Table 5.1 Design Criteria for Sewerage Facilities (cont'n)

Item	Design Criteria
Structural Design of Facilities (1) Interceptor	Minimum dia. of sewer: RC 300 mm Force main crossing waterways: less than 200mm in dia. Earth cover: max.5.0 m below G.L min.1.0 m below G.L
(2) Manhole	Manhole type: Japanese standard Manhole spacing: Pipe dia. — Max.spacing less than 600 mm — 40 m 800 - 1200 mm — 80 m more than 1200 mm — 120 m
(3) Overflow chamber	Installation type Open channel/U type drain without a cover channel/U type drain with a cover Drainage pipe/conduit Weir type: submerged weir Screen: bar type(75 mm) sand deposit: 30 cm below invert level of sewer
(4) Siphon	River crossing:parallel installation velocity: 20-30 % up at upstream to downstream
(5) Pump station	Monhole type: less than 5.0 m^3/min. Common type: more than 5.0 m^3/min.
(6) Activated sludge treatment process	Design criteria are summarized in the design covering the following facilities. Primary Sedimentation Basin Stormwater Sedimentation Basin Aeration Tank Secondary Sedimentation Basin Disinfection Tank Gravity Thickener Digestion Tank Mechanical Dewatering

SECTION 6 WASTEWATER COLLECTION SYSTEM

The alignments of main interceptors and pump stations employing combined collection method were designed in the Master Plan for the target year of 2011. In the context of the Master Plan sub-main interceptors in the preliminary design area were additionally designed with the design flow for the final target year of 2011. Current conditions, especially with reference to land availability for major sewerage facilities are taken into account as follows:

(1) Existing public roads are planned as the routes of interceptors. The information on public roads is included in Data Report 3.6.1. It is regarded that the sewer routes along klongs are not practical in the fact that houses are located therein making difficult to ensure land area both for sewers and pump stations.
(2) Location of pump stations are arranged considering land availability, sometimes against economical construction.

Distribution of population and wastewater quantity was made in use of population density by land use type (refer to Supporting Report 3.6.1).

Alignments of interceptors and pump stations are shown in Figure 6.1 and their profiles in Figure 6.2 (refer to hydraulic calculation in Supporting Report 3.6.1) The design of two(2) pump stations and one(1) inverted siphon are presented in Figures 6.3 and 6.4, respectively.

Table 6.1 presents composition of collection facilities. Design fundamentals and specifications of pump stations and inverted siphon are included in Supporting Report 3.6.2. Number of overflow chambers is also shown in the same Supporting Report.

Table 6.1 Wastewater Collection Facilities

Interceptor			Manhole		
Dia. (mm)	Length (m)	Ave. Earth Cover (m)	Kind	Number	Ave. depth (m)
300	1,485	1.9	No.1	155	3.1
400	2,550	2.5	No.2	26	3.8
500	725	3.4	No.3	22	4.0
600	857	2.7	Special	1	4.2
800	1,595	2.7			
1,000	1,240	2.4	Total	204	
1,200	50	4.3			
			Pump station : 2 stations		
Total	8,502		Inverted siphon : 1 unit		

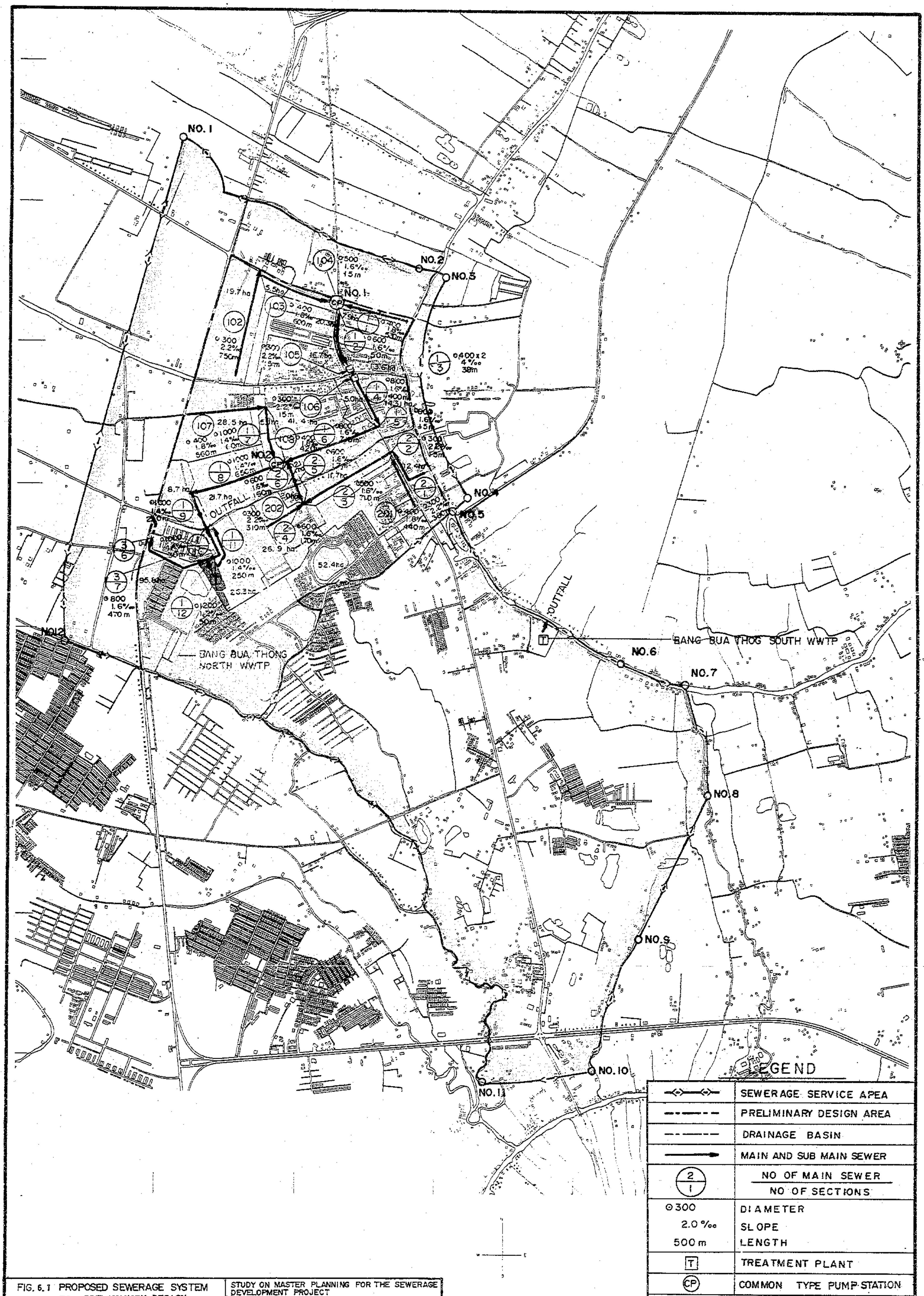
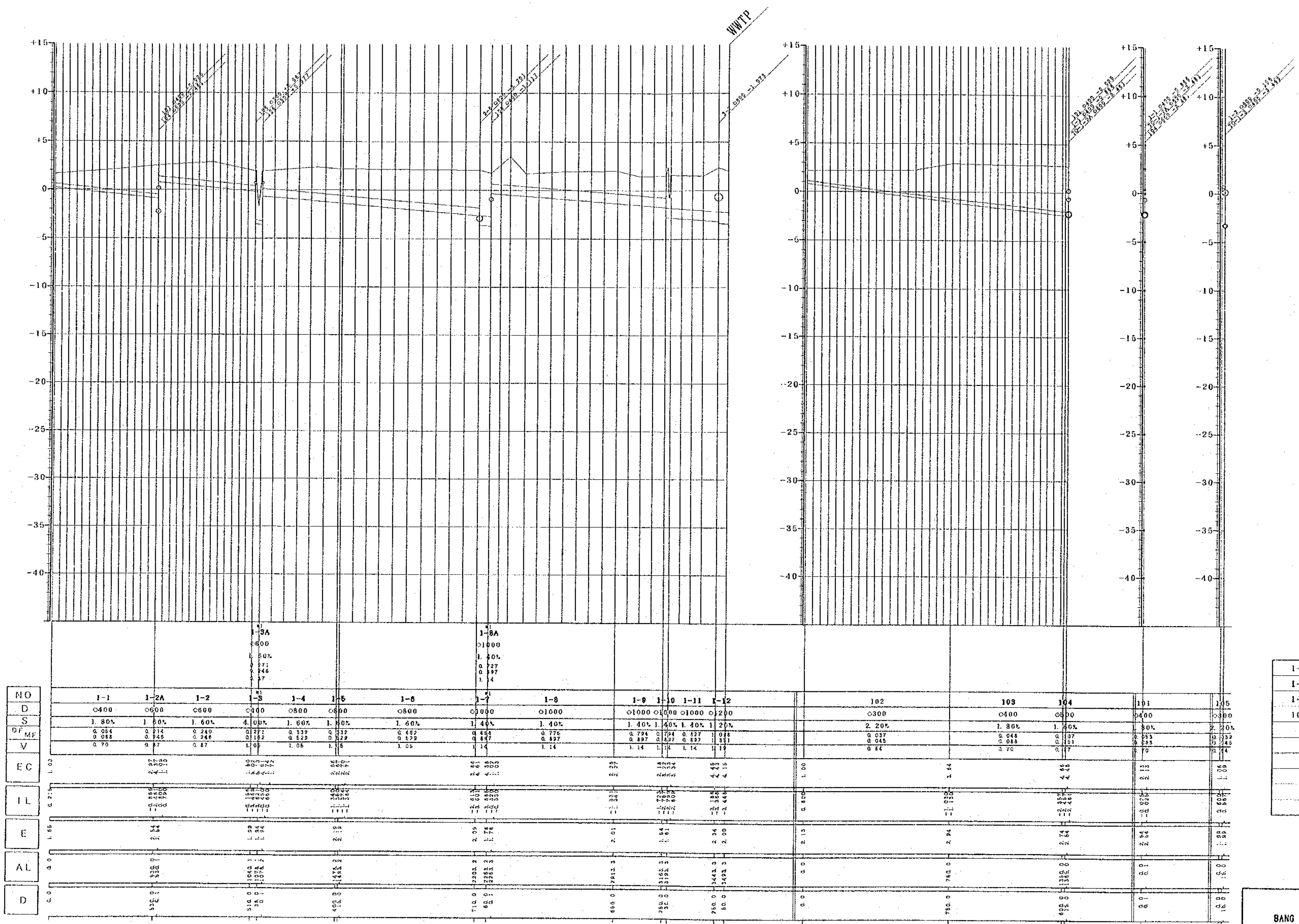


FIG. 6.1 PROPOSED SEWERAGE SYSTEM FOR PRELIMINARY DESIGN (BANG BUA THONG MUNICIPALITY)

STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



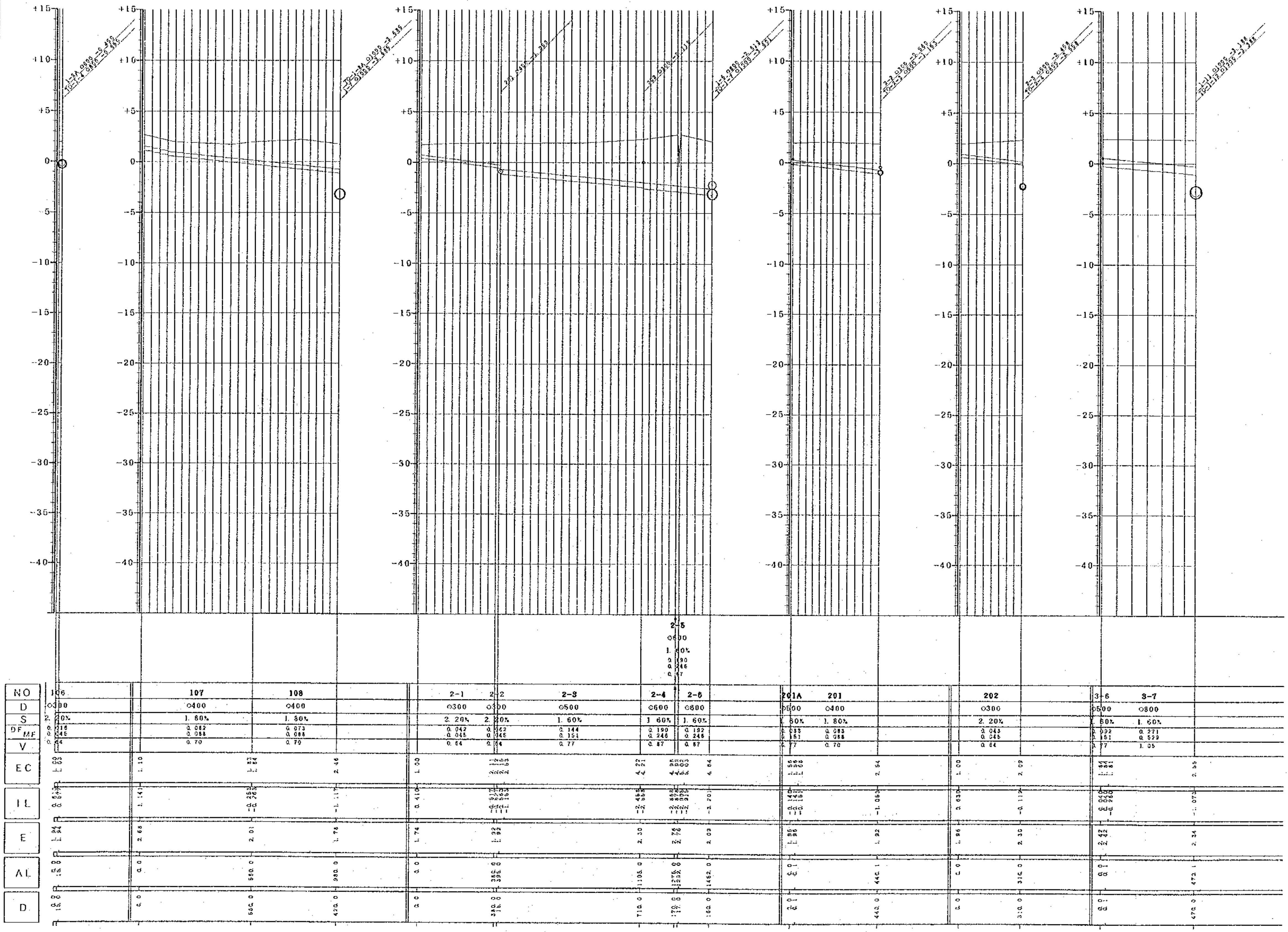
LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

1-1	1-2A	1-2	1-3	1-3A
1-4	1-5	1-6	1-7	1-8A
1-8	1-9	1-10	1-11	1-12
102	103	104	101	105

FIGURE 6.2 (1)	V 1:200
BANG BUA THONG - NORTH	H 1:10,000
PRELIMINARY DESIGN FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY	



LEGEND

Item	Description
N O	NO. of Sewers
D	Diameter
S	Slope
D F M F	Design Flow Maximum Flow for Pipe
V	Velocity
E C	Earth Cover
I L	Invert Level
E	Elevation
A L	Accumulated Length
D	Distance

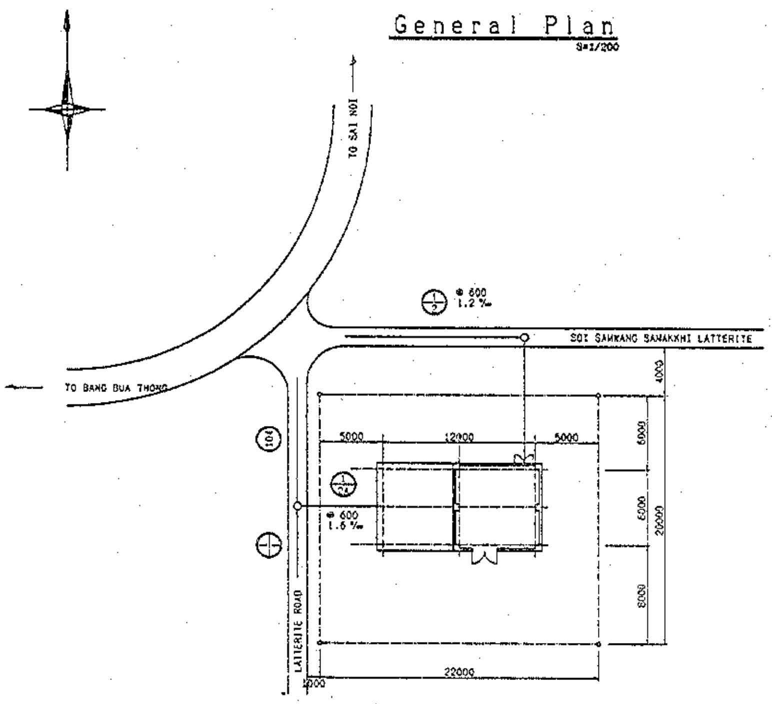
No. of Sewers

106	107	108	2-1	2-2
2-3	2-4	2-5	2-6	201A
201	202	3-6	3-7	

FIGURE 6.2 (2) BANG BUA THONG - NORTH	V 1:200 H 1:10,000
PRELIMINARY DESIGN FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY	

NO. 1 PUMP STATION

General Plan



Water Levels Diagram

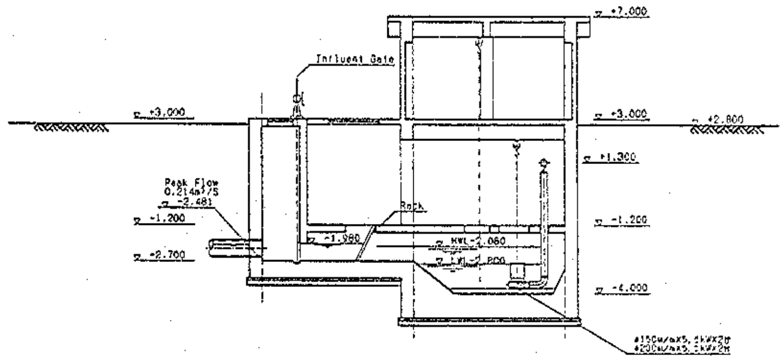


Figure 6.3. (1)-1
Preliminary Design of No. 1 Pump Station
Bang Bua Thong Area

NO. 1 PUMP STATION

S=1/100

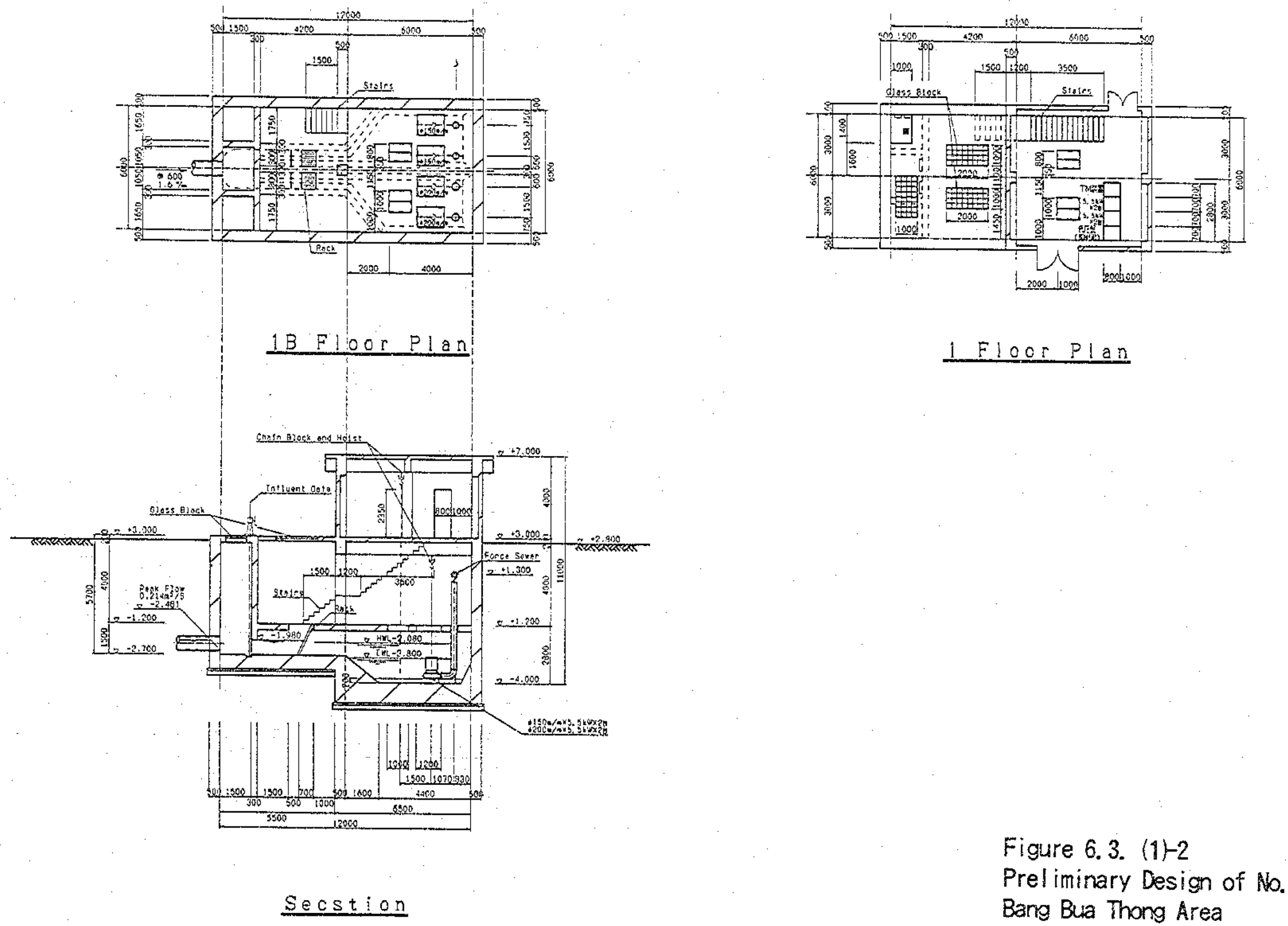
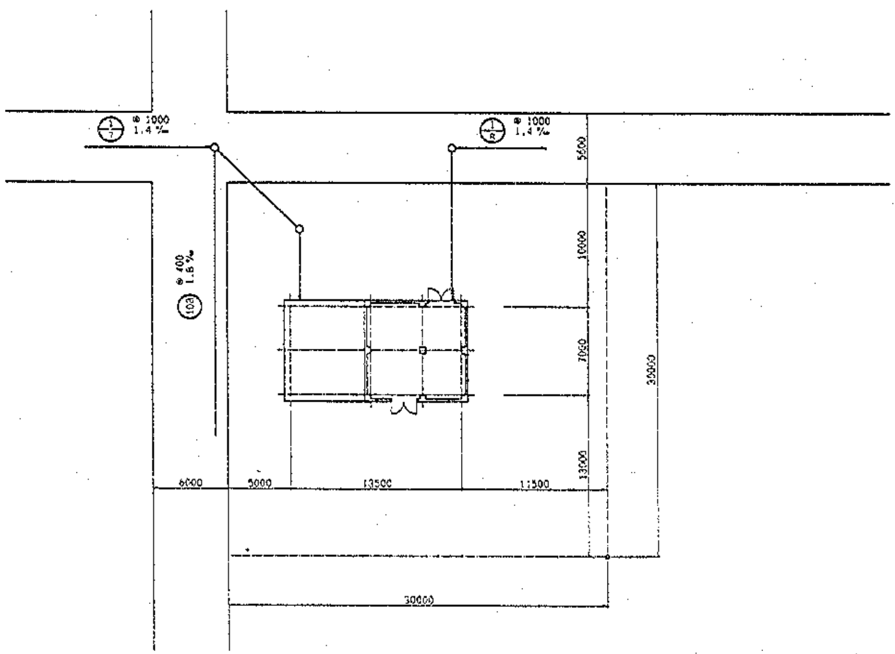


Figure 6.3. (1)-2
Preliminary Design of No. 1 Pump Station
Bang Bua Thong Area

NO. 2 PUMP STATION

General Plan

S=1/200



Water Levels Diagram

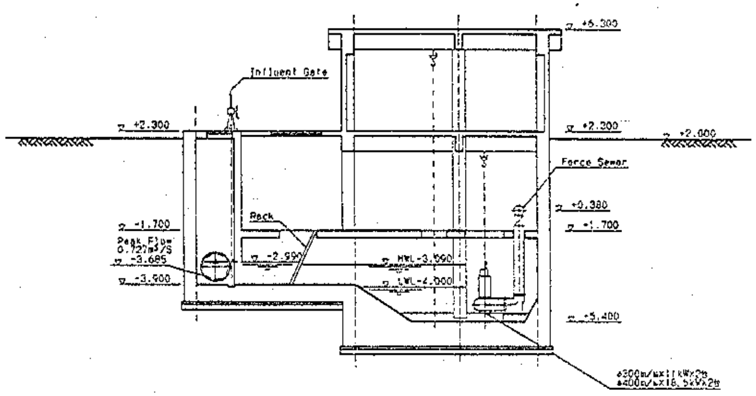


Figure 6.3. (2)-1
Preliminary Design of No. 2 Pump Station
Bang Bua Thong Area

NO. 2 PUMP STATION

S=1/100

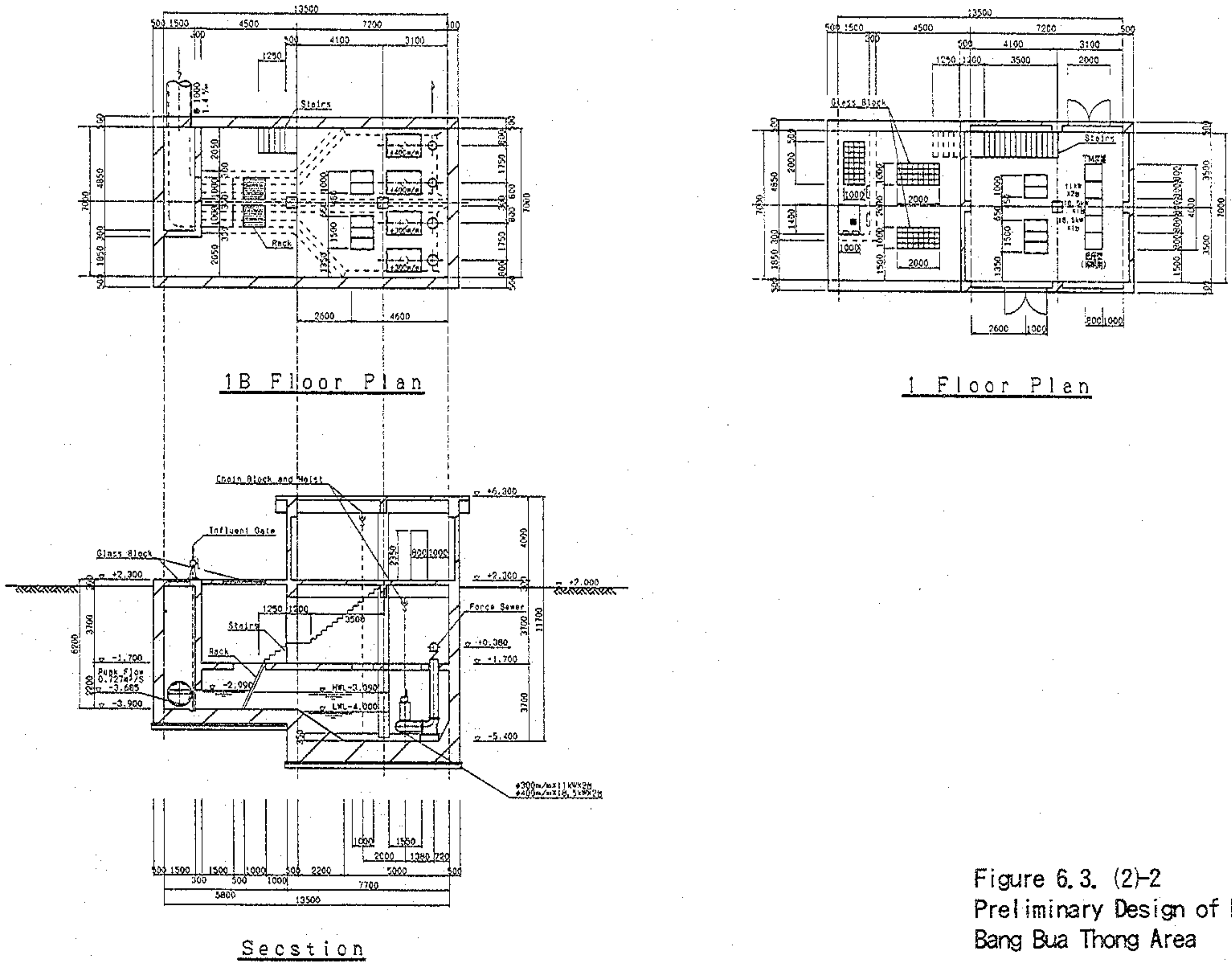


Figure 6.3. (2)-2
Preliminary Design of No. 2 Pump Station
Bang Bua Thong Area

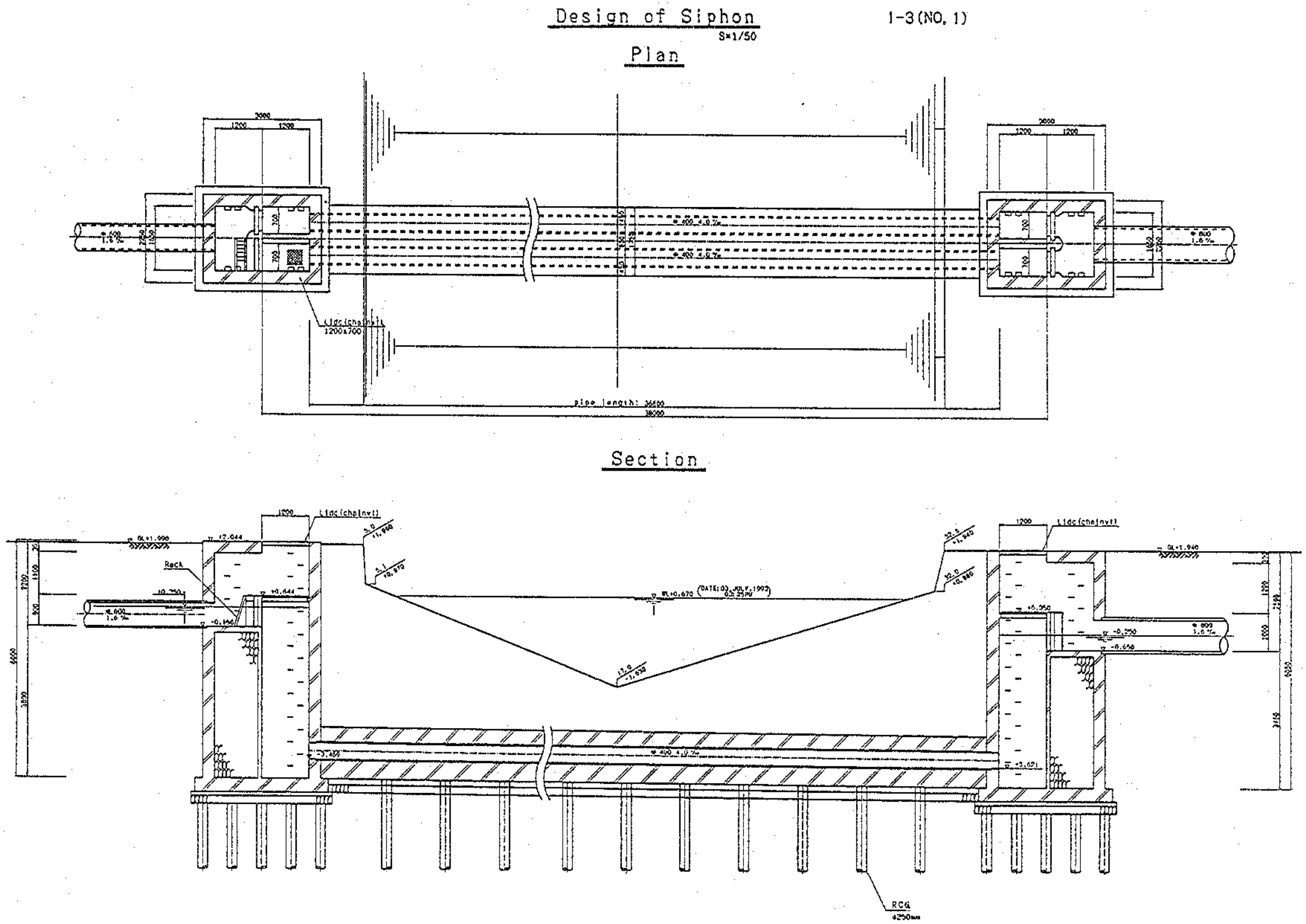


Figure 6.4. Preliminary Design Siphon

SECTION 7 WASTEWATER TREATMENT AND SLUDGE DISPOSAL SYSTEM

7.1 Wastewater Treatment Plant Site

The proposed wastewater treatment plant site is located in Pimol Ratcha 5 village, in the premise of Wat Molee behind Chol Lada housing estate. The site currently used as paddy field is accessible from Bang Bua Thong -Taling road with a distance of about 400 m. It is encompassed by three housing estates, chol Lacha, P. Phasuk and Chantima (present population in the estates : about 4,500).

The land areas required for master plan and preliminary design are 3.0 ha and 1.8 ha , respetively.

Ground elevation at the proposed site ranges from +0.95 m to +1.2 m with an average of +1.08 m amsl. The highest flood level is about 0.3 m above existing elevation based on the past flood records.

Soil conditions are obtained from boring test conducted at the site as follows:

The top surface layer of 0 - 13 m depth is composed of soft clay, followed by dense to very dense silty sand at the depth of 13 - 22 m.

The N value of this subsoil are:
- Less than 10 at shallow depth less than 13 m.
- Greater than 40 in deep layers (deeper than 15 m)

Details are included in Data Report 3.7.1. The supporting layer of the structures is proposed to be 15 m below existing ground level.

7.2 Design Wastewater Quantity and Quality

Wastewater quantity and quality on a daily average basis to be treated in 2001 and 2011 were studied in the Master Plan and previous section. Basic figures for design of sewerage facilities are discussed hereunder.

(1) Wastewater Quality

Conventional activated sludge treatment method is employed after comparative study of possible treatment methods in the Master Plan. Effluent quality requirements are less than 20 mg/l BOD and 30 mg/l SS. Design temperature is assumed to be 25°c. While influent BOD concentration flowing into the wastewater treatment plant is estimated using Section 4.2, Chapter 3. Design influent quantity (daily maximum basis) is assumed as follows:

BOD : 150 mg/l (calculated from total BOD load and quantity)

SS : 150 mg/l (assumed refering to previous projects)

(2) Wastewater Quantity

The quantity of wastewater flowing into the treatment plant is summarized by design flow in its fluctuation through the day. Total wastewater quantity for capacity calculation includes the amount discharged from four(4) housing estates. Inclusion of the wastewater from the estates was concluded both for economial treatment in the design area, and limited capacity of the existing facilities and needs of continuous maintenance system.

In accordance with aforementioned design criteria; daily average, daily maximum and hourly maximum wastewater quantity for capacity calculation is summarized in comparison with those in the final target year. The required capacity for the preliminary design year (2001) is about 1/2 (46%) of that for final target year (2011).

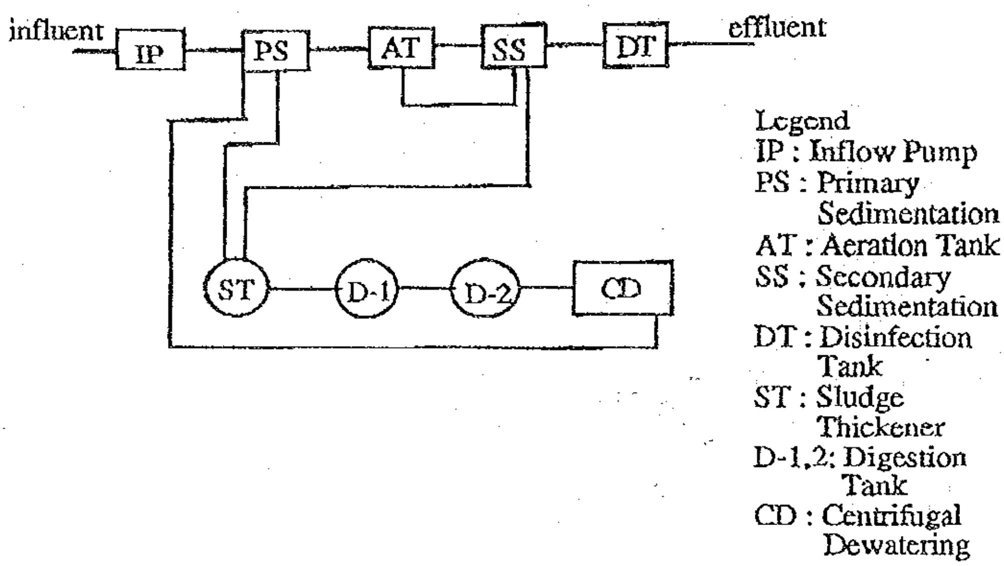
Wastewater Quantity	Year 2001 (m^3/d)	Year 2011 (m^3/d)
Daily Average	9,100	19,700
Daily Maximum	10,900	23,600
Hourly maximum	14,200	30,700
Wet Weather Flow	42,600	92,100

7.3 Design of Wastewater and Sludge Treatment Facilities

7.3.1 Design Considerations

Activated treatment system comprises wastewater treatment facilities, primary sedimentation basin, aeration tank and final sedimentation basin, and sludge treatment facilities, sludge thickener and sludge digestion tank. This system can save land area required comparing with other potential methods, while it needs sophisticated technology both in construction and O & M. The flow diagram of the wastewater treatment process is shown in Figure 7.3.1.

Figure 7.3.1. Wastewater Treatment Process



Design conditions for the treatment facilities are summarized in Table 7.3.1.

Major considerations for design of treatment facilities are summarized for the study of Rang Sit. The average ground elevation of main local road is 2.0 m amsl (1.8-2.5m) and the elevation of the road facing the planned WWTP is also 2.0 m amsl. Water level of the receiving waterway is more or less 1.0m during rainy season. Based on the experience flood level was about 30 cm higher than existing ground level. Thus, average ground elevation of the WWTP was planned to be 2.3m amsl.

Countermeasures are recommended in Section 7.3.1 for Rang Sit area to follow up the possible discrepancies between the design and conditions at the target year.

Table 7.3.1 Design Conditions for the Treatment Facilities

Item	Conditions				
Design Flow (m^3/d)	Daily Ave.	Daily Max.	Hourly Max.		
	9,100	10,900	14,200		
Removal Ratio (%)	Inbluent Quality(mg/l)	Primary Sedi.	Effluent from Sedi. (mg/l)	Final Sedi.	Effluent Quality (mg/l)
	BOD 150	30	105	81.0	20
	SS 150	35	97.5	69.2	30

Item	Conditions			
Sludge Conditions (%)	Return sludge density	0.7	Thickened sludge organic material ratio	60
	Return sludge ratio	25	Efficiency of Digestion Tank	90
	Raw sludge density	2	Digestion ratio	50
	Excess sludge density	0.7	Efficiency of Dewatering (centrifugal)	95
	Thickened sludge Den.	3	Dewatered sludge moisture content	79
	Digested sludge Den.	3	Dosing ratio	1.1
	Efficiency of thickener	80		

The following are outline of unit treatment facilities.

(1) Wastewater treatment

1) Inflow Pump Station

Raw wastewater firstly flows into this facility and is pumped up to the primary sedimentation basin. Coarse materials and sand in the wastewater are removed in provision of a screen and grit chamber to protect the pump units and reduce loads to the succeeding facilities.

2) Primary Sedimentation Basin

The function of the primary sedimentation basin is to remove suspended solids, organic and/or inorganic, by gravitational sedimentation, which decrease BOD and SS substances to be loaded into the biological treatment process. Originating from its role, the primary sedimentation process is the preliminary treatment process in the biological treatment process.

For quick removal of settled sludge, a sludge rake and sludge pump are provided in the basin.

3) Aeration Tank

This facility is highly important in the biological treatment process. Aeration is the method of propagating various kinds of aerobic bacteria with organic matter in the sewage being the source of nutrition. This activated sludge process is to remove organic matter by coagulating suspended solids and colloidal matter through bacterial metabolism. The clarifying functions of the activated sludge process are summarized below.

(1) Absorption of organic matter

(2) Oxidation and Assimilation of absorbed organic matter

(3) Formation of a floc for quick sedimentation

Aerated effluent separates solids from liquid in the secondary sedimentation basin in the next process, and the supernatant water flows out, while the settled sludge is returned to the aeration tank as activated sludge, and again employed in the sewage treatment process. The surplus sludge is treated by the sludge treatment process.

4) Final Sedimentation Basin

Aeration tank effluent separates solids from liquid in the basin and the liquid flows out to the next process.

In the basin, sludge rake, sludge pump and scum collector are provided as the primary sedimentation basin.

Return sludge to the aeration tank and excess sludge to the sludge treatment process are returned from the final sedimentation basin.

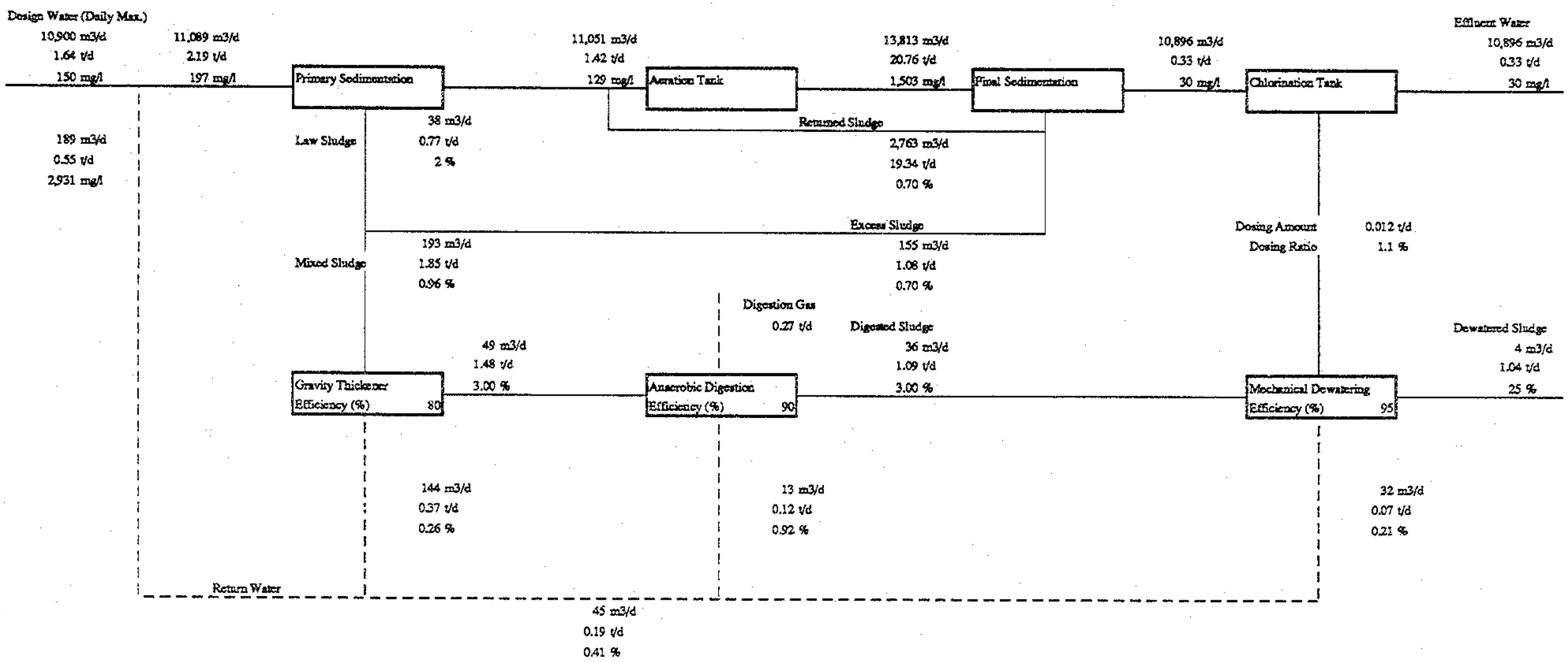
5) Disinfection Tank

This facility is designed to remove bacterium from the effluent, Calcium hypochlorite dosing to the effluent is adopted as the disinfecting agent.

(2) Sludge treatment

The flow diagram of the proposed sludge disposal system is shown in Figure 7.3.2 including mass balance of suspended solid.

Figure 7.3.2 Mass Balance of SS in Rangsit Sewage Treatment Plant



The mass balance for the final target year is shown in Supporting Report 3.7.3.1. Table 7.3.2 presents required capacity of major facilities both for preliminary design and final target year.

Table 7.3.2 Design Capacity of Sludge Treatment Facilities

Facility	Preliminary Design	Final Target Stage (2011)
Gravity Type Thickener	$193m^3/d$, 1.85t/d	$419m^3/d$, 4.01t/d
AnaerobicDigestion Tank	$49m^3/d$, 1.48t/d	$107m^3/d$, 3.21t/d
Centrifugal Dewatering	$36m^3/d$, 1.09t/d	$79m^3/d$, 2.36t/d

The following are the outline of sludge treatment facilities.

1) Gravity Thickener

Gravity thickening is accomplished in a tank similar in design to a conventional sedimentation basin. Mixed sludge is fed to a center feed well. The feed sludge is allowed to settle and compact, and thickened sludge is withdrawn from the bottom of the tank.

2) Anaerobic Digestion Tank

Anaerobic digestion of sludge is classified into four(4) from its different operation system as standard-rate, single-stage high-rate, two-stage and separate system. Two-stage digestion system is proposed as the optimum sludge digestion process for this project.

3) Centrifugal Dewatering

The following four(4) mechanical dewatering processes are considered as alternatives for this project.

- Belt Filter Press
- Filter Presses
- Vacuum Filtration
- Centrifugal Dewatering

These four(4) mechanical dewatering processes are compared from technical and economical view points. Centrifugal dewatering process is selected as an optimum dewatering process for this project, because of the low density of SS of influent wastewater to the Treatment plant.

Solid bowl type is selected from other two(2) centrifugal dewatering process of disc-nozzle and basket types.

7.3.2 Design of Facilities

Capacity calculation and determination of dimensions for respective treatment units are made. Detailed calculation results are included in Supporting Report 3.7.3.2.

The composition of treatment system was established considering design flow (daily max. basis) for the final target year, 23,600 m^3/d and this design flow, 10,900 m^3/d. A total of four(4) treatment unit systems are planned with a capacity of 5,900 m^3/d for each unit system. Two unit systems with the joint capacity of 11,800 m^3/d are designed for the first stage program.

Table 7.3.3 Shows design of facilities for the first stage project.

Layout plan and hydraulic profile of the treatment system are shown in Figure 7.3.3 and 7.3.4.

SECTION 8 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE OF THE FACILITIES

8.1 Construction plan, and Operation and Maintenance

Construction methods for major sewerage facilities including sewers, pump stations and treatment plant are discussed in the Master Plan. Additional descriptions for overflow chamber, inverted siphon and pump stations (manner of pump operation) are included in this Section.

(1) Interceptors

Open trench method is employed for pipe laying in provision of sheet pile for the excavation of more than 2 m deep. The excavation is done either by means of man-power or backhoe.

(2) Overflow Chamber

The overflow chamber shall be installed under public roads. In case of wastewater collection discharged from housing estates, the facility shall be placed at the junction of the pipe from estates and public road/drainage along the road.

Table 7.3.3 (1) Specifications of Wastewater Treatment Plant

Item	Specifications
1) Grit Chamber	
(Dry Weather)	
Numbers	1 units
Dimension	(W) 1.0 m x (L) 9.0 m
Effective Depth	(H) 0.4 m
Retention Time	21.9 sec.
Surface Loading	1,578 m3/m2/day
(Wet Weather)	
Numbers	1 units
Dimension	(W) 1.4 m x (L) 9.0 m
Effective Depth	(H) 0.4 m
Retention Time	15.3 sec.
Surface Loading	2,254 m3/m2/day
3) Primary Sedimentation Tank	
Type of Tank	Circular
Numbers	2 units
Diameter	(D) 15.0 m
Effective Depth	(H) 4.0 m
Retention Time	3.1 hr.
Surface Loading	31 m3/m2/day
Weir Loading	116 m3/m/day
4) Stormwater Sedimentation Tank	
Type of Tank	Circular
Numbers	3 units
Diameter	(D) 14.0 m
Effective Depth	(H) 3.0 m
Retention Time	1.0 hr.
Surface Loading	69 m3/m2/day
Weir Loading	240 m3/m/day
5) Aeration Tank	
Type of Tank	Rectangular
Numbers	2 units
Dimension	(W) 12.0 m x (L) 36.0 m
Effective Depth	(H) 3.0 m
BOD - SS Loading	0.30 kg/kg/day
Aeration Time	5.7 hr
BOD Volumetric Load	0.44 kg/m3/day
Sludge Age	3.60 days

Table 7.3.3 (2)Specifications of Wastewater Treatment Plant

Item	Specifications
6) Secondary Sedimentation Tank	
Type of Tank	Circular
Numbers	2 units
Diameter	(D) 17.0 m
Effective Depth	(H) 2.5 m
Retention Time	2.5 hr
Surface Loading	24 m3/m2/day
Weir Loading	102 m3/m/day
7) Disinfection Tank	
Numbers	3 units
Dimension	(W) 2.0 m x (L) 60.0 m
Effective Depth	(H) 1.5 m
(Dry Weather)	
Contact Time	71.3 min.
(Wet Weather)	
Contact Time	18.3 min.
8) Gravity Thickener	
Numbers	1 units
Diameter	(D) 6.0 m
Effective Depth	(H) 4.0 m
Solids Loading	65.4 kg/m2 day
Thickening Time	14.1 hr
9) Digester	
(1st Digester)	
Numbers	2 units
Diameter	(D) 12.0 m
Effective Depth	(H) 5.0 m
Digestion Time	22.9 days
(2nd Digester)	
Numbers	2 units
Diameter	(D) 8.5 m
Effective Depth	(H) 5.0 m
Digestion Time	11.5 days

Table 7.3.3 (3) List of Major Mechanical and Electrical Equipment for Wastewater Treatment Plant

Item	Specifications		Quantity
1) Grit Chamber			
- Manual Coarse Bar Screen	1,000 mm(W) x 3,000 mm(H)		2
- Manual Fine Bar Screen	1,400 mm(W) x 2,600 mm(H)		2
- Sand Pump and Washing Equipment	ϕ 80 mm x 0.5 m3/min. x 10m	2.2 kw	1
2) Inflow Pump Station			
- Submersible Pump	ϕ 250 mm x 4.93 m3/min.	15 kw	2
- Submersible Pump (Stormwater)	ϕ 450 mm x 19.72 m3/min.	55 kw	1
3) Primary Sedimentation Tank			
- Sludge Scraper (Center Drive)	ϕ 15.0 m x 3.8 m(H)	0.4 kw	2
- Sludge Draw off Pump	ϕ 100 mm x 0.15 m3/min. x 6 m	5.5 kw	2
- Inlet Value	ϕ 350 mm Sluice Manual		2
4) Aeration Tank			
- Surface Aerator (Bridge Mount Type)		11 kw	6
- Inlet Value	ϕ 350 mm Sluice Manual		2
5) Final Sedimentation Tank			
- Sludge Scraper (Center Drive)	ϕ 17.0 m x 2.3 m(H)		2
- Sludge Recirculation Pump	ϕ 150 mm x 1.04 m3/min. x 5 m	15 kw	2
- Inlet Value	ϕ 350 Sluice Mannual		2
- Excess Sludge Draw off Pump	ϕ 100 mm x 0.12 m3/min. x 6 m	5.5 kw	2
6) Disinfection Tank			
- Dosing Pump	0 ~ 3 l/min. x	0.4 kw	2
- Hypochlorite Storage Tank	4 m3		2
- Inlet Gate	1,000 mm(W) x 1,000 mm(H)		1
- Outlet Gate	1,200 mm(W) x 1,200 mm(H)		1
7) Gravity Thickener			
- Sludge Draw off Pump	ϕ 100 mm x 0.15 m3/min. x 6 m	5.5 kw	1
8) Digester			
- Sludge Draw off Pump	ϕ 100 mm x 0.13 m3/min. x 6 m	5.5 kw	2
- Agitation Blower	2.8 m3/min. x 7 m	15 kw	2
- Desulfurizer	1,000 m3/d Dry Type		1
- Waste Gas Burner	1 m3/min.		1
- Gas Transfer Blower	1 m3/min. x 6 m	5.5 kw	2
9) Dewatering Unit			
- Sludge Feeding Pump	0 ~ 1 m3/hr. x	2.2 kw	1
- Polymer Dosing Pump	0 ~ 10 l/min. x	0.4 kw	1
- Centrifuge Type	4 ~ 5 m3/hr.	(7.5 kw/2.2kw)	2
- Beltconveyor & Hopper	10 m3	0.75 kw	1
10) Laboratory Equipments			
- BOD Measurement Kit			1
- COD Measurement Kit			1
- SS Measurement Kit			1
- DO / Temperature Meter			1
- PH Meter			1
- Coliform Group Counting Kit			1

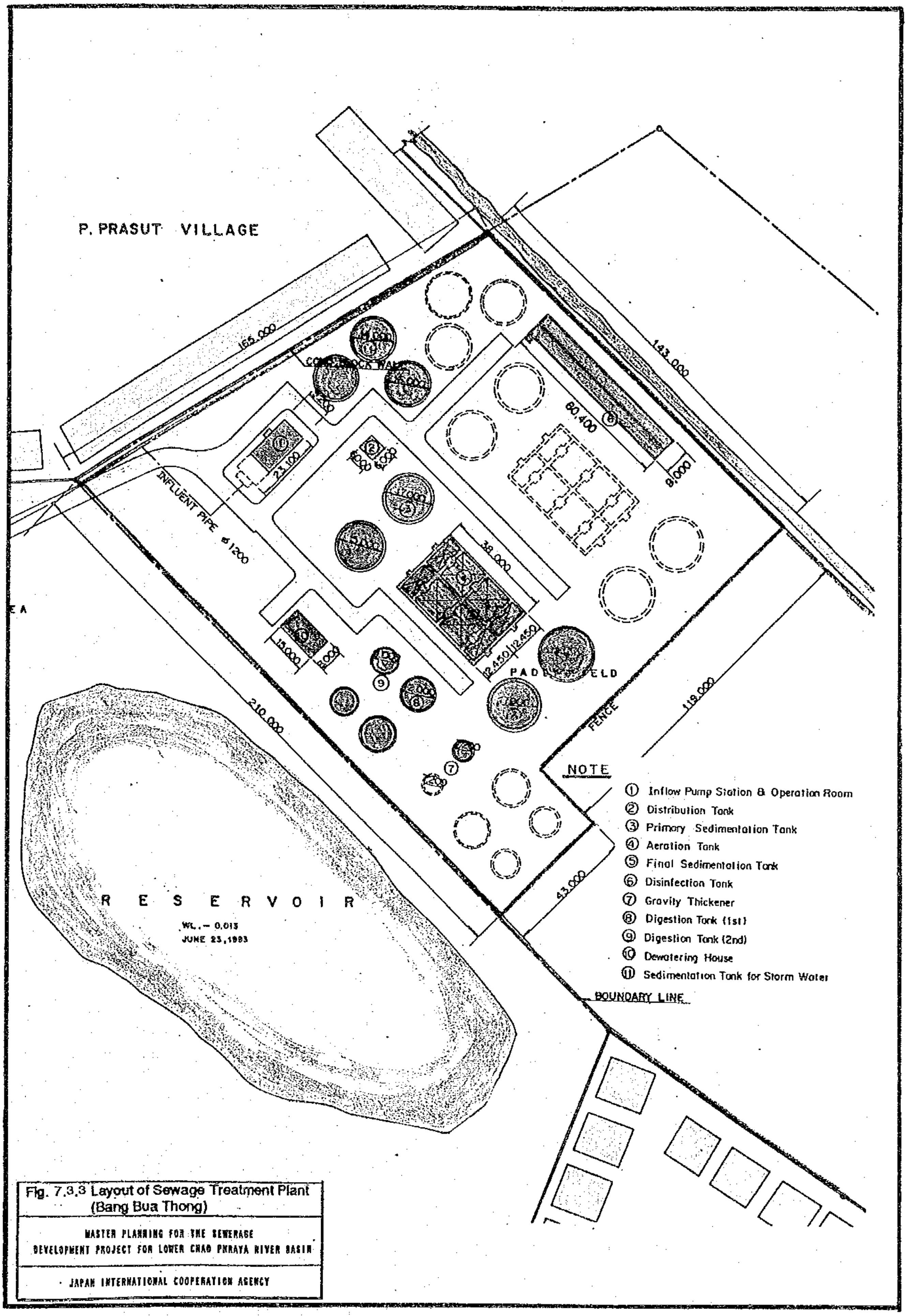


Fig. 7.3.3 Layout of Sewage Treatment Plant (Bang Bua Thong)

MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

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HYDRAULIC PROFILE

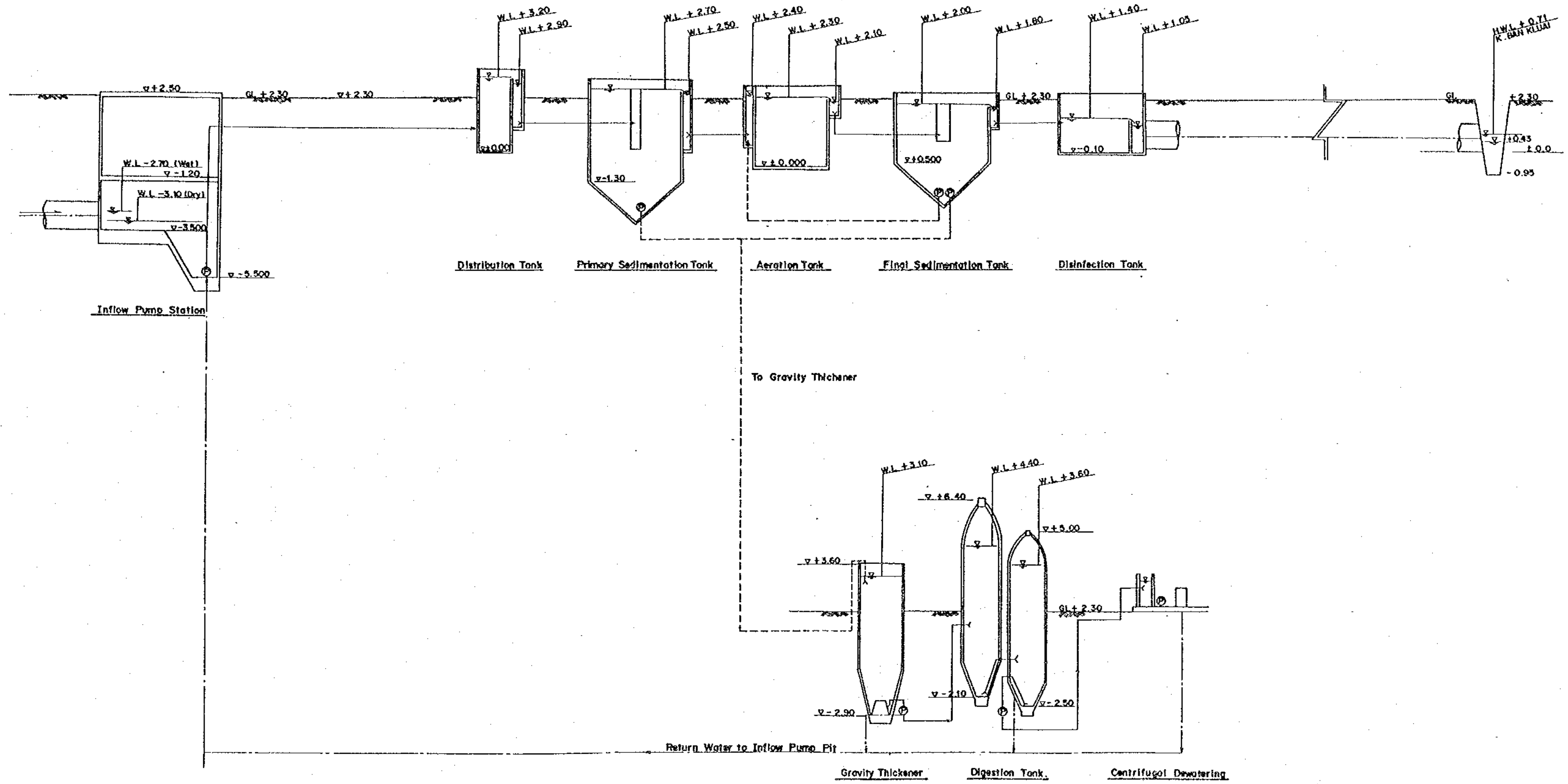

Fig. 7.3.4 Hydraulic Profile of Sewage Treatment Plant (Bang Bua Thong)

MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

In construction of the chamber at the drainage along the road, consolidation of inflow drainages thereto shall be made to design the neighboring chambers with a distance of about 500 m.

A manhole shall be installed at the junction of interceptor and sewer from the overflow chamber.

(3) Inverted Siphon

The parallel pipes in application of open cut method shall be installed crossing klong provided with chambers at both inlet and outlet parts. Drain pits with a depth of about 1.0 m and stop boards are necessary at the chambers. If the depth of the chamber exceeds 5 m, drain pump facility is necessary. In principle, pile foundation shall be adopted in consideration of the soil consolidation. The pipes shall be covered with reinforced concrete and installed at least 0.5 m below the river bet (There is no plan on dredging/improvement of klongs). The cover installed on the top at the chamber, upstream of the inverted siphon, shall be arranged to release wastewater upon receipt of abnormal pressure.

(4) Pump Station

Ground elevation at the pump station shall be determined taking into account of those in the surrounding area and levee. A large pump station will require pile foundation because of sub-soil condition with bearing strata at about 15 m below ground surface. Sheet piling may be applicable for excavetion.

Pump type shall be submersible one without grit chamber prior to pump pit. A bar screen with 75 mm mesh shall be provided. A generator set is not considered, however, central monitoring and local control shall be provided.

Number of pump units are as follows:

- The number of units is more than two.
- Four (4) units shall be provided for comparatively large pump station. Number of units by pump diameter is:
  - a) Two(2) units with each capacity of 1/2 hourly max.

b) Two(2) units with each capacity of hourly max.

c) Four(4) units as the total of item a) and b) shall be operated for wet weather flow.

Operation of pump units shall be done according to flow fluctuation.

a) Daily average wastewater
Under common condition during dry season, two(2) units of pump with a capacity of 1/2 hourly max. each shall be used. During the repair period of these units, either one of the two units with a capacity of hourly max. each shall be operated.

b) Daily max. wastewater
Operation of pump unit/s shall be done in the same procedure as item a).

c) Hourly max. wastewater
Under common condition, 2 units of pump with a capacity of 1/2 hourly max. each shall be used. Either one of two units with a capacity of hourly max. each can be operated, if the abovementioned units are broken down.

d) Wet weather wastewater
Four units of pump shall be operated at one time.

(5) Wastewater Treatment Plant
Pile foundation is required for construction of treatment facilities.

In any cases, for a) to c), the pump units shall be operated alternatively.

8.2 Mitigating Measures against Potential Negative Impact

Potential environmental problems caused by sewerage projects and countermeasures thereto are discussed in Section 3.16, Chapter 2, Part II covering different stages from designing to operation and maintenance of major sewerage facilities. Further descriptions on the preliminary design area are included in this section. Countermeasures to be considered during design stage are reflected in the previous section of this plan. Those for construction, and operation and maintenance stages are discussed hereunder.

(1) Construction Stage

Interceptor

Interferences with klongs and the main road are major concern for installation of interceptors. The main sewer route is planned along Road No 3215 passing in the central portion of the municipality. Houses are located along the road. Traffic congestion/blocking of access to houses/buildings are to be minimized. Careful construction schedule and arrangements to get cooperation from inhabitants are requisites. Crossing the road shall also be done ensuring partial traffic using open cut method for pipe laying. The work crossing klong Phra Phimon and klong Ban Klual across above mentioned road shall be managed to minimize interference with river transportation (small boat).

The construction of inverted siphon shall be done using sheet pile ensuring a half water way for traffic convenience during the work.

Wastewater treatment plant

With regard to the construction of wastewater treatment plant, traffic congestion at the junction of access road to the treatment plant and Bang Bua Thong - Taling Chan Road shall be managed. Adequate buffer areas surrounding the treatment plant shall also be ensured in the existence of three housing estates comparatively near the site.

(2) Operation and Maintenance Stage

Interceptors and pump stations

Routine inspection work shall be done along sewer routes for preventive countermeasures with attentions to sewer trench cave-in, manhole structure and overflow of wastewater from sewers. Maintenance at the chamber of inverted siphon (overflow, etc.) and discharge pipe (effect by adverse flow from main river) shall be carefully done. Periodic removal of deposit at overflow chamber is essential to keep functioning the sewerage systems.

A quick action to the pump accident for maintenance of pump stations shall be done in full use of a central monitoring system. Inspection of sewers for illegal connections to interceptors and obstractions is necessary. Dissemination of information on the maintenance of sewerage systems is important in addition to prevent disposal of solid waste in sewers.

Wastewater treatment plant

Common problems to wastewater treatment plants such as odor and noise are to be minimized through careful operation and maintenance, and operation monitoring. The control of effluent quality shall be done to meet fluctuation of wastewater quantity and quality according to yearly increase of service area and its water consumption. Depending on the concentration of organic substances, modified arrangements of treatment facilities shall be made.

SECTION 9 COST ESTIMATES AND CAPITAL INVESTMENT PROGRAM

9.1 Construction Cost

The project cost on 1993 price level consists of direct cost, indirect cost, contingency and engineering fee. Assumed percentages for major factors are as follows:

- Contingency : 20 % of direct cost
- Engineering fee(design and construction supervision) :
  17 % of total construction cost including contingency

Currency exchange rates are set for calculation of cost requirements in Baht: 1 US$ = 25 Baht = 105 yen

Data base is those collected in Thailand; market price for materials and equipment, and construction unit in the similar projects.

(1) Direct cost for construction of sewerage facilities

Direct cost including tax covers thouse for interceptors with accessories, pump stations and treatment facilities. Most of construction materials and equipment are available in Thailand except for mechanical and electrical equipment. Unit prices of basic materials and equipment are referred to in the Master Plan.

Cost estimates on unit cost base

Unit construction cost per meter was estimated for installation of interceptors. The standard costs in terms of pipe diameter and earth cover are included in Supporting Report 9.1.1. Likewise unit construction costs for manhole, overflow chamber connected to existing drainage pipe were prepared as shown in supporting Report 9.1.1. While, costs for inverted siphon, pump station and treatment plant are estimated by each facility.

(2) Total Construction Cost

Direct construction costs for interceptors, manhole, inverted siphon, overflow chambers and pump stations are estimated. Detailed calculation results are included in Supporting Report 9.1.2. Table 9.1.1 summarizes project cost. Land acquisition cost is estimated based on local information. The costs are divided into domestic and foreign (imported materials and equipment) portions.

Table 9.1.1 Project Cost on 1993 Price Level
(Unit: Million Baht)

Description	Domestic Portion	Foreign Portion	Total
1. Direct Cost			
1.1 Collection System			
(1)Interceptor	74.3	-	74.3
(2)Manhole	2.8	-	2.8
(3)Overflow Chamber	0.4	-	0.4
(4)Inverted Siphon	1.1	0.2	1.3
(5)Pump Station	9.4	11.4	20.8
Sub-Total	88.0	11.6	99.6
1.2 Treatment Plant			
(1)Civil & Architec. Facilities	30.9	-	30.9
(2)Mechanical Facility			
(3)Electrical Facility	-	89.6	89.6
Sub-Total	30.9	89.6	120.5
Total of item 1	118.9	101.2	220.1
2. Contingency	23.8	20.2	44.0
3. Total of Construction Cost (1 + 2)	142.7	121.4	264.1
4. Engineering Cost	44.9	-	44.9
5. Land Acquisition Cost	150.5	-	150.5
Grand Total	338.1	121.4	459.5

Note : 1.1(1) includes maintenance equipment / car
1.2(2) includes P.S monitoring facility

9.2 Operation and Maintenance Cost

Annual operation and maintenance cost for the year 2001 by major facility was estimated using data collected in Thailand.

(1) Interceptors and accessories

Inspection of sewer routes is a routine work for maintenance of sewers. Cleaning of sewers shall be done at least twice a year. Mechanical methods are to be employed as discussed in the Master Plan. Unit cost required per meter was estimated at 21.5 Baht in assumption of the followings.

Annual cost required is 366 x 10^3 Baht(21.5 Baht/m x 8,500 m x 2 times)

(2) Pump station

Cost requirements include those for labor, electric power, fuel and repairment of facilities.

1) Labor Cost

Staff composition and cost requirements to cover two(2) pump stations were estimated as follows:

Staff Member & No.		Unit Cost/Month (x 10^3 Baht)	Annual Cost (x 10^3 Baht)
Technician	1	5	60.0
Labor	2	2.35	56.4
Total	3		116.4

2) Operation and Maintenance Cost

Item		Unit Cost /percentage	Consumption /initial cost(x10^3Baht/year)
Operation:	Power	1.65 B/KWH	853
Maintenance:	Civil/archi. structure	1 % of construction cost	94
	Mechanical and Electrical equip.	3 % of construction cost	342
	Total		1,289

(3) Wastewater Treatment Plant

Labor cost and, operation and maintenance cost were estimated by major item.

1) Labor Cost

Staff Member & No.		Unit Cost/month (x 10^3 Baht)	Annual Cost (x 10^3 Baht)
Manager	1	12	144.0
Mecha. Eng.	2	8.2	196.8
Elect. Eng.	1	8.2	98.4
Operator	4	5.0	240.0
Labor	2	2.35	56.4
Total	10		735.6

Note: Inclusion of night shift

2) Operation and Maintenance Cost

Item		Unit Cost /percentage	Consumption /initial cost (x10^3Baht/year)
Operation:	Power	1.65 B/KWH	4,125
	Chlorine	16 B/kg	70
Maintenance:	Civil/archi. structure	1 % of construction cost	309
	Mechanical and Electrical equip.	3 % of construction cost	2,688
	Total		7,192

The following are the summary of annual O & M cost for the capacity of 2001 covering above mentioned items.

Item	cost Requirement (x10^3 Bhat)
1.Interceptors & accessories	366
2.Pump Stations	
(1) Labor	116
(2) O & M	1,289
Sub Total	1,405
3.Wastewater T.P	
(1)Labor	737
(2)O & M	7,192
Sub Total	7,929
4.Total Cost	9,700

9.3 Capital Investment Program

The first stage program was established starting from 1994 to complete by the middle of 1997 under the following assumptions.

(1) Detailed Engineering Design: One(1) year period
(2) Construction period of wastewater treatment plant: 1.5 years
(3) Budgetary arrangement and approval procedures: as required for consulting services and construction works

Figure 9.3.1 shows implementation schedule and manners of implementation by item are enumerated.

(1) Budgetary arrangement and relevant procedures for project implementation

Arrangements by the Government in either use of domestic or foreign assisted finances shall be done timely both for consulting services and construction of sewerage facilities. Tendering and approval by related agencies are requisites with some months. For consulting service it is necessary to be performed at the beginning of 1994. During 1995, arrangements for construction work is also required.

(2) Land acquisition

Prior to the construction work, land area shall be purchased or ensured for right-of-way (interceptor routes). The activities shall be done during the years 1995 and 1996. The land acquisition covers two(2) pump stations and treatment plant site.

(3) Construction of sewerage facilities

Interceptors with accessories including overflow chambers and inverted siphon are planned to be constructed during 1996 and 1997 (8 months) before completion of treatment plant.

Pump stations are also to be completed by the middle of 1997(6 months). The longest construction period of one and a half year is assumed for the treatment plant starting from the beginning of 1996. Procurement of a maintenance vehicle and laboratory equipment shall be done by the middle of 1997.

Figure 9.3.1 Implementation Program for the First Stage Project

Item \ year	1994	1995	1996	1997
1. Budgetary arrangement & other procedures				
1.1 Budgetary Arrangement	—	—		
1.2 Tendering	–	—		
1.3 Approval procedure	–	– —		
2. Land Acquisition				
2.1 Right-of-way for Interceptors (19.7km)			----	
2.2 Pump Station (8st.)			------	
2.3 Treatment Plant		---------		
3. Construction Work				
3.1 Interceptors w/ accessories			—	—
3.2 Pump Stations			—	—
3.3 Treatment Plant			—	—
4. Consulting Services				
4.1 Engineering Design	—	—		
4.2 Const. Supervision			—	—

(4) Consulting Services

Detailed design of sewerage facilities is assumed to be conducted by the beginning of 1995. Construction supervision shall be done during the construction period by experienced engineers.

Table 9.3.2 shows capital investment program between 1994 and 1997.

SECTION 10 ORGANIZATION AND MANAGERIAL ASPECTS

10.1 General Arrangements

Organizational arrangements both in national and local levels are recommended covering the following items. Details are referred to in Section 10.1, Rang sit area.

(1) Strengthening of PWD and OSW
(2) Creation of NSWA (National Sewage Works Authority)
(3) Legal arrangement

Table 9.3.2 Capital Investment Program for First Stage Project

(Unit: Million Baht)

Item \ Year	1994			1995			1996			1997			Total		
	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total
1. Interceptors W/Accessories							31.4	0.1	31.5	47.2	0.1	47.3	78.6	0.2	78.8
2. Pump Stations							2.8	3.4	6.2	6.6	8.0	14.6	9.4	11.4	20.8
3. Treatment Plant							21.6	62.7	84.3	9.3	26.9	36.2	30.9	89.6	120.5
Sub-Total (item 1-3)							55.8	66.2	122.0	63.1	35.0	98.1	118.9	101.2	220.1
4. Contingency							11.2	13.2	24.4	12.6	7.0	19.6	23.8	20.2	44.0
5. Consulting Fee															
(1) Detailed Design	30.3		30.3	3.4		3.4							33.7		33.7
(2) Supervision							7.8		7.8	3.4		3.4	11.2		11.2
6. Land Acquisition				150.0		150.0	0.5		0.5				150.5		150.5
Sub-Total (item 4-6)	30.3		30.3	153.4		153.4	19.5	13.2	32.7	16.0	7.0	23.0	219.2	20.2	239.4
Total	30.3		30.3	153.4		153.4	75.3	79.4	154.7	79.1	42.0	121.1	338.1	121.4	459.5

Note : Dom.; Domestic portion
Foreign; Foreign portion
Procurement of maintenance car is included in item 1.
Laboratory equipment is considered in item 3.

(4) Financial arrangement

(5) Establishment of training courses

10.2 Local management

In accordance with implementation schedule for the first stage project, necessary arrangements shall be done. Major requirements are referred to in Section 10.2, Rang Sit area covering the followings.

(1) Creation of Local Sewage Works Authority (LSWA)

(2) Training

SECTION 11 FINANCIAL PLANNING

11.1 Financing the Project Cost: Central Government

Options on financial Arrangements by the central government are studied in the previous section for Rangsit covering the two areas, Rangsit and Bang Bua Thong.

11.2 Cash Flow and Household Burden of O&M and Local Land Acquisition Cost

While the capital construction cost is borne by the Central Government, the acquisition cost of land is not totally included. Local municipality must acquire the land for sewerage facility with 25% of the cost.

Should the entire land acquisition cost be financed by the 50% foreign land and 50% local loan with the weighted average capital cost of 7% for 25 years with the grace period of 5 years. The break even cost per household user becomes 121 Baht per year in 1999 and drops to 67 Baht in 2024. The real burden on the household user, however, becomes 482 Baht in 1999 and decreases to 267 in 2026. This is because the FIRR should be maintained in such a level that the local financial project be feasible. The FIRR should be somewhere greater than 7%, but less than the prevailing capital market cost of, say, 12%. The FIRR turned to be 8.7% in Bang Bua Thong.

The above figure would indicate the maximum burden on the household user should Rangsit be financed entirely by the combination of foreign and local loans. Should Rangsit obtain through official procedures, subsidy and grant, the real burden on the household user would be smaller.

The cash flow is indicated in col(6) of Table 11.2.1. Col(6) is equal to col(4) multiplied by col(5) and further multiplied by a factor of 4.

Table 11.2.1 Bang Bua Thong Cash Flow and Household User Cost
Pop in 1991 = 45,786, 2.4% Increase

Year	25%Land Cost Million (1)	O&M Cost Million (2)	Loan Cost 25%Land Million (3)	H User (4)	H User Br'kEv'n (3)/(4) Baht (5)	Net Income Million (7)	H User Cost Baht (8)
1994		9.70	1.34	11991		-11.04	
1995	19.20	9.70	1.34	12279		-11.04	
1996		9.70	1.34	12573		-11.04	
1997		9.70	1.34	12875		-11.04	
1998		9.70	1.34	13184		-11.04	
1999		9.70	1.63	13500	121	6.51	482
2000		9.70	1.63	13824	118	6.51	471
2001		9.70	1.63	14156	115	6.51	460
2002		9.70	1.63	14496	112	6.51	449
2003		9.70	1.63	14844	110	6.51	439
2004		9.70	1.63	15200	107	6.51	429
2005		9.70	1.63	15565	105	6.51	418
2006		9.70	1.63	15939	102	6.51	409
2007		9.70	1.63	16321	100	6.51	399
2008		9.70	1.63	16713	97	6.51	390
2009		9.70	1.63	17114	95	6.51	381
2010		9.70	1.63	17525	93	6.51	372
2011		9.70	1.63	17945	91	6.51	363
2012		9.70	1.63	18376	89	6.51	354
2013		9.70	1.63	18817	87	6.51	346
2014		9.70	1.63	19268	85	6.51	338
2015		9.70	1.63	19731	83	6.51	330
2016		9.70	1.63	20204	81	6.51	322
2017		9.70	1.63	20689	79	6.51	315
2018		9.70	1.63	21186	77	6.51	307
2019		9.70	1.63	21694	75	6.51	300
2020		9.70	1.63	22215	73	6.51	293
2021		9.70	1.63	22748	72	6.51	286
2022		9.70	1.63	23294	70	6.51	280
2023		9.70	1.63	23853	68	6.51	273
2024		9.70	1.63	24426	67	6.51	267

Col(1) = Loan financed by 50% foreign and 50% Local, with 7% interest 25 years, with 5 years of grace period

FIRR = 0.087892

Col(7) = Col(5)*col(6)*4 for 1999 to 2024
Col(8) = Col(6)*4 for 1999 to 2024

11.3 Affordability

In the Master Plan, it was estimated that the household income in highly industrialized Municipality of Rangsit would reach 430,670 Baht in 2011. This is the average figure and the low household income in Rangsit would be much less, say, less than one third. Using the figure of one third of 430,670 give 143,556 Baht. In the case of Bang Bua Thong, the relative cost of household user would become 482 Baht in 1999, 0.33% of household income of 143,556 Baht. Should the the project loan cost by the Central Government be added to Bang Bua Thong household users, this figure would increase to 1,375 in 1999 and 777 Baht in 2024, respectively.

11.4 Recommendations

It is generally agreed upon that the burden on the household user be 1% or less. Should the household income in Rangsit and Bang Bua Thong be in the neighborhood of 150,000 Baht in 2011, the relative burden on household users would not a be problem.

However, in the first five years between 1994 and 1999, some form of subsidy and grant will be much to be desired in Bang Bua Thong where the relative burden on household users is substantially high.

With respect to local financing, each municipality will be advised to utilize a combination of foreign and local loans to the extent that their local financial resources will not be too much burdened. This study has provided one practical and feasible solution as 50% foreign loan and 50% local loan. There are other combinations of foreign and local loans also.

Some serious effort of obtaining a portion of land acquisition cost will highly be recommended because it shows strong local determination on the part of the sewerage project, portraying the image of joint project between the Central Government and the local municipality.

Finally, if not the last, public education and persuasion effort will highly be valuable for the dissemination of the value of this project throughout the country.

11.5 FINANCIAL Sensitivity Analysis

When the loan amount is fixed, the cash flow depends upon the revenue generated from the expected household user. As in most cases, the revenue collection efficiency, defined as the ration of the expected revenues to the actual revenues collected. When the collection efficiency drops to, say 80%, the expected FIRR also drops accordingly.

Three scenarios are assumed: The first is 80% revenue collection efficiency and the second, 70%, and the third, 60%, respectively both in Rangsit and Bang Bua Thong. A summary of the three scenarios is presented in Table 11.5.1.

Table 11.5.1 Sensitivity Analysis of Financial Returns

	FIRR	Rangsit (%)
Scenario 1:	80% Revenue Collection	6.7
Scenario 2:	70% Revenue Collection	5.5
Scenario 3:	60% Revenue Collection	4.3

As indicated above, the FIRR is highly sensitive to a change of revenue collection efficiency.

SECTION 12 BENEFITS OF THE PROJECT

12.1 Economic Benefits

Significant economic benefits to public health of the community can be derived from installation of an adequate sewerage system. The benefits to be derived from the sewerage systems as recommended in this Master Plan can be classified into three categories, (1) water qualitative improvement benefits, (2) private health and sanitation benefits, and (3) economic benefits attributable to the increase in land value.

(1) Water Quality Improvement of Chao Phra River

The most significant benefits that may be derived from the sewerage project is water quality improvement of Chao Phra River and the other channels.

Table 12.1.1 shows a summary of the projection results reflecting the effects of sewerage projects in the lower Chao Phraya river basin.

Table 12.1.1 Effects of Sewerage Projects

Water Quality Checking Point	Environmental Quality Standard (BOD mg/l)	Projected Water Quality	
		w/o sewerage system	with sewerage system
R1	1.5	1.3	1.3
R2	1.5	1.5	1.0
R3	2.0	2.2	1.9
R4	2.0	6.2	2.3

As shown in Table 12.1.1, it is obvious that the sewerage projects in the study area will contribute enormously for improvement of the water quality at the checking points,although water quality at R4 would be critical comparing with the environmental standard.

(2) Health and Sanitation Improvement Benefits

(a) Private Health and Sanitation Benefits

The sewerage project also contributes to the reduction of private health costs through improved health and sanitation, particularly through the reduction of water-borne diseases.

The benefits can be measured by the reduction of private health costs attributable to the incidence of the water-borne diseases.

The economic loss to the community due to the reduction of the water-borne diseases is estimated. Quantification of health cost is determined through the direct relationship between the water-borne diseases and the cost of for treatment and care. For the purpose of this study, health cost is quantified, taking three factors into consideration; cost of medical treatment and care, income lost due to hospitalization, and out-patient consultation, it is expressed as the sum of these three factors:

The three factors are listed below:

a) medical cost of treatment and care per person at a hospital
b) medical cost of treatment and care per person per consultation
c) illness cost per person

Medical cost of a) and b) was 232.6 Baht in 1991, compared with illness cost of 99.4 Baht in 1991..

Then annual health cost was estimated at 1.7 million in 1994 and 2.5 million Baht in 2024 in this study area of Bang Bua Thong sewerage project.

(b) Public Health Improvement Benefits Increase of opportunity in different water uses:

Improvement of water quality in the main river/klongs enables residents to use water for recreational purpose and others. In addition, contribution to the Chao Phraya river is expected to achieve water quality standard.

(c) Mortality and morbidity of the inhabitants would be reduced. The people use water in klongs for multiple purposes, even if for bathing being exposed to polluted water. In this connection, it is expected for the sewerage system to diminish the chance of communicable diseases.

(3) Improvement of Land Use

(a) The sewerage service help promote effective land use such as expansion of residential area and commercial activities.

(b) Increase of tax income: Tax revenues from the increase of property(land and buildings, structures, etc.) and of business activities may be expected.

(c) Development of employment opportunity and markets for construction materials and equipment. Construction of sewerage system, and operation and maintenance work will contribute to the local economy through the increase of employment opportunity and expansion of markets relevant to the sewage works.

(d) A quantitative attempt to measure property value attributable to the sewerage factor:

An attempt to quantify economic benefits attributable to the increase in land price. Average Land price in the project service area is indicated as 27,585 Million Baht in 1993, as shown in Table 12.1.2.

Table 12.1.2 Land Value in the Project Service Area in Bang Bua Thong, 1993

Land Use Type	hectar (1)	Price (2)	Value (3)
Commercial Area	95	6000	5700
Medium Density Area	188	4000	7520
Low Density Area	307	3000	9210
Institutional Area	19	2000	380
Industrial Area	0	1000	0
Other Area	955	500	4775
Total Value of Land			27585

It is assumed that the land price will increase at 5% per year from 1993 to 2000. The sewerage service area is assumed to contribute to 5% of the value of land increase. Net benefit of the increase of land value attributable to the sewerage project indicated in col(5) of Table 12.1.3.

Table 12.1.3 Economic Benefits and Economic Rate of Return
(Million Baht)

Year	Project Cost (1)	O&M Cost (2)	LandValue (3)	5% Inc of land '94-2010 (4)	Sewage Factor 5 % (5)	PvtH'lth Benefit (6)	Total Benefit (5)+(6) (7)	Net Cash Flow (7)-(2) (8)
1994	30.3	22.485	28,964	1,379	69	1.7	70.7	40.4
1995	153.4	22.485	30,412	1,448	72	1.7	74.1	(79.3)
1996	154.7	22.485	31,933	1,521	76	1.7	77.8	(76.9)
1997	121.1	22.485	33,530	1,597	80	1.8	81.6	(39.5)
1998		22.485	35,206	1,676	84	1.8	85.6	85.6
1999		22.485	36,967	1,760	88	1.8	89.8	89.8
2000		22.485	38,815	1,848	92	1.8	94.3	94.3
2001		22.485	40,756	1,941	97	1.9	98.9	98.9
2002		22.485	42,793	2,038	102	1.9	103.8	103.8
2003		22.485	44,933	2,140	107	1.9	108.9	108.9
2004		22.485	47,180	2,247	112	1.9	114.3	114.3
2005		22.485	49,539	2,359	118	1.9	119.9	119.9
2006		22.485	52,016	2,477	124	2.0	125.8	125.8
2007		22.485	54,616	2,601	130	2.0	132.0	132.0
2008		22.485	57,347	2,731	137	2.0	138.6	138.6
2009		22.485	60,215	2,867	143	2.0	145.4	145.4
2010		22.485	63,225	3,011	151	2.1	152.6	152.6
2011		22.485	63,225	0	0	2.1	2.1	2.1
2012		22.485	63,225	0	0	2.1	2.1	2.1
2013		22.485	63,225	0	0	2.1	2.1	2.1
2014		22.485	63,225	0	0	2.2	2.2	2.2
2015		22.485	63,225	0	0	2.2	2.2	2.2
2016		22.485	63,225	0	0	2.2	2.2	2.2
2017		22.485	63,225	0	0	2.2	2.2	2.2
2018		22.485	63,225	0	0	2.3	2.3	2.3
2019		22.485	63,225	0	0	2.3	2.3	2.3
2020		22.485	63,225	0	0	2.3	2.3	2.3
2021		22.485	63,225	0	0	2.4	2.4	2.4
2022		22.485	63,225	0	0	2.4	2.4	2.4
2023		22.485	63,225	0	0	2.4	2.4	2.4
2024		22.485	63,225	0	0	2.5	2.5	2.5
							EIRR =	0.4809

Shadow Price: 40% Foreign and 60% Local contents are assumed
Project cost = Foreign portion[.4 *1.2]+ Local[0.6(0.2*1.0 + 0.8*0.8)]
Foreign capital cost = 1.2, Local capital cost = 1.0, Local labor = 0.8
Local capital = 20% of local portion, labor = 80% of local portion
Shadow price factor = 0.984 [0.4*1.2+0.6*0.2*1.0+0.6*0.8*0.8]
Col(1) and Col (2) adjusted by 0.984
Land Value = 27,585 Million Baht in 1993, 5% Increase from 1994-2010
O&M Cost is borne by H Users

12.2 Economic Justifications

Socio-economic benefits derived from sewerage project are qualitatively discussed in the Master Plan. In the preliminary design, the benefits are also described qualitatively. Nevertheless, a quantitative trial measurement on (2) and (3) is attempted as an index of economic benefits.

An attempt to quantify economic benefits on the basis of the increase of land value and of the reduction of private health costs attributable to the sewerage project indicate that EIRR becomes 48%. This figure appears reasonable to justify the project on economic grounds. However, as will be indicated in 12.3 sensitivity analysis, this figure of EIRR should be interpreted with caution. Underlying assumptions and conditions may be subject to change and are sometimes difficult to foresee some fundamental changes of the socio-economic environment.

In view of qualitative improvement and quantitative measurement, the realization of sewerage project will bring about substantial advantages. Further deterioration of water quality in the public water body is indispensable without provision of sewerage project. The future opportunity cost is bound to increase should the project be delayed any further. Thus, there exist stronger and constructive reasons for justifying the sewerage project on qualitative and quantitative grounds both.

12.3 Economic Sensitivity Analysis

The EIRR of 30.8% appear high enough to justify the project on economic grounds. However, the key is the land value and its increase. However, the major contributing factor to the value of EIRR is the assumptions made under land value and land value increase. Should the assumptions indicated may change, the value of EIRR will also be altered.

Thus it the value of EIRR should be interpreted with caution. When the volume of land transactions decreases by 50%, then the EIRR drastically drops from 48.1% to 12.5%. Similarly when the volume of transactions decreases to one third, then EIRR will become 4.9%. The worst scenario that one fourth of land transactions is generated, then the EIRR becomes 1.3%, as shown in Table 12.3.1.

Table 12.3.1 Sensitivity Analysis of Economic Returns

	EIRR (%)
Scenario 1: Land Transactions Reduced into Half	12.5
Scenario 2: Land Transactions Reduced into One Third	4.9
Scenario 3: Land Transactions Reduced into One Fourth	1.3

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