2005	0	84	84	257	173
12	2006	0	84	84	260	176
13	2007	0	84	84	263	179
14	2008	0	84	84	266	182
15	2009	0	84	84	268	185
16	2010	0	84	84	271	188
17	2011	125	84	209	274	65
18	2012	125	84	209	277	68
19	2013	0	84	84	280	196
20	2014	0	84	84	283	199
21	2015	0	84	84	286	202
22	2016	0	84	84	286	202
23	2017	0	84	84	286	202
24	2018	0	84	84	286	202
25	2019	0	84	84	286	202
26	2020	0	84	84	286	202
27	2021	0	84	84	286	202
28	2022	0	84	84	286	202
29	2023	0	84	84	286	202
30	2024	0	84	84	286	202



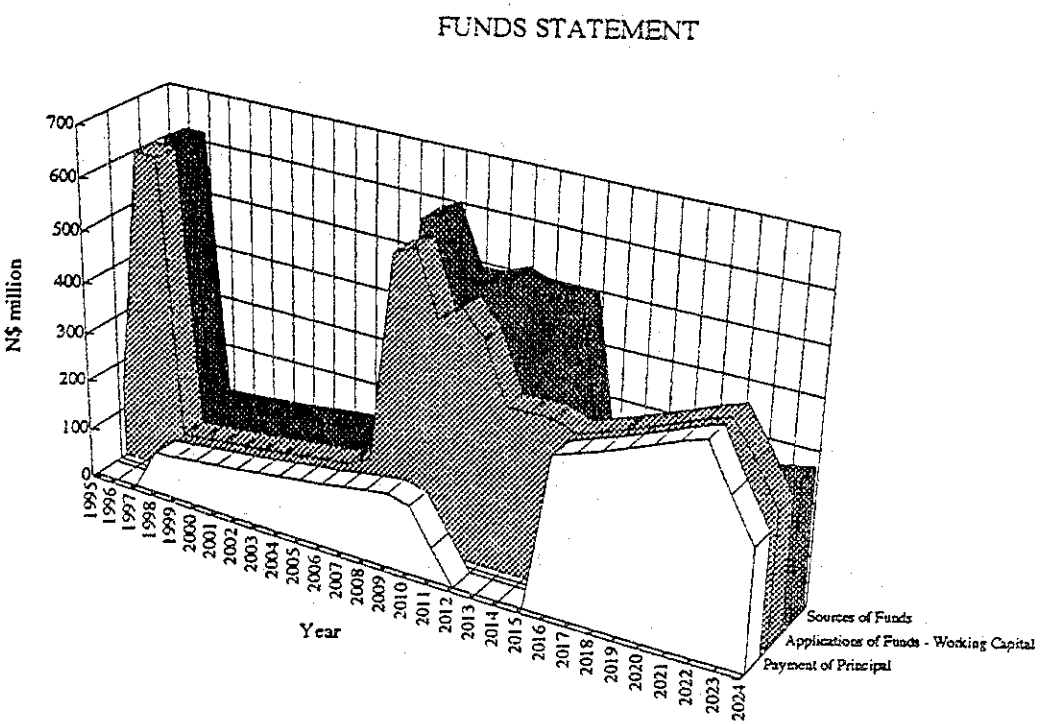


Fig. 8.1 Financial Statement - Proposed Plan

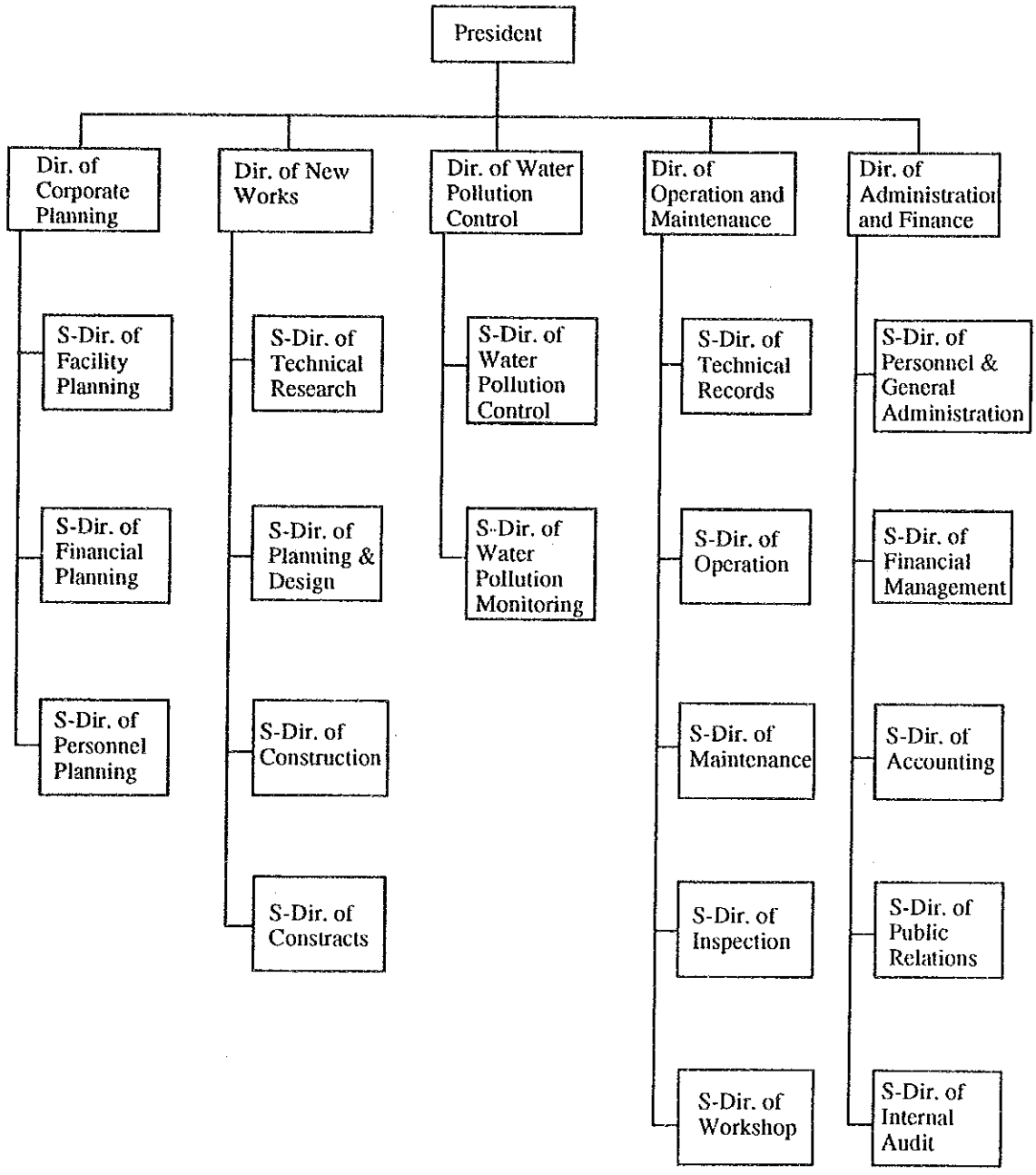


Fig. 8.2 Proposed Structure of Sewerage Organization

CHAPTER 9

CHAPTER 9 RECOMMENDATIONS

1. Immediate Project Implementation

Sewage collection system covers existing population of 94% in D.F. Mexico and of 85% in Mexico State. While only small portion of collected wastewater is treated for reuse purpose. Consequently a large proportion of collected wastewater is being discharged without any treatment to the rivers through Gran Canal and Emisor Central. The discharged untreated wastewater has resulted in the deterioration of the environmental conditions in the downstream areas and has also adversely affected the inhabitants.

An immediate implementation of the Urgent Project is necessary for both improvement of the overall sanitary environment at the downstream irrigation areas and increasing agricultural product.

Hence, it is recommended to commence the necessary financial procurement at the earliest.

Furthermore, it is recommended that the inflow pumping station at the intersection point of Los Remedios river and La Compania river along Gran Canal should also be constructed simultaneously with the proposed Texcoco treatment plant for conveying the wastewater to the treatment plant.

2. Introduction of Social Education Program

The importance of wastewater treatment as a protective measure for the spreading of parasitic diseases can not be ignored. However social education program to prevent human exposure and to reduce parasitic infections is also necessary.

The population with higher potential risk of parasitic infections can be classified into three categories; field workers and families, consumers and people living near the field. An educational program for these people should be initiated. Major aspects to be included in the program are listed below.

- Importance of using appropriate footwear and gloves by field workers
- Properly cooking vegetables, meat and boiling milk
- Providing immunization against Typhoid, Hepatitis A etc.
- Providing facilities for Diarrhea diseases
- Emphasizing importance of personal and food hygiene
- Providing health education to mothers and also children in the schools
- Providing immunization facilities for the children in the schools

Decades ago in Japan when organic manure (human waste) was used nation-wide and the sewerage system was not much developed, many Japanese had parasitic warms. The break-out of water-borne diseases did not have any news value because it was such a common happening unlike in the present-day Japan. The Japanese suffered from a general health problem in those days due to such circumstances.

Besides providing wastewater treatment facilities, an educational program, as mentioned above was initiated and the importance of this program has been observed in Japan. At present the % of population suffering from parasitic diseases in Japan is negligible.

3. Detailed Design of the Treatment Plant

This report elaborates feasibility study stage of the project. The main purposes of this feasibility study have been summarized below:

- Establishment of design criteria
- Selection of the optimum wastewater and sludge treatment process
- Basic design of the wastewater and sludge treatment plant for the Urgent Project
- Economic and financial evaluation

Hence in detailed design stage, especially following studies should be conducted in more detail.

- Designing layout of wastewater and sludge treatment plant with due consideration to the actual implementation program
- Estimation of solid content of activated and thickened sludge by pilot test
- Designing size of aeration tank and return sludge feeding system
- Detailed analysis of soil characteristics and detailed design of foundation structure.