Electricity is received from Ayutthaya Province and distributed through a local office at Sena which occupies an area of 0.5 rai. The number of users within the municipality is 5,300, while number of outside users is 11,087.

6.2 Existing Sanitation/Sewerage and Flood Protection Facilities

6.2.1 Existing Sanitation Facilities

The municipality operates 2 trucks, each with a capacity of 10 m^3, to collect 200-300 m^3 of refuse, 5 to 6 times/d and dispose them at a dumping site 5 km from the municipality, which has an area of 4 rai. There are about 20 workers, operating the waste disposal. The disposal method is mostly by burning. An incinerator has been finally constructed within the area.

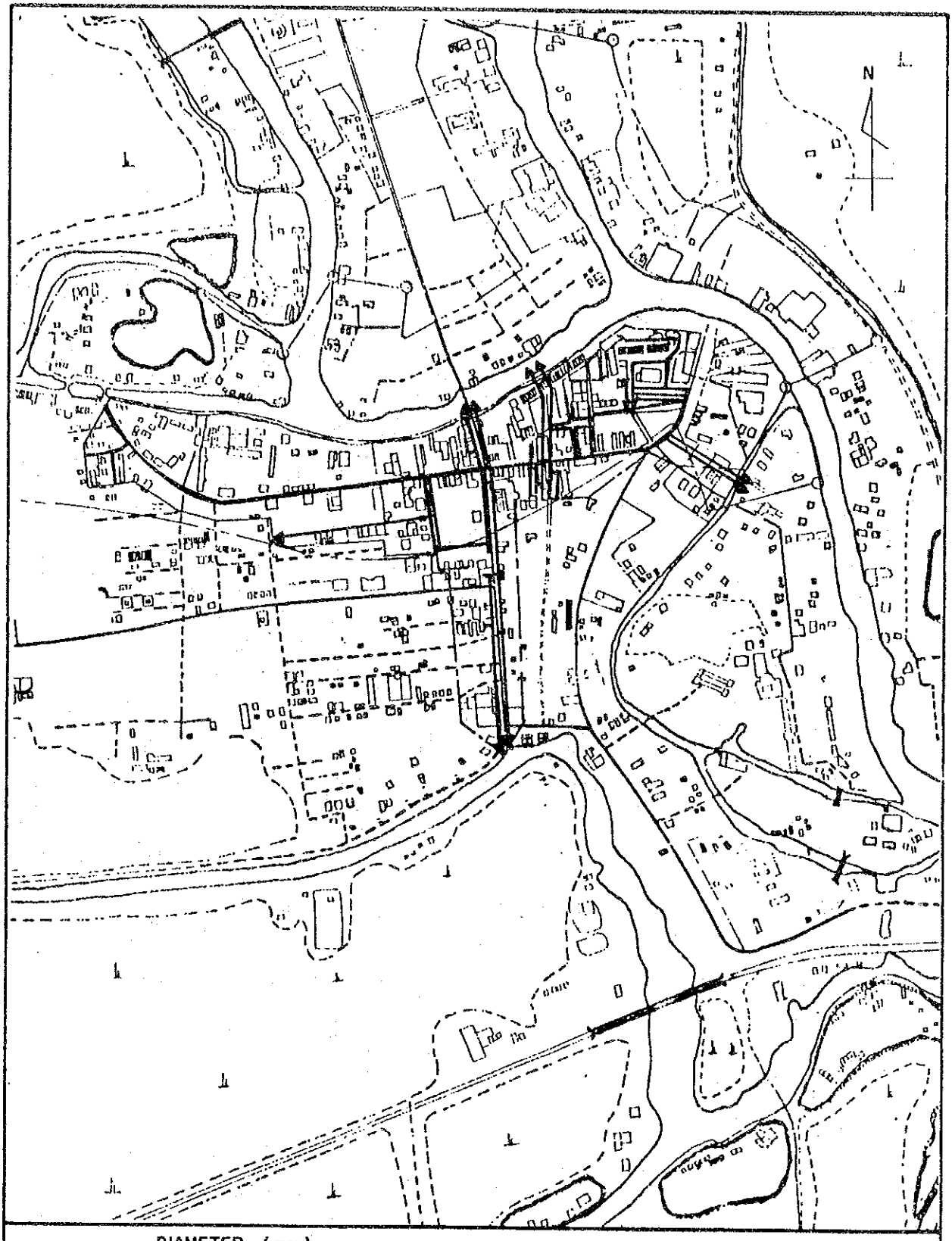
On-site treatment and disposal of nightsoil is practiced as mentioned in Section 3, Chapter 2.

6.2.2 Existing Sewerage Facilities

About 40% of sewers consisting of reinforced concrete pipes with a diameter of 400 mm are provided along the existing roads in the municipality. However, 70% of the existing sewers are deteriorating. The discharge points of the sewers are located either at the Noi river or the Pathunam canal. Composition of existing drainage facilities is summarized in Table 6.2.1. Area coverage and location of drains are shown in Figure 6.2.1.

Table 6.2.1 Existing Drainage Facilities

Size (mm)	Length (m)	Type	Drainage Area (ha)
dia. 400 - 1,000	6,470	RC. Pipe	45.0



LEGEND : 600 DIAMETER (mm.)
DRAINAGE PIPE —→ OUTFALL —·—·— DRAINAGE AREA BOUNDARY SCALE 1:10000

FIGURE 6.2.1 EXISTING DRAINAGE SYSTEM SENA MUNICIPALITY

STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

6.2.3 Flood Protection Facilities

There are no existing flood protection facilities, although once in every four years during the months of August and September flood problems occur within the market area and the bus station with water levels rising to about 0.5 m above the ground level.

6.3 Water Supply

The water supply in the areas along Sena to Ayutthaya road is provided by Sena waterworks of PWA which covers an area of 1 rai and uses surface water from the Noi river as well as ground water. Due to high turbidity of water of the Noi river, a 2.5 rai filtering plant had also been built. There is one ground water well, 120 m deep with a generating capacity of 1500 m^3/d, with an average daily production rate of 1,200 - 1,500 m^3/d. (PWA had a plan to install another well about 200 m deep, with a production capacity of 750 m^3/d, by 1989).

6.4 Population and Land Use

Land use at present and in the future (2011) is referred to in Section 3, Chapter 2 and Figure 6.4.1 presents the projection in the year 2011.

Study area and population are as follows:

Area & Population	Present Municipality	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
Area(km^2)	1.20	0.79	1.99	24.11	26.10
Pop. in 1991	4,607	1,610	6,217		
Pop. in 2011	7,790	1,610	9,400		

6.5 Quality and Quantity of Wastewater

6.5.1 Unit Wastewater and Pollution Load on a Generation Basis

(1) Domestic Wastewater

Unit quality (BOD) and quantity on the daily average basis at present and in design year are tabulated breaking down into sullage and toilet waste.

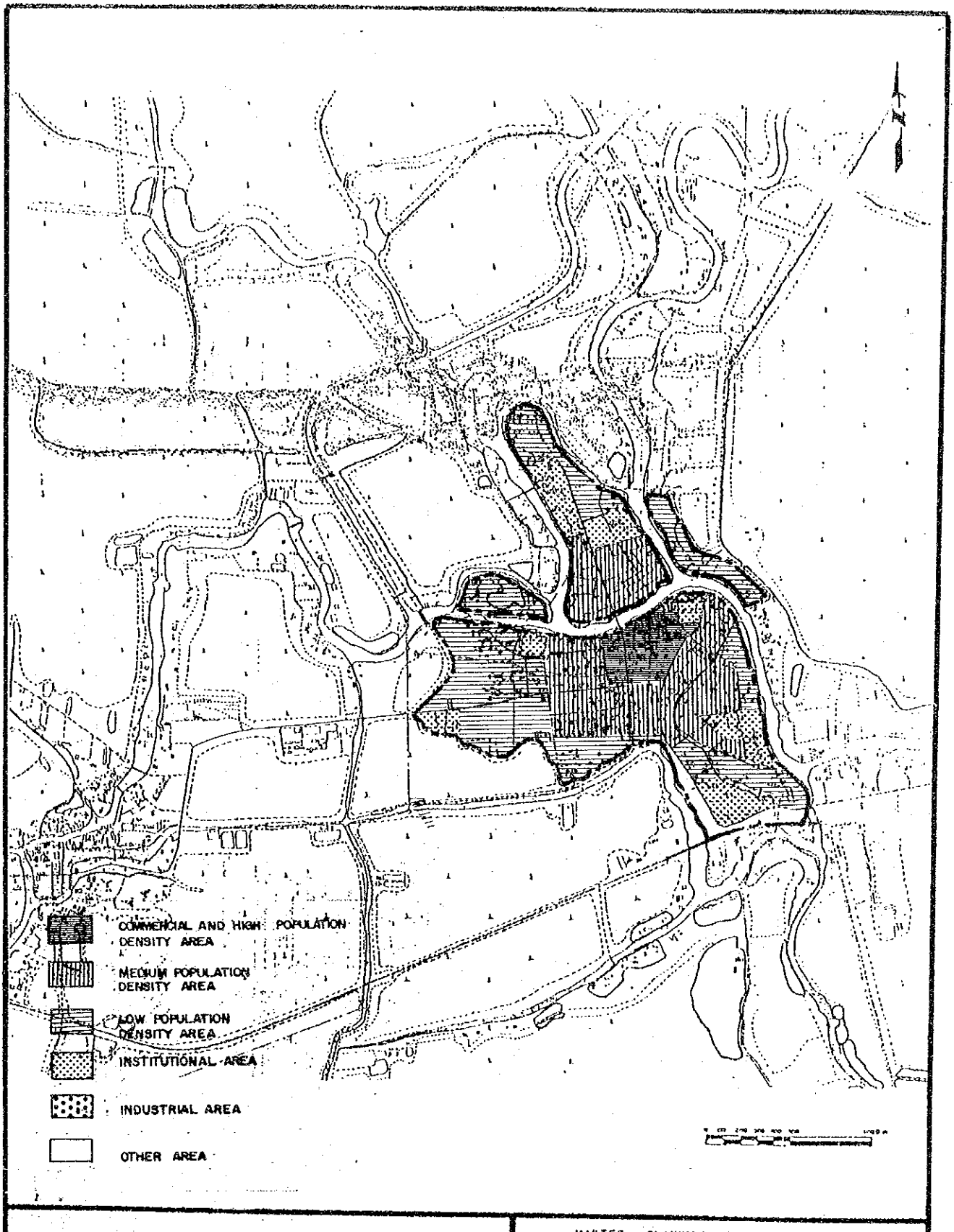


FIGURE 6.4.1 FUTURE LAND USE - YEAR 2011 (SENA)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Domestic wastewater discharge is assumed at 80% of water consumption. Toilet waste is treated by septic tank with assumed treatment efficiency of 50%.

Year	Unit Wastewater (lpcd)			Unit BOD Load (gpcd)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Present	100	12	112	33.6	5.5	39.1
Design Year (2011)	136	24	160	35.1	5.5	40.6

(2) Business Wastewater

Those for business wastewater (commercial and institutional) is assumed to be 30% and 40% of domestic wastewater for the present and design year (2011), respectively.

	Unit Wastewater (lpcd)	Unit Pollution Load (BOD gpcd)
Present	32	6.1
Design Year (2011)	64	7.7

6.5.2 Discharged Wastewater and BOD Load

(1) Domestic Wastewater

Wastewater quantity and BOD load based on a discharge basis are estimated for the present and design year (2011) multiplying service population by unit wastewater quantity/BOD load. The following are the estimation results.

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	625	75	700	1,278	226	1,504
BOD Load (kg/d)	208.9	34.2	243.1	329.9	51.7	381.6

(2) Business Wastewater

Discharged wastewater quantity and BOD load are estimated in the same procedure as domestic wastewater as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	200	602
BOD Load (kg/d)	37.9	72.4

(3) Total Wastewater Quantity and BOD Load

Total discharged wastewater quantity and BOD load (daily average basis) at present and in the design year (2011) for Sena Sewerage Development are figured out as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	900	2,106
BOD Load (kg/d)	281.0	454.0

6.6 Proposed Sewerage System

6.6.1 Service Area

The service area covers 199 ha with present population of about 6,200. The subject area is sub-divided into three drainage areas by the Noi river and several canals as follows;

- Northern area surrounded by Jao-Jet to Pak Hai canal and the Noi river (north of Pathunam canal)

- Central area including urban area of Sena municipality surrounded by Ayutthaya to Ban-Sali Mooban road and the Noi river.

- Eastern area with low population density between Ayutthaya to Ban-Sali Mooban road and the Noi river.

Topography in the service area is generally flat, though some khlongs exist as mentioned above. A single sewerage system is recommended for design population of about 9,400 as shown in Figure 6.6.1.

There is a clustered area about 2.5 km from Sena municipality. The area is regarded as an individual sewerage system in this plan. However, combined treatment of wastewater with that of Sena municipality, increasing about 20% of its treatment capacity, may be an alternative assumption of additional service population of 2,000 (ϕ250 mm - ϕ300 mm sewers shall be installed along existing canal to connect WWTP in Sena).

Location of WWTP for Sena sewerage project is selected in view of land availability at the southern outside of the service area.

6.6.2 Wastewater Collection System

Wastewater collection system in application of the combined collection method is proposed. Distribution of population and wastewater quantity was made based on population density assumed by land use type (refer to calculation table in Supporting Report 3.6.6).

Alignments of main interceptors and pump stations are proposed as shown in Figure 6.6.1. The profile of sewers is presented in Figure 6.6.2. (refer to hydraulic calculation in Supporting Report 3.6.6). The following are descriptions on the sewer systems.

- Two (2) sewer systems are planned covering the service area.

- Interceptors 1/1 - 1/4 start from the junction of Piaina river and Tamsith Sena road and reach to WWTP via urban area.

- Interceptors 2/1 - 2/4 along Ayutthaya road start from the Noi river and connect to 1/3 interceptor.

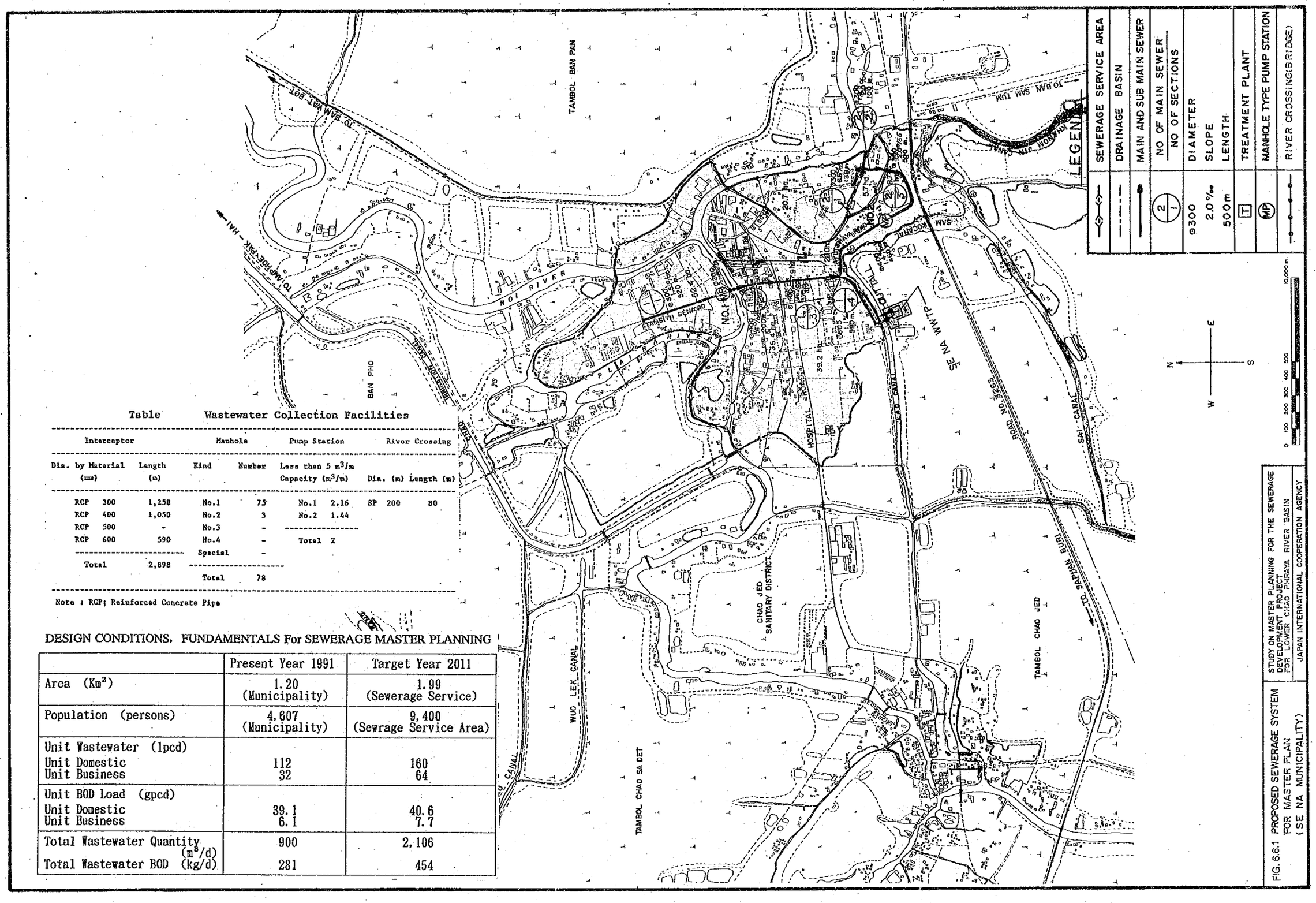


Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station		River Crossing	
Dia. by Material (mm)	Length (m)	Kind	Number	Less than 5 m³/m Capacity (m³/m)		Dia. (m)	Length (m)
RCP 300	1,258	No.1	75	No.1	2.16	SP 200	80
RCP 400	1,050	No.2	3	No.2	1.44		
RCP 500	-	No.3	-				
RCP 600	590	No.4	-	Total	2		
		Special	-				
Total	2,898						
		Total	78				

Note : RCP; Reinforced Concrete Pipe

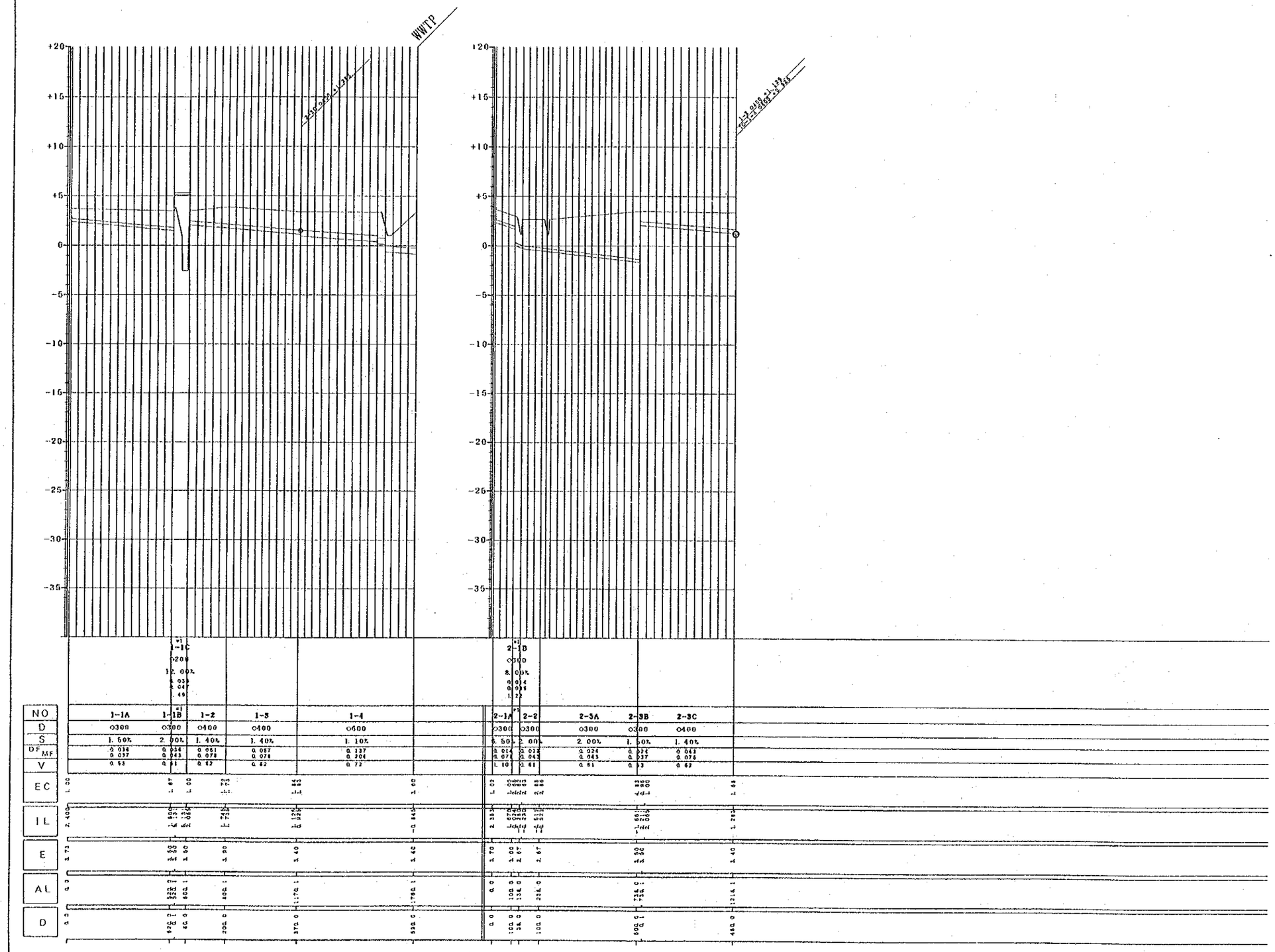
DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km²)	1.20 (Municipality)	1.99 (Sewerage Service)
Population (persons)	4,607 (Municipality)	9,400 (Sewrage Service Area)
Unit Wastewater (lpcd)		
Unit Domestic	112	160
Unit Business	32	64
Unit BOD Load (gpcd)		
Unit Domestic	39.1	40.6
Unit Business	6.1	7.7
Total Wastewater Quantity (m³/d)	900	2,106
Total Wastewater BOD (kg/d)	281	454

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

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. 6.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (SE NA MUNICIPALITY)



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

1-1A	1-1B	1-1C	1-2	1-3
1-4	2-1A	2-1B	2-2	2-3A
2-3B	2-3C			

FIG. 6.6.2
SENA

V 1:200
H 1:10,000

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 6.6.1 summarizes planned collection facilities. Details on pump specifications and siphon are included in Supporting Report 3.A.6 - 3.C.6.

Table 6.6.1 Wastewater Collection Facilities

Interceptor		Manhole		Pump Station		River Crossing		
Dia. by Material (mm)	Length (m)	Kind	Number	Less than 5 m^3/m Capacity		Dia. (m)	Length (m)	
RCP 300	1,258	No.1	75	No.1	2.16	SP 200	80	
RCP 400	1,050	No.2	3	No.2	1.44			
RCP 500	-	No.3	-					
RCP 600	590	No.4	-	Total	2			
		Special	-					
Total	2,898							
		Total	78					

Note : RCP; Reinforced Concrete Pipe

6.6.3 Wastewater Treatment and Sludge Disposal System

(1) Wastewater Treatment and Disposal Methods

The wastewater discharge in the sewerage development area of Sena municipality is estimated to be 2,106 m^3/d in the year of 2011. Groundwater infiltration at 20% of wastewater discharge is assumed. The design wastewater to the treatment plant is estimated to be 2,600 m^3/d. The effluent quality is expected to be less than 40 mg/l as BOD.
The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

1) Stabilization Pond
2) Aerated Lagoon
3) Oxidation Ditch

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land area and easiness of O&M as shown below (Details are included in Supporting Report 3.1.6.2).

Evaluation Item	Stabilization Pond	Aerated Lagoon	Oxidation Ditch
(1) Construction Cost (million Baht)	3.77	7.11	15.70
(2) Land Cost (million Baht)	5.43	2.94	1.66
(3) O/M Cost (million Baht/year)	0.06	0.27	1.52
(4) Required Land Area (ha)	4.34	2.42	1.33
(5) Easiness of O/M			
- Adaptability of overload	A	A	B
- Required technology level	A	A	B
- Sludge disposal	A	A	C

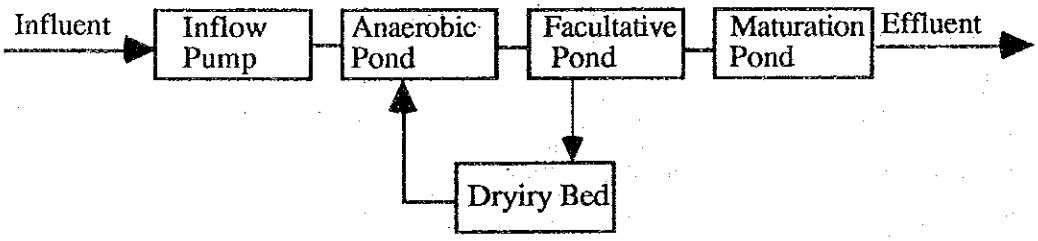
Note : 1) Construction Cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C: hard

As evident from cost comparison in NPV (refer to Supporting Report 3.1.6.3), stabilization pond system is the most economical.

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Sena is now occupied by paddy field and fish pond. The proposed treatment plant of stabilization pond with a capacity of 2,600 m^3/d requires a net land area of 4.34 ha.

The flow sheet of stabilization pond system and the capacity dimension and other relevant details of each treatment facility is shown below.



Flow of Stabilization Pond System

Inflow Pump :	Design capacity	4,000 m^3 /d (hourly max. dry)
		12,000 m^3/d (hourly max. wet)
:	Capacity	2.78 m^3/min. with 6.2 m hydraulic head (hourly max. dry)
		8.33 m^3/min. with 6.2 m hydraulic head (hourly max. wet)
Grit Chamber:	Surface loading	1,667 $m^3/m^2/d$ (dry weather)
		2,500 $m^3/m^2/d$ (wet weather)
:	Retention time	31 sec (dry), 21 sec (wet)
:	Size	0.6 m(W) x 4.0 m(L) x 0.6 m(D) x 2 units (1 unit for dry weather)
:	Constructed with R.C	
Anaerobic Pond:	Pond capacity	13,000 m^3
:	Pond surface area	4,600 m^2
:	Retention time	5 days
:	Dimension	40 m(W) x 57.5 m(L) x 4.0 m(D) x 2units
:	Embankment protected by masonry	
Facultative Pond:	Pond capacity	13,000 m^3
:	Pond surface area	7,500 m^2
:	Retention time	5 days
:	Dimension	50 m(W) x 75 m(L) x 2.0 m(D) x 2 units
:	Embankment protected by masonry	
Maturation Pond:	Pond capacity	13,300 m^3
:	Pond surface area	10,400 m^2
:	Retention time	5.12 days
:	Dimension	40 m(W) x 65 m(L) x 1.5 m(D) x 4 units
:	Embankment protected by masonry	
Drying Bed :	Drying area	80 m^2
:	Detention time	15 days
:	Dimension	4 m x 5 m x 4 units

The treated water is discharged to Noi river through Samko canal. Layout of the treatment plant and hydraulic profile are shown in Figure 6.6.3 and Figure 6.6.4, respectively. Further study shall be made on the adoption of anaerobic pond and polishing pond during F/S stage.

6.7 Cost Estimates

6.7.1 Construction Cost

In the previous chapter, cost functions for interceptors, pump stations (more than 5 m^3/min.) and wastewater treatment plants are developed. Land acquisition cost is also considered to come up with the total construction cost. The following are cost requirements (million Baht) for the design year 2011.

(1) Direct Cost	
1) Interceptor	52.8
2) Pump Station	---
3) W.W.T.P.	3.77
Total of Direct Cost	56.57
(2) Contingency (20% of Direct cost)	11.3
(3) Total of Construction Cost ((1)+(2))	67.87
(4) Engineering & Construction Supervision (17% of (3))	11.5
(5) Land Acquisition	
1) Pump Station	---
2) W.W.T.P.	5.43
Total of Land Acquisition	5.43
Grand Total (million Baht)	84.8

Wastewater Treatmentplant

Wastewater Treatment method	Stabilization Pond System
Plant Space Area (ha)	4.34
Treatment Copacity (m^3/d) (inclusive of G.W)	2,600
Discharge Point	Samko Canal

Main Facilitie's

1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ 150m/m×1.4m^3/min×6.2"H×2units
(Wet Season)	ϕ 200m/m×2.65m^3/min×6.2"H×2units
2) Grit Chamber	Constructed with R.C.
	Size
	0.6"W×4.0"L×0.6"D×2units
	(1unit for dry weather)
3) Anaerobic Pond	Enbankment protected by masonry
	Dimension
	40"W×57.5"L×4.0"D×2units
	Retention Time 5 days
4) Facultative Pond	Enbankment protected by masonry
	Dimension
	50"W×75"L×2.0"D×2units
	Retention Time 5 days
5) Maturation Pond	Enbankment protected by masonry
	Dimension
	40"W×65"L×1.5"D×4units
	Retention Time 5.1 days
6) Drying Bed	Dimension
	4"×5"×4units
	Detention Time 15 days

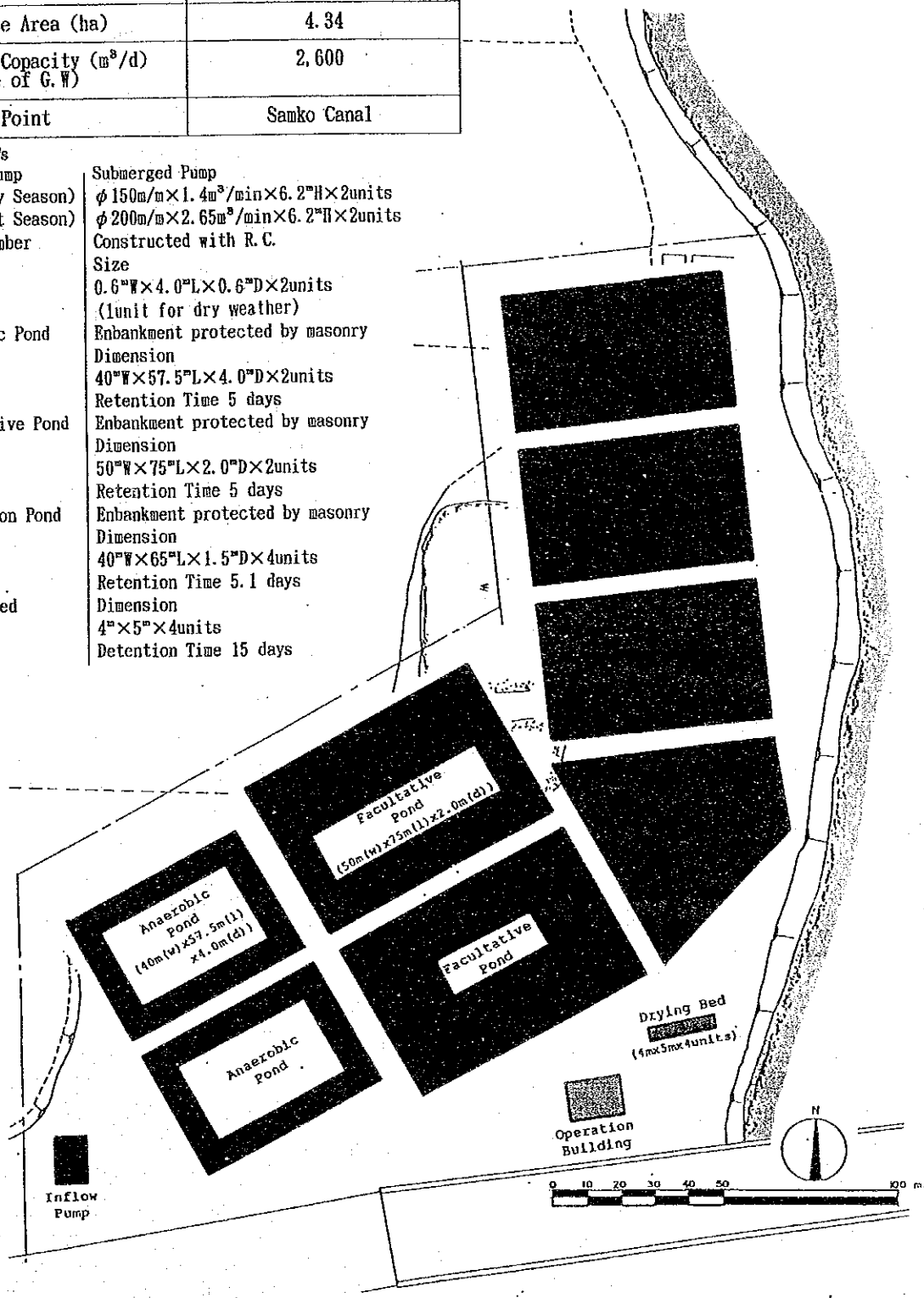


FIGURE 6.6.3 Layout of Sewage Treatment Plant (Sena)

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JAPAN INTERNATIONAL COOPERATION AGENCY

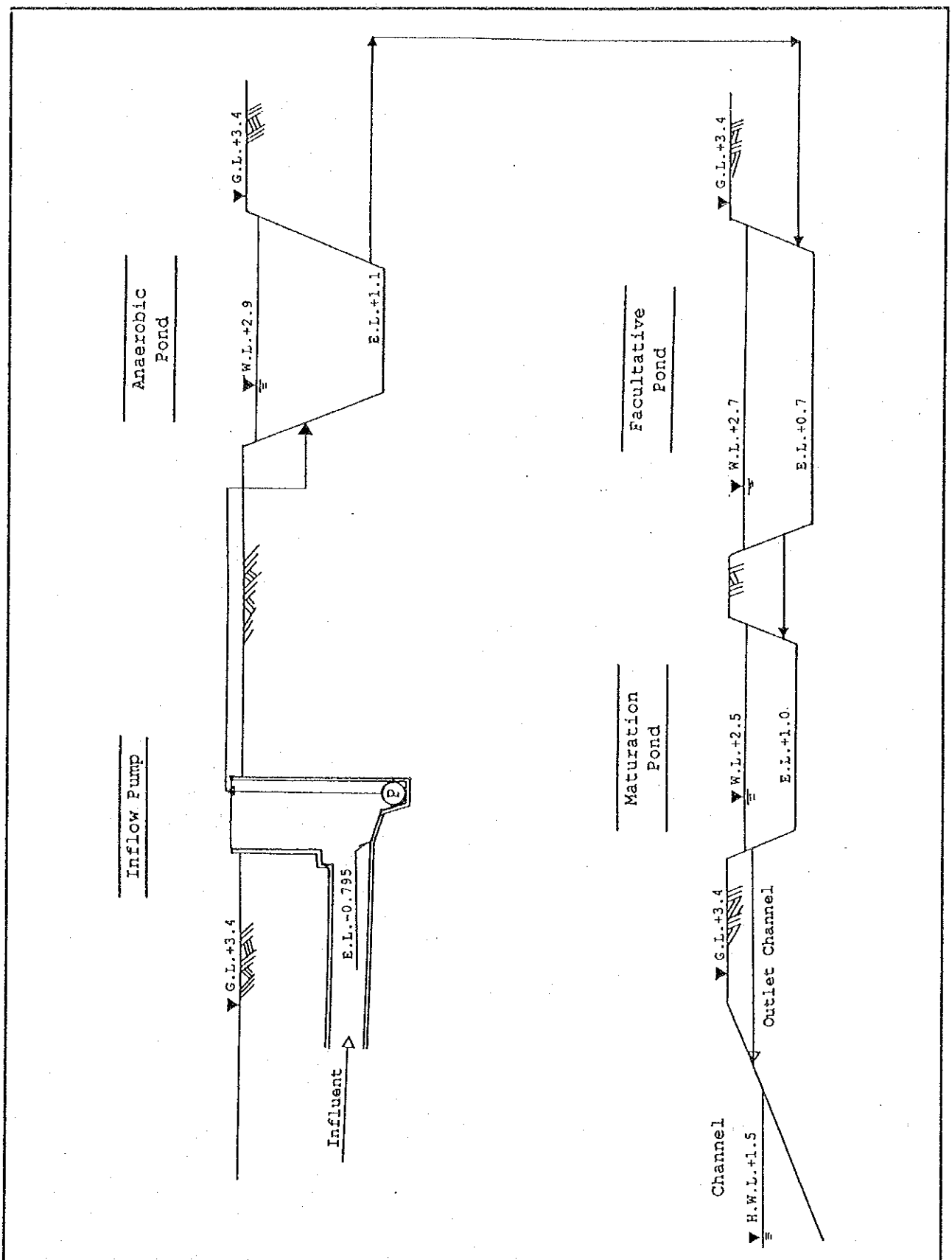

Figure 6.6.4 Hydraulic Profile of Sewage Treatment Plant (Sena)

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JAPAN INTERNATIONAL COOPERATION AGENCY

6.7.2 Operation and Maintenances

Annual Operation and Maintenance cost (thousand Baht) is estimated using cost functions/unit cost studied in the previous Chapter.

(1) Interceptor	181
(2) Pump Station	—
(3) W.W.T.P.	60
Total of O&M Cost	241

6.8 Implementation Plan

The provision of a complete sewerage system for the entire study area with its increasing population, will require a great investments of capital fund as estimated in the previous section. Some are within the study area is presently undeveloped land and environmental conditions of such area are different from built-up area. Although the study area needs to be sewered in early stage, the urgency of sewerage requirements is different depending on the land use features of areas. Staged construction will be advantageous to minimize the excessive initial investment and capital expenditures.

Implementation program is prepared for the first 20 years, dividing into 4 stages of five year each, taking the design period up to the year 2011 into account. The schedule is assumed giving priority to developed/being developed areas.

Stage	Period	Works with Priority
1st	1991-1995	Preparatory work & design of facilities
2nd	1996-2001	Construction for eastern area
3rd	2002-2006	Construction for western area
4th	2007-2011	Construction for northern area

6.9 Administrative and Financial Study

6.9.1 General

The staffing and assisuments of this municipality are strictly requlated by ministry of Interior.

There is very little room for the municipality to play in integration of the propsoed sewerage system.

6.9.2 Existing Administrative System

Sena is a small municipality with the existing population of 4,607 in 1991. The size of the municipal administration is almost proportional to the population. Figure 6.9.1 shows the present organization of the municipality. It has five (5) divisions:

- Treasury division
- Engineering division
- Health and Environment Division
- Education Division

One unique feature of the municipality is that one of its divisions is Health and Environment Division, which is dealing with solid waste and night soil disposal.

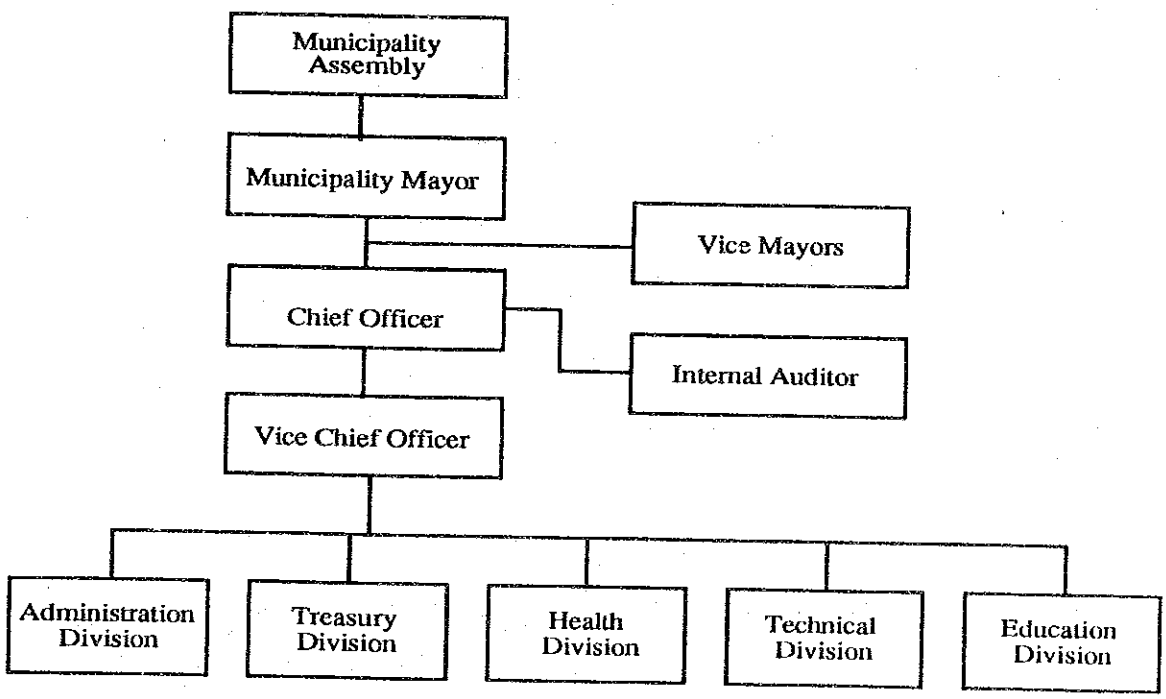


Figure 6.9.1 Administrative Structure of Municipality of Sena

6.9.3 Recommendations

There are two possible options to establish and organizaiton for sewerage management:

- (A) to integrate in into the municipal organization (see Figure 6.9.2)
- (B) to create an inddependent one (see FIgure 6.9.3)

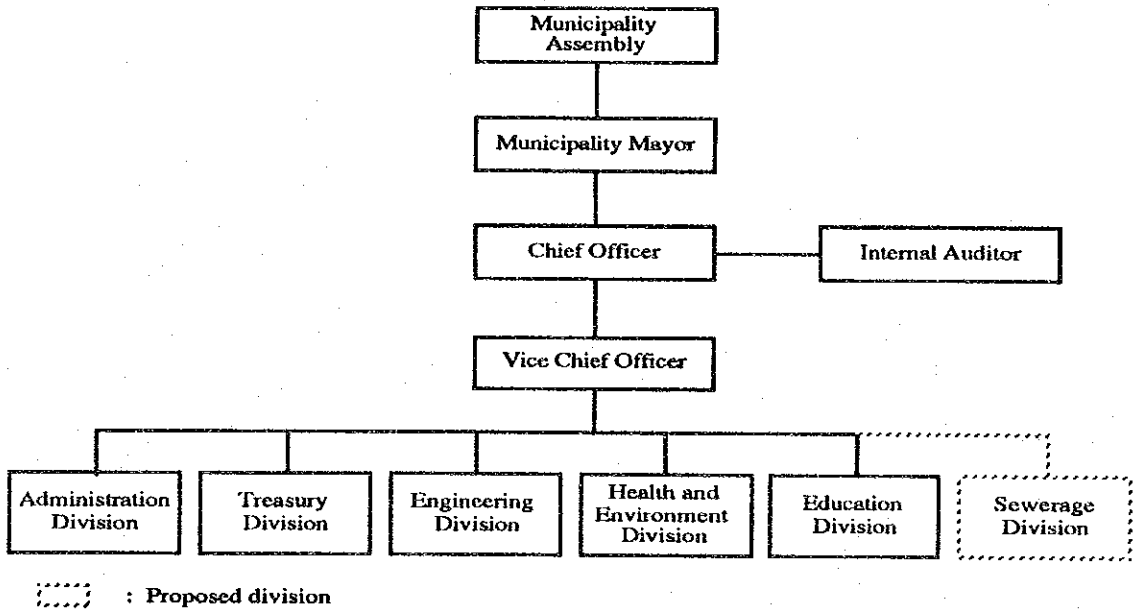


Figure 6.9.2 Option (A) for Municipality of Sena

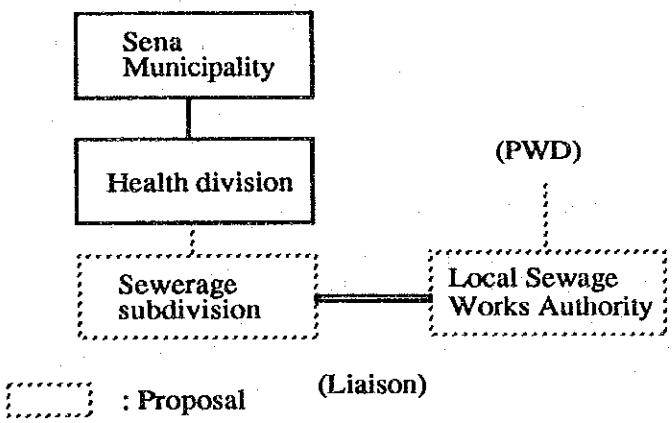


Figure 6.9.3 Option (B) for Municipality of Sena

Based on the implementation plan, the staffing requirement is estimated to manage the proposed sewerage system as follows:

Stage	Period	Staffing requirement
1st	1991 - 1995	3
2nd	1995 - 2001	5
3rd	2002 - 2006	9
4th	2007 - 2011	18

6.9.4 Financial Considerations

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 17%. While the amount of fixed investment varies with fiscal year, this figure of 17% was not high among eight municipalities.

Sena has not yet developed social infrastructure, compared with that of Rangsit and Bang Bua Thong. The proportion of public fixed investment to total expenditures was only 6.8% in 1991. This appears to reflect that the greater the portion of public fixed investment, the smaller the relative burden of land acquisition cost. For example, when public fixed investment increases to, say, 10% of total expenditures, the relative burden of land acquisition cost becomes also 10%. Thus, the relative burden of 17% while a little high, should be interpreted in a frame work not only of fixed investment but also of total expenditures.

Nevertheless, when the relative burden exceeds a certain figure, say, 10%, it will add substantial burden on local municipality. This is due to limited capability of increasing local revenues in financing a large public investment project as the sewerage project.

Sena is no exception. Financing options that are available are (1) municipality development fund, (2) environment fund, or (3) increasing local revenues.

Environmental fund is available to local agencies in the form of grant and/or loan. It is recommended that Sena explore loan financing to allocate financial burden into the future, compared to raising local revenues or utilizing municipality development fund whose objectives are more general than those of environmental fund.

The average household user cost in item 4.3 of Table 6.9.1 is well below one percent of low household income in 2011 for Sena. The user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Sena would transfer to the user, and the other, the loss of the sewerage revenue collection that could be compensated for and would be included as part of the user charge.

The household users were estimated on the basis of the project service area in 2011. The household is assumed to have 4.1 persons on the average. We have also assumed that household users as sewerage users for simplicity. The average sewerage user cost was calculated on O&M cost divided by [(0.7+0.2x1.2+0.1x2)(number of household users)].

The average rate of non household users could be assumed to pay as high as the highest progressive rate of the household user rate structure. The progressive rate structure is 1.0 to 1.3 to 2.0 for low, medium, and high household income group respectively. A summary is shown in 4.4 of Table 6.9.1.

Finally, affordability will be considered. The affordability level is defined as the ratio of the average household user cost to low household income level of 96,571 Baht in 2011 in the Central Region. With available data on household income by Ang Thong, the figure indicated in 4.5 of Table 6.9.1 would then be updated and could also be modified with allocation of loan cost among the users.

Table 6.9.1 Selected indicators for Sena

1.1	Service Pop in 2011	9,400
1.2	Household Users in 2011	2,292
2.1	Total Expenditures, 1991 (Thousand Baht)	19,564
2.2	Investment on Land & Const., 1991 (Thousand Baht)	7,832
2.3	Land Acquisition Cost (Thousand Baht)	1,335
2.4	Relative Burden (2.3/2.2) in %	17
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	3
3.1	Total Revenues, 1991 (Thousand Baht)	25,434
3.2	Central Government Support, 1991 (Thousand Baht)	4,392
4.1	Treatment capacity (m3/d), in 2011	2,600
4.2	Unit O&M Cost of 4.1, in 2011	0.25
4.3	Household Users Cost/Year, in 2011 without loan	105
4.4	Progressive Rates: 1:1.3:2.0 in 2011	91 118 181
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	49
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	0.16%

SECTION 7

RANGSIT AREA

SECTION 7 RANGSIT AREA

7.1 Description of the Study Area

The study area is adjacent to Bangkok area which is extended along Phaholyothin road. It is consisting of two S.Ds; Khu Kot and Prachatipat S.Ds.

Khu Kot S.D. is one of the S.Ds in Lamloola and Pathum Thani. The total area is about 12.5 km^2 consisting of seven villages. The climate common to the two S.Ds is mild with the maximum temperature of 38.2°C in summer and the minimum temperature of 17.6°C in winter. The average annual temperature is 28.8°C and the average annual rainfall is 928.4 mm. The topographic characteristic is mainly a flat terrain in the irrigation area covering an area of about 90,000 ha along the east bank of the Chao Phraya river.

The Khu Kot area has one private fresh market located at Talat Si Moon Muang covering an area of 50 rai. The electricity consumption is about 26,000 kw/month, at present, with the number of users having been increased to about 1,200 households/year. There are 11,000 telephones installed around the area. There are about 17 public roads some of which are still under construction. Many buildings are under construction as well. More than 1,000 commercial shops exist in the area, most of which consist of beverages, tailoring, mechanical wares, etc. The area has 11 housing projects.

Prachatipat S.D. is in Amphoe Thanyaburi, Pathum Thani with an area of 20.14 km^2, it has two slaughterhouses which are managed by the S.D., but they were constructed by a private construction company. The first slaughterhouse has an area of 2 rai, animals slaughtered per day are pigs(24), buffaloes(3). The second slaughterhouse has an area of 5 rai, animals which is being slaughtered per day are pigs(25) and buffaloes(11-16). The water source is from Khlong Rangsit. There is a sedimentation tank provided wherein the wastewater could enter before draining into khlong. Future plan is made of relocating the slaughterhouse site because it creates noise and air pollution in the nearby residential areas.

7.2 Existing Sanitation and Sewerage Facilities

7.2.1 Existing Sanitation Facilities

The Khu Kot S.D. operates 1 vacuum truck and 6 trucks to collect 150 ton of refuse per day and dispose them at a dumping site which is a private land but free of charge. It covers an area of 80 rai. There are about 47 workers operating the waste disposal. The collection fee per house is equivalent to 10 Bahts per month.

Prachatipat S.D. is currently operating 5 units of trucks. The total amount of garbage is estimated at about 67 tons per day, but the collection capacity is only 60%, which is equivalent to about 40 tons per day of refuse collection and dispose them at Tambol Khlong Song, Amphoe Khlong Luang with an area of 12 rai. In the future, disposal site will be increased to 150 rai and trucks be increased to 16 units.

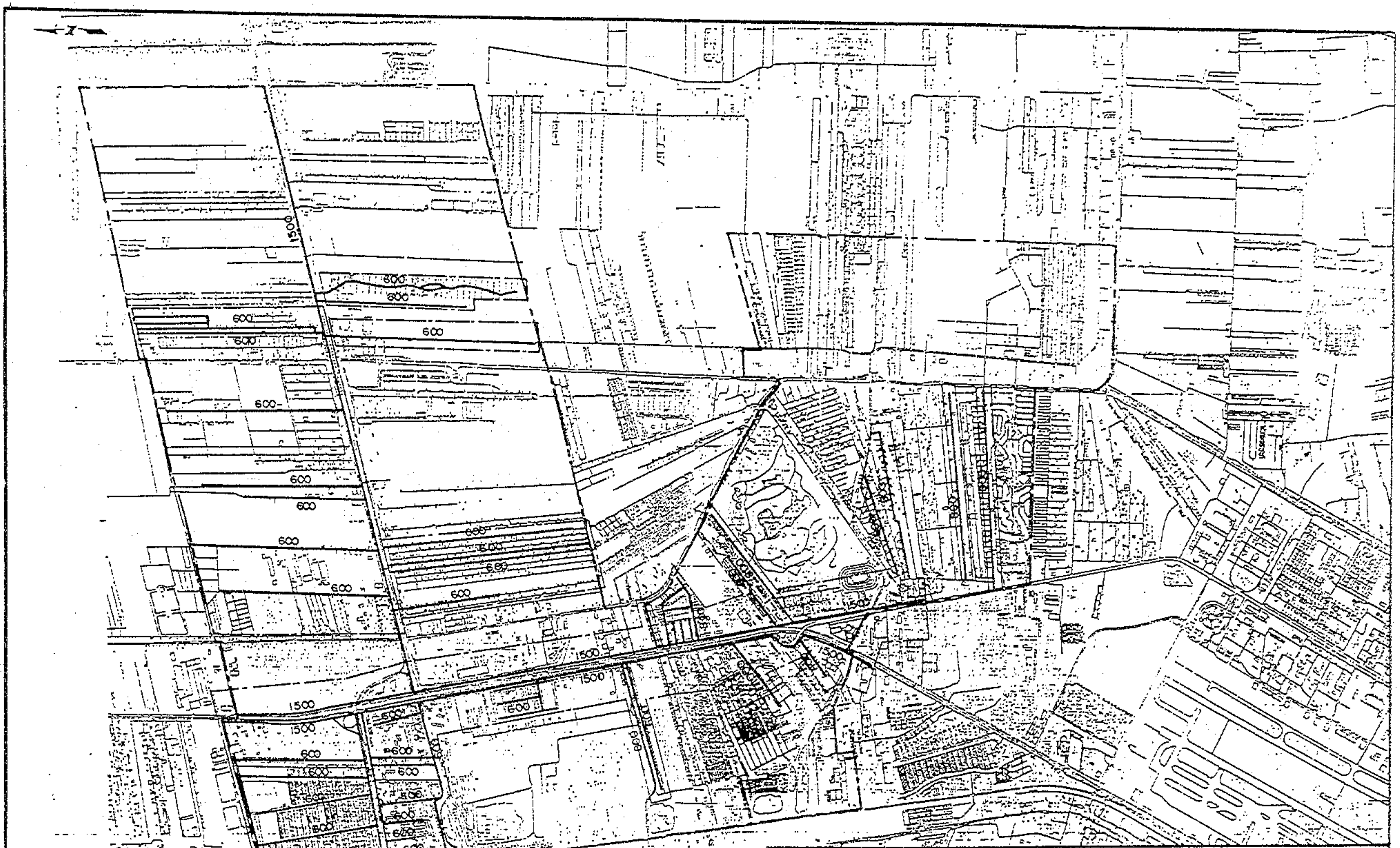
On-site treatment and disposal of nightsoil is practiced as mentioned in Section 3, Chapter 2.

7.2.2 Existing Sewerage Facilities

Drainage facilities in Khu Kot S.D. are only installed along the national road. Combined rain water and sanitary sewage is discharged directly into the nearby channels connected to khlongs. The situation in Prachtipat is more or less same as those in Khu Kot S.D. Drainage with a diameter of 200 mm-300 mm is only installed along the roads. Composition of existing drainage facilities is summarized in Table 7.2.1. Area coverage and location of drains are shown in Figure 7.2.1.

Table 7.2.1 Existing Drainage Facilities

Size (mm)	Length (m)	Type	Drainage Area (ha)
dia. 400	400	RC. Pipe	5.0
600	43,900	RC. Pipe	785.0
800	10,100	RC. Pipe	150.0
1,000	650	RC. Pipe	7.0
1,500	20,100	RC. Pipe	467.0
Total	75,150		1,414.0



LEGEND: 600 DIAMETER (mm.) DRAINAGE PIPE ⟶ OUTFALL —·—·— DRAINAGE AREA BOUNDARY SCALE 1:3500

FIGURE 7.2.1 EXISTING DRAINAGE SYSTEM RANGSIT AREA

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

JAPAN INTERNATIONAL COOPERATION AGENCY

7.3 Water Supply

Water supply in Khu Kot S.D. is provided by PWA but water supply is insufficient. Water source is derived from 2 deep wells about 250-300 m deep. The water pump with a capacity of 240 m^3/hr is operated through the day.

The water supply of Prachatipat S.D. is also carried out by PWA. Water sources are from Khlong Prem Prachakorn and groundwater, but at present water source from Khlong Prem Prachakorn is halted because of poor water quality. The total production is 5,280 m^3/d and per capita water consumption is equivalent to 200 liters/d. The filtering tank which belongs to S.D. can produce about 900m^3/d. The disadvantage of groundwater use is its potential cause of land subsidence.

7.4 Population and Land Use

The Khu Kot S.D. has many non-registered residents, most of them are working at construction sites and factories. There are 11 projects for development of housing estates.

In Prachatipat S.D. the agricultural land occupies with a percentage of 78.62, while the remaining 21.38% is for commercial and residential areas. In the west side of Highway No.1, it is widely used for commercial purposes wherein public markets are located. In the east side, residential and agricultural areas are predominant.

Land use at present and in the future (2011) is referred to in Section 3, Chapter 2 and Figure 7.4.1 presents the projection in the year 2011.

Study area and population are as follows:

Area & Population	Present Municipality	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
Area (km^2)	33.30	-	33.30	-	33.30
Pop. in 1991	100,600	-	100,600		
Pop. in 2011	154,000	-	154,000		

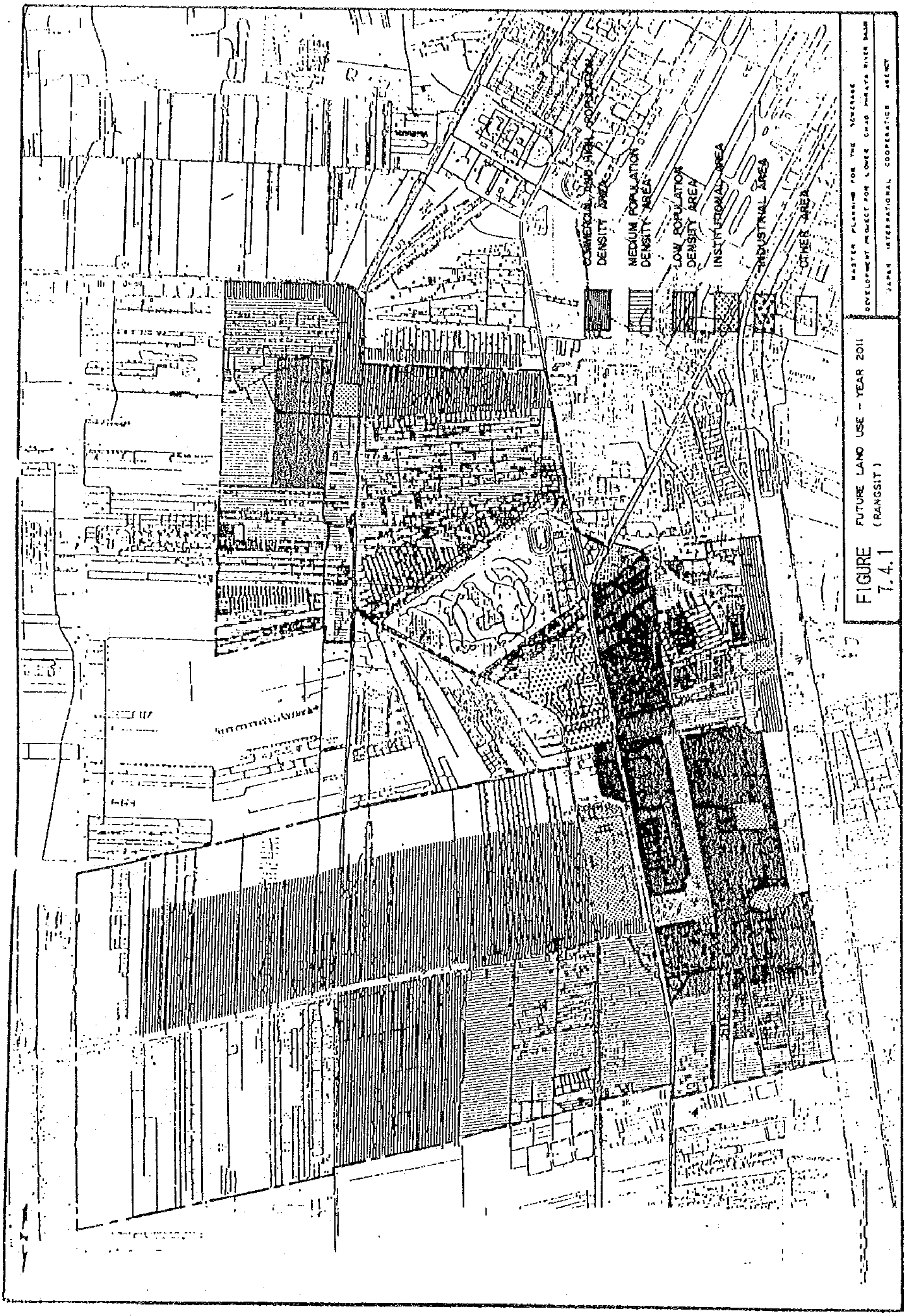


FIGURE 7.4.1 FUTURE LAND USE - YEAR 2011 (RANGSIT)

7.5 Quality and Quantity of Wastewater

7.5.1 Unit Wastewater and Pollution Load on a Generation Basis

(1) Domestic Wastewater

Unit quality (BOD) and quantity on the daily average basis at present and in design year are tabulated breaking down into sullage and toilet waste.

Domestic wastewater discharge is assumed at 80% of water consumption. Toilet waste is treated by septic tank with assumed treatment efficiency of 50%.

Year	Unit Wastewater (lpcd)			Unit BOD Load (gpcd)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Present	136	24	160	33.6	5.5	39.1
Design Year (2011)	170	24	194	35.1	5.5	40.6

(2) Business Wastewater

Those for business wastewater (commercial and institutional) is assumed to be 30% and 40% of domestic wastewater for the present and design year (2011), respectively.

	Unit Wastewater (lpcd)	Unit Pollution Load (BOD gpcd)
Present	64	10.1
Design Year (2011)	94	11.4

(3) Industrial Wastewater

Present unit wastewater and pollution load being discharged by industries were surveyed by DOI. Details are mentioned in Chapter 6 of Part I (Data Report 3.7.5).

7.5.2 Discharged Wastewater and BOD Load

(1) Domestic Wastewater

Wastewater quantity and BOD load based on a discharge basis are estimated for the present and design year (2011) multiplying service population by unit wastewater quantity/BOD load. The following are the estimation results.

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	13,686	2,414	16,100	26,180	3,696	29,876
BOD Load (kg/d)	3,380.2	553.3	3,933.5	5,405.4	847.0	6,252.4

(2) Business Wastewater

Discharged wastewater quantity and BOD load are estimated in the same procedure as domestic wastewater as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	6,438	14,476
BOD Load (kg/d)	1,016.1	1,755.6

(3) Industrial Wastewater

Industrial wastewater will be collected and treated by the proposed sewerage system in future. Discharged industrial wastewater and pollution load are as follows:

Discharged Industrial Wastewater: 7,712 m^3/d
(Khu khot 5,420 m^3/d; Prachatipat 5,240 m^3/d)
Discharged Industrial Pollution Load: BOD 2,756.5 kg/d
SS 6,185.1 kg/d

(4) Total Wastewater Quantity and BOD Load

Total discharged wastewater quantity and BOD load (daily average basis) at present and in the design year (2011) for Rangsit Sewerage Development are figured out as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	30,250	52,064
BOD Load (kg/d)	7,706.1	10,764.5

7.6 Proposed Sewerage System

7.6.1 Service Area

The subject area of the two S.Ds is developed as a comprehensive area along Phaholyothin road. Therefore, it is practical to construct the sewerage system covering both S.Ds. In the Khu Kot area, development by the private sector is considerable and acquisition of land for the WWTP is difficult.

The service area is determined as a single sewerage system merging the two S.Ds in addition to the housing areas adjacent to the system boundary. The area coverage is about 3,330 ha with present population of 100,600 in a total as shown in Figure 7.6.1. The design population in 2011 is projected to be 154,000.

In view of the difficult condition to acquire the land in the SDs, treatment plant site is selected at Khlong Nung, Khlong Luang S.D.

7.6.2 Wastewater Collection System

Wastewater collection system in application of the combined collection method is designed as shown in Figure 7.6.1. There is no systematic road network in the area.

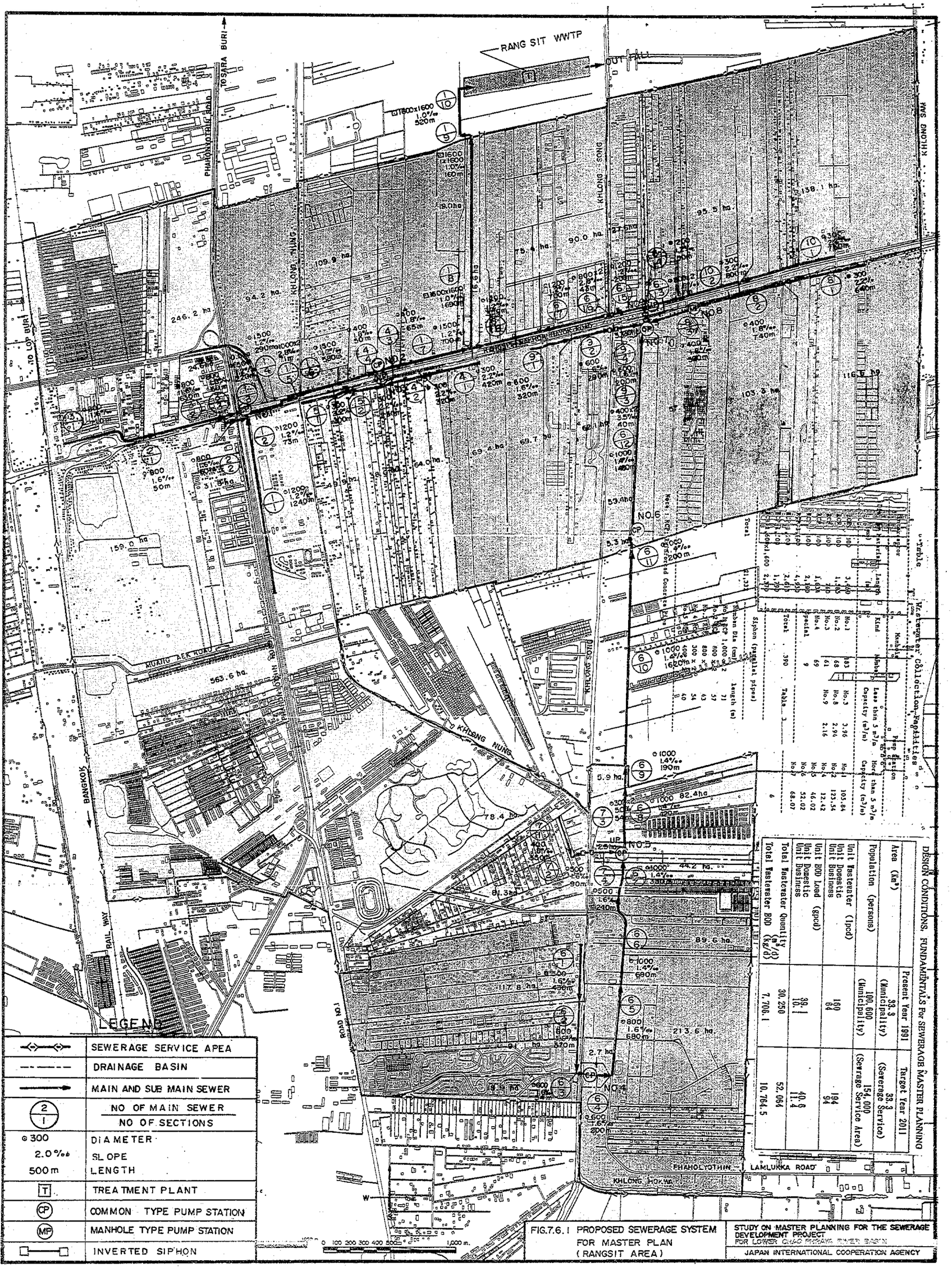


FIG.7.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (RANGSIT AREA)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Distribution of population and wastewater quantity was made using population density assumed by land use type (refer to calculation table in Supporting Report 3.7.6).

Alignments of main interceptors and pump stations are proposed as indicated in Figure 7.6.1. The profile of Sewers is shown in Figure 7.6.2 (refer to hydraulic calculation in Supporting Report 3.7.6). The following are brief descriptions on the sewer systems.

- The service area is covered by ten (10) sewer systems, which are merged to two sewerage sub-systems.

- Interceptors 1/1 - 1/10 along khlong Rangsit start from the central part of the service area (east side of Phaphonyothin R.D) and cross klong Rangsit before reaching to WWTP.

- Interceptors 6/1 - 6/18 start from the southern part of the service area and are planned to cross Khlong Song. After that it is located along Rang Sit - Lamlukka R.D before crossing klong Rang Sit. Then it joins 1/8.

The following are secondary main connected to the above systems:

- 2/1 interceptor starts from the west side of Phaphonyothin R.D at north-western part of the service area and connects to 1/2 interceptor.

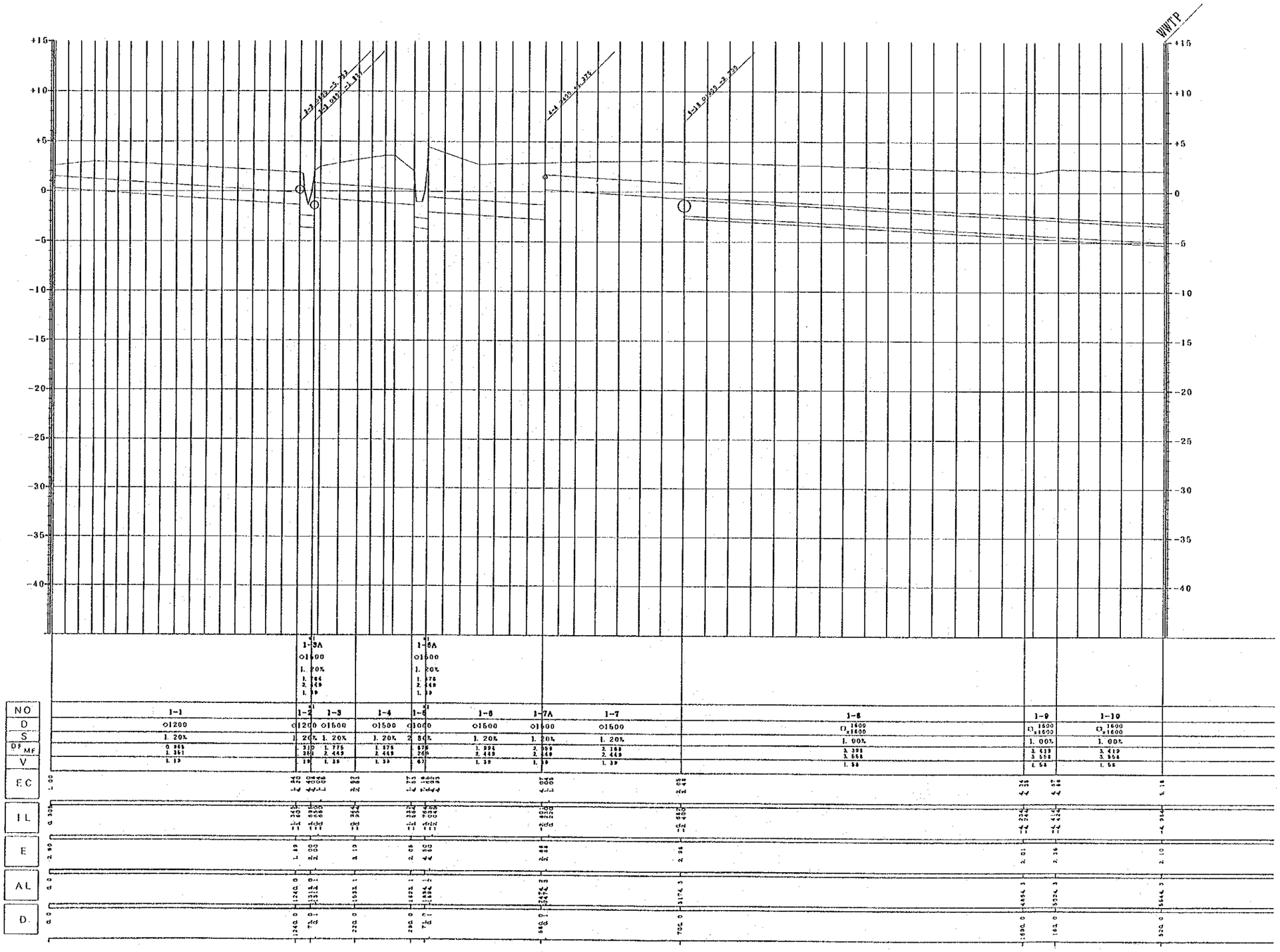
- 3/1 interceptor starts from northwestern boundary of the service area and connects to 1/3 interceptor.

- 4/1 - 4/4 interceptors connect to 1/7 crossign klong Rang Sit.

- 5/1 - 5/2 interceptors are starting from the junction of klong Nung and klong Rang Sit to connect to 4/3.

- 7/1 - 7/4 interceptors start from southern part of the service area, near klong Nung and connect to 6/8.

- 9/1 - 9/4 interceptors along klong Rang Sit are connected to 6/13.



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	1-2	1-3A	1-3	1-4
1-5	1-6A	1-6	1-7A	1-7
1-8	1-9	1-10		

FIG. 7.6.2 (1)
RANGSIT

V 1:200
H 1:10,000

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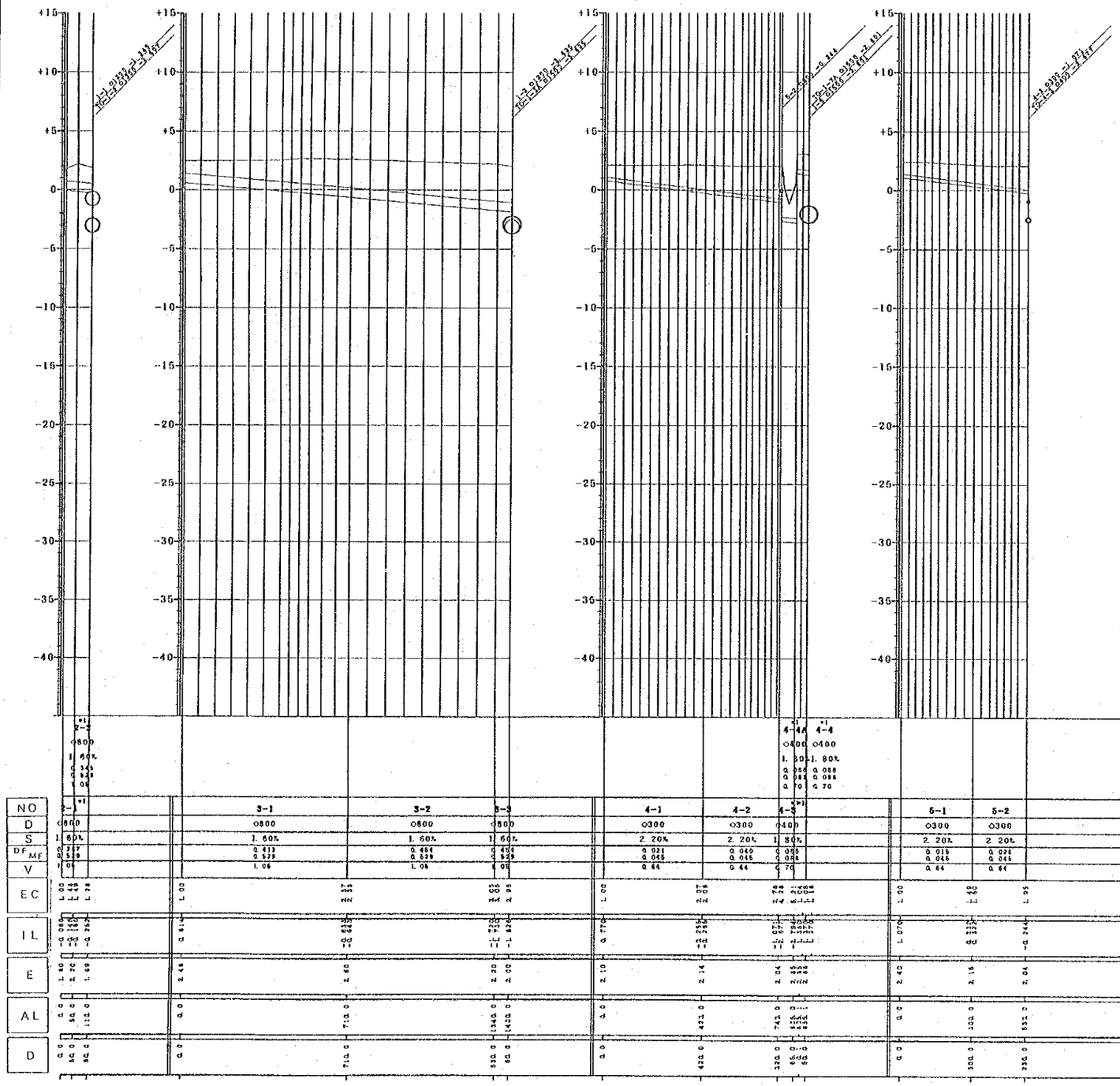
JAPAN INTERNATIONAL COOPERATION AGENCY



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

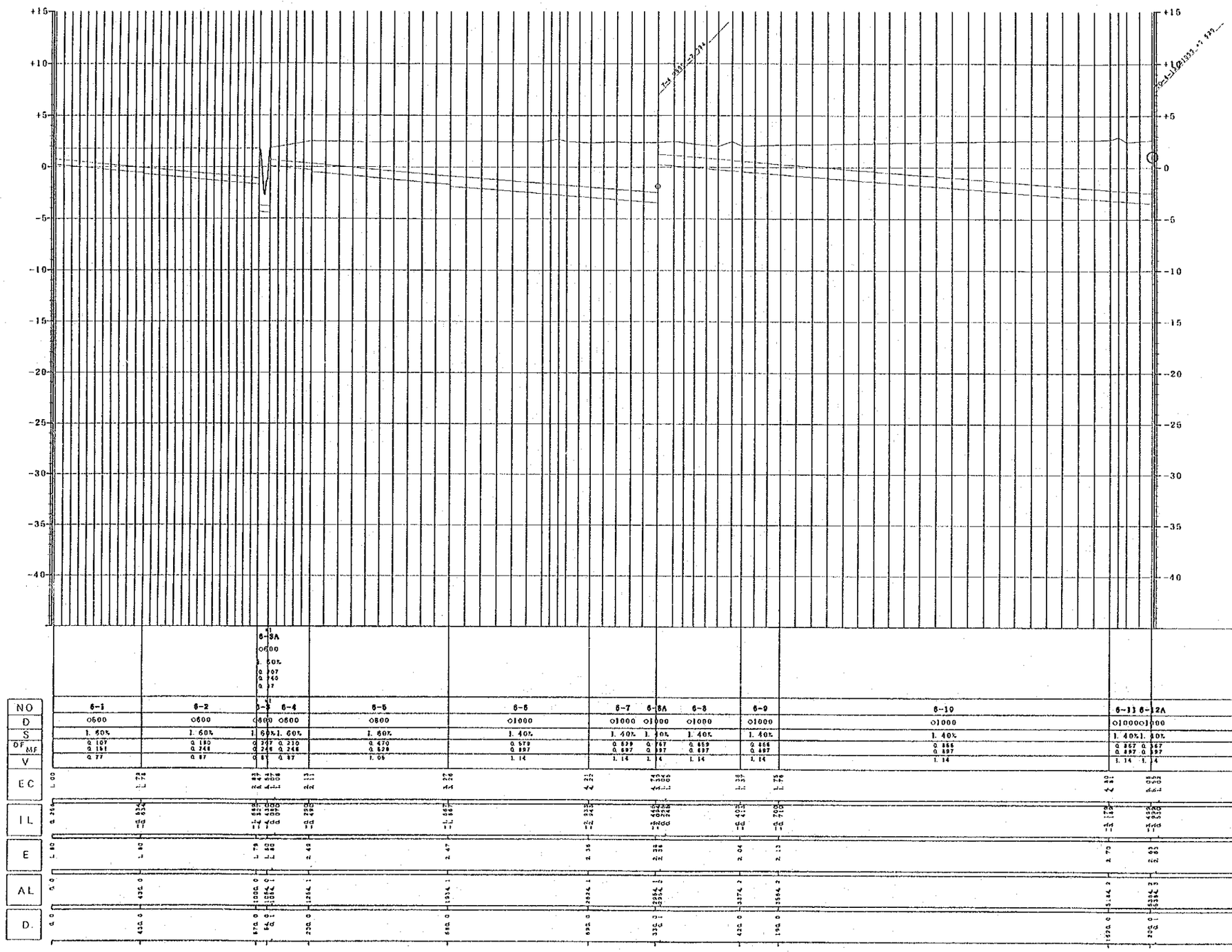
2-1	2-2	3-1	3-2	3-3
4-1	4-2	4-3	4-4A	4-4
5-1	5-2			

FIG. 7.6.2 (2)
RANGSIT

V 1:200
H 1:10,000

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

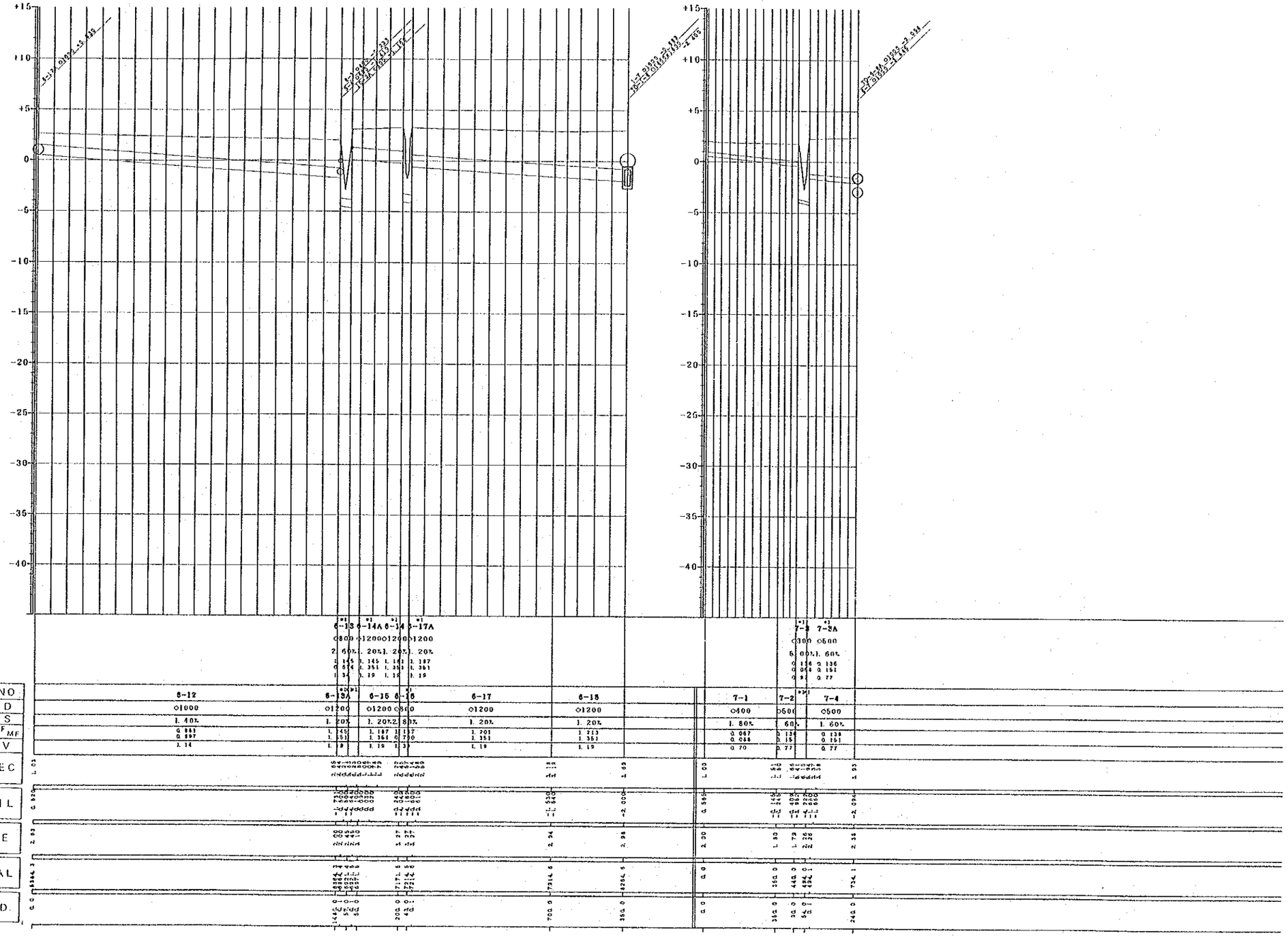
6-1	6-2	6-3	6-3A	6-4
6-6	6-8	6-7	6-8A	6-8
6-9	6-10	6-11	6-12A	

FIG. 7.6.2 (3)
RANGSIT

V 1:200
H 1:10.000

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

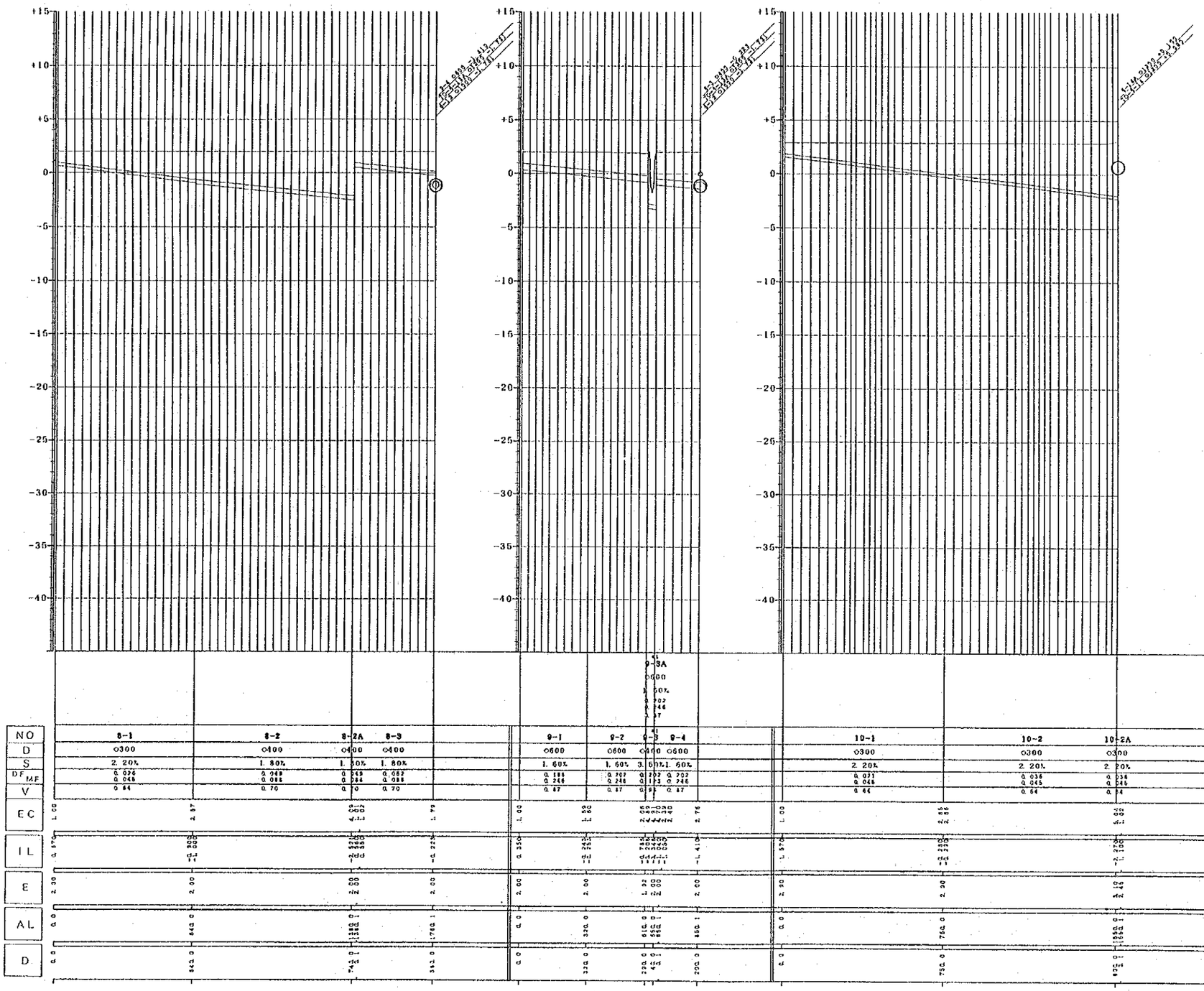
6-12	6-13A	6-13	6-14A	6-14
6-15	6-16	6-17A	6-17	6-18
7-1	7-2	7-3	7-3A	7-4

FIG. 7.6.2 (4)
RANGSIT

V 1:200
H 1:10,000

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

8-1	8-2	8-2A	8-3	9-1
9-2	9-3	9-3A	9-4	10-1
10-2	10-2A			

FIG. 7.6.2 (5)
RANGSIT

V 1:200
H 1:10,000

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 7.6.1 shows composition of collection facilities. Details on pump specifications and siphon are included in Supporting Report 3.1.6.

Table 7.6.1 Wastewater Collection Facilities

Interceptor		Manhole		Pump Station			
Dia. by Material (mm)	Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)		More than 5 m^3/m Capacity (m^3/m)	
RCP 300	3,460	No.1	183	No.3	3.96	No.1	105.84
RCP 400	1,585	No.2	68	No.8	2.94	No.2	123.54
RCP 500	760	No.3	61	No.9	2.16	No.4	12.42
RCP 600	1,634	No.4	69			No.5	46.02
RCP 800	2,190	Special	9			No.6	52.02
RCP 1,000	4,930					No.7	68.07
RCP 1,200	2,613	Total	390	Total	3		
RCP 1,500	1,790					Total	6
RCB 1,600x1,600	2,370						
Total	21,332						

Siphon (parallel pipes)

Number	Dia (mm)	length (m)
No.1	RCP 1,000 x 2	71
No.2	RCP 800 x 2	57
No.3	RCP 800 x 2	43
No.4	RCP 300 x 2	54
No.5	RCP 400 x 2	40

Note : RCP; Reinforced Concrete Pipe

7.6.3 Wastewater Treatment and Sludge Disposal System

(1) Wastewater Treatment and Disposal Methods

The wastewater discharge in the sewerage development area of Rangsit area is estimated to be 52,064 m^3/d in the year of 2011. Groundwater infiltration at 20% of wastewater discharge is assumed. The daily average design wastewater to the treatment plant is estimated to be 62,500 m^3/d. The effluent quality is expected to be less than 20 mg/l as BOD.

The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

1) Oxidation Ditch (OD)
2) Conventional Activated Sludge (AS)
3) Rotating biological Contactor (RBC)

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land area and easiness of O&M as shown below (Details are reffered to in Supporting Report 3.1.6.2).

Evaluation Item	Oxidation Ditch	Activated Sludge	RBC
(1) Construction Cost (million Baht)	484.06	598.75	759.62
(2) Land Cost (million Baht)	113.75	93.75	83.75
(3) O/M Cost (million Baht/year)	40.73	38.71	42.14
(4) Required Land Area (ha)	9.1	7.5	6.7
(5) Easiness of O/M			
- Adaptability of overload	A	C	C
- Required technology level	A	B	C
- Sludge disposal	B	B	B

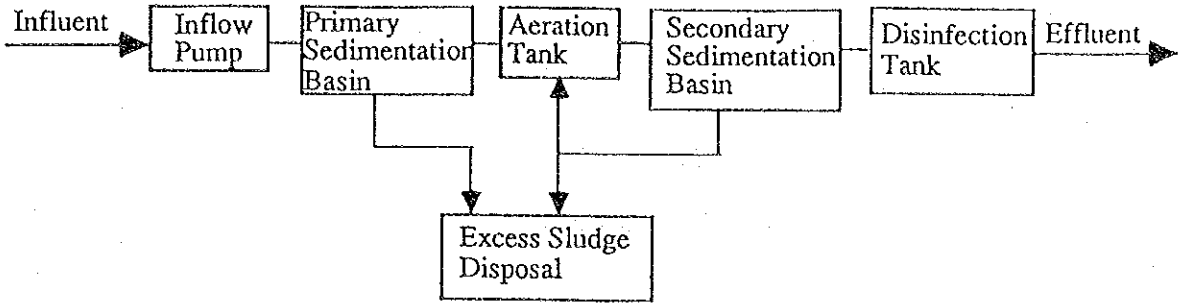
Note : 1) Construction Cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C: hard

From cost comparison in NPV (refer to Supporting Report 3.1.6.3), Oxidation ditch system and Activated Sludge system are economically on the same level. However, available land area for treatment plant in Rangsit area is limitted. Then, conventional activated sludge system is proposed.

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Rangsit is the paddy field located in Khlong Luang S.D. The proposed treatment plant of conventional activated sludge with a capacity of 75,000 m^3/d requires a net area of 7.5 ha.

The flow sheet of conventional activated sludge system and the capacity dimension and other relevant details of each treatment facility is shown below.



Inflow Pump	:	Design capacity	97,500 m^3/d (hourly max. dry)
			292,500 m^3/d (hourly max. wet)
	:	Capacity	67.7 $m^3/min.$ with 7.3 m hydraulic head (hourly max. dry)
			203.1 $m^3/min.$ with 7.3m hydraulic head (hourly max. wet)
Grit Chamber	:	Surface loading	: 1,847 $m^3/m^2/d$ (dry weather)
			: 2,770 $m^3/m^2/d$ (wet weather)
	:	Retention time	: 32 sec (dry), 22 sec (wet)
	:	Size	: 1.6 m(W) x 11 m(L) x 0.7 m(D) x 6 units (3 units for dry weather)
	:	Constructed with R.C	
Primary sedimentation basin	:	Design wastewater	75,000 m^3/d (daily max. dry)
	:	Dimension	ϕ 16 m x 4.0 m(D) x 12 units
	:	Surface loading	31.1 $m^3/m^2/d$
	:	Sedimentation time	3.1 hours
	:	Constructed with R.C	
Stormwater Sedimentation	:	Design discharge	217,500 m^3/d (hourly max. wet - daily max. dry)
	:	Dimension	ϕ 18.5 m x 3 m (D) x 12 units
	:	Surface loading	67.5 $m^3/m^2/d$
	:	Sedimentation time	1.1 hours

	:	Constructed with R.C
Aeration Tank	:	Design wastewater 75,000 m^3/d (daily max. dry)
	:	Dimension 15.0 m(W) x 75.0 m(L) x 3.0 m(D) x 6 units
	:	Aeration time 6.5 hours
	:	BOD-SS loading 0.31 kg-BOD/kg-SS/d
	:	MLSS 1,478 mg/l (25% return sludge)
	:	Constructed with R.C
Secondary sedimentation basin	:	Design wastewater 75,000 m^3
	:	Dimension ϕ 18.5 m(W) x 2.5 m(D) x 12 units
	:	Retention time 2.6 hours
	:	Surface loading 23.3 $m^3/m^2/d$
	:	Constructed with R.C
Sludge thickener	:	Design sludge volume 1,332 m^3/d (12.76 ton-DS/d)
	:	Dimension of tank ϕ 6.0 m x 4.0 m(D) x 6 units
	:	Detention time 12.2 hours
Sludge digestion tank	:	Design sludge volume 340 m^3/d
	:	Dimension of tank ϕ 17.0 m x 5.0 m(D) x 6 units ϕ 12.0 m x 5.0 m(D) x 6 units
Centrifugal dewatering	:	Design digested sludge 250 m^3/d
	:	Operation time 6 hours x 6 days per week
	:	Capacity 8 ~ 10 m^3/hr x 2 units 15 ~ 18 m^3/hr x 2 units

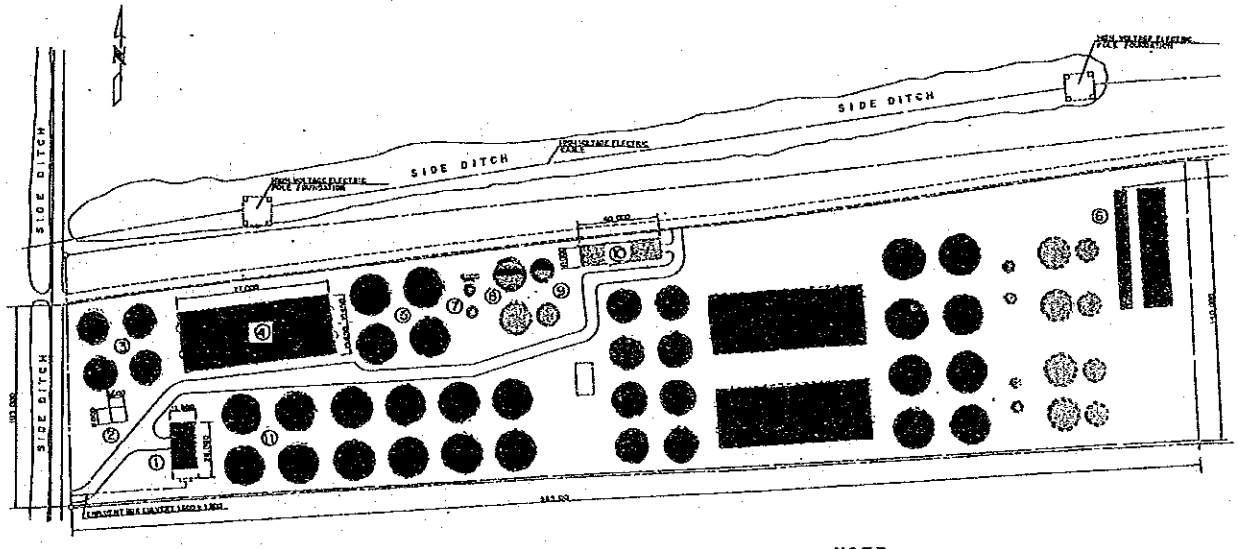
The treated water is discharged to Khlong Song. Layout of the treatment plant and hydraulic profile are shown in Figure 7.6.3 and Figure 7.6.4, respectively.

Wastewater Treatmentplant

Wastewater Treatment method	Conventional Activated Sludge System
Plant Space Area (ha)	7.5
Treatment Capacity (m^3/d) (inclusive of G.W)	75,000
Discharge Point	Khlong Song

Main Facilities

1) Inflow Pump — Submerged Pump
   (Dry Season) — ϕ350m/m×11.6m^3/min×7.3"H×2units
   ϕ500m/m×23.2m^3/min×7.3"H×2units
   (Wet Season) — ϕ800m/m×66.9m^3/min×7.3"H×2units
2) Grit Chamber — Constructed with R.C.
   Size
   1.6"W×11"L×0.7"D×6units
   (3units for dry weather)
3) Primary Sedimentation Tank — Constructed with R.C.
   Dimension
   ϕ16.0"×4.0"D×12units
   Retention Time 3.1 hr.
4) Aeration Tank — Constructed with R.C.
   Dimension
   15"W×75"L×3"D×6units
   Retention Time 5.9 hr.
5) Secondary Sedimentation Tank — Constructed with R.C.
   Dimension
   ϕ18.5"×2.5"D×12units
   Retention Time 2.6 hr.
6) Chloriration Tank — Constructed with R.C.
   Dimension
   2"W×180"L×2"D×3units
   Contact Time 10 min.
7) Sludge Thickener — Constructed with R.C.
   Dimension
   ϕ6.0"×4"D×6units
   Thickening Time 12.2 hr.
8) Anaerobic Digention Tank — Constructed with R.C.
   Dimension
   ϕ17"×5"D×6units
   ϕ12"×5"D×6units
   Digestion Time 1st stage 20 days
   2nd stage 10 days
9) Mechanical dewatering — Centrifugal dehydrator
   8~10m^3/hr - 2 units
   15~18m^3/hr - 2 units



NOTE

① Inflow Pump Station & Operation Room
② Distribution Tank
③ Primary Sedimentation Tank
④ Aeration Tank
⑤ Final Sedimentation Tank
⑥ Disinfection Tank
⑦ Gravity Thickener
⑧ Digestion Tank (1st)
⑨ Digestion Tank (2nd)
⑩ Dewatering House
⑪ Sedimentation Tank for Storm Water

Figure. 7.6.3 Layout of Sewage Treatment Plant (Rangsit)

STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

HYDRAULIC PROFILE

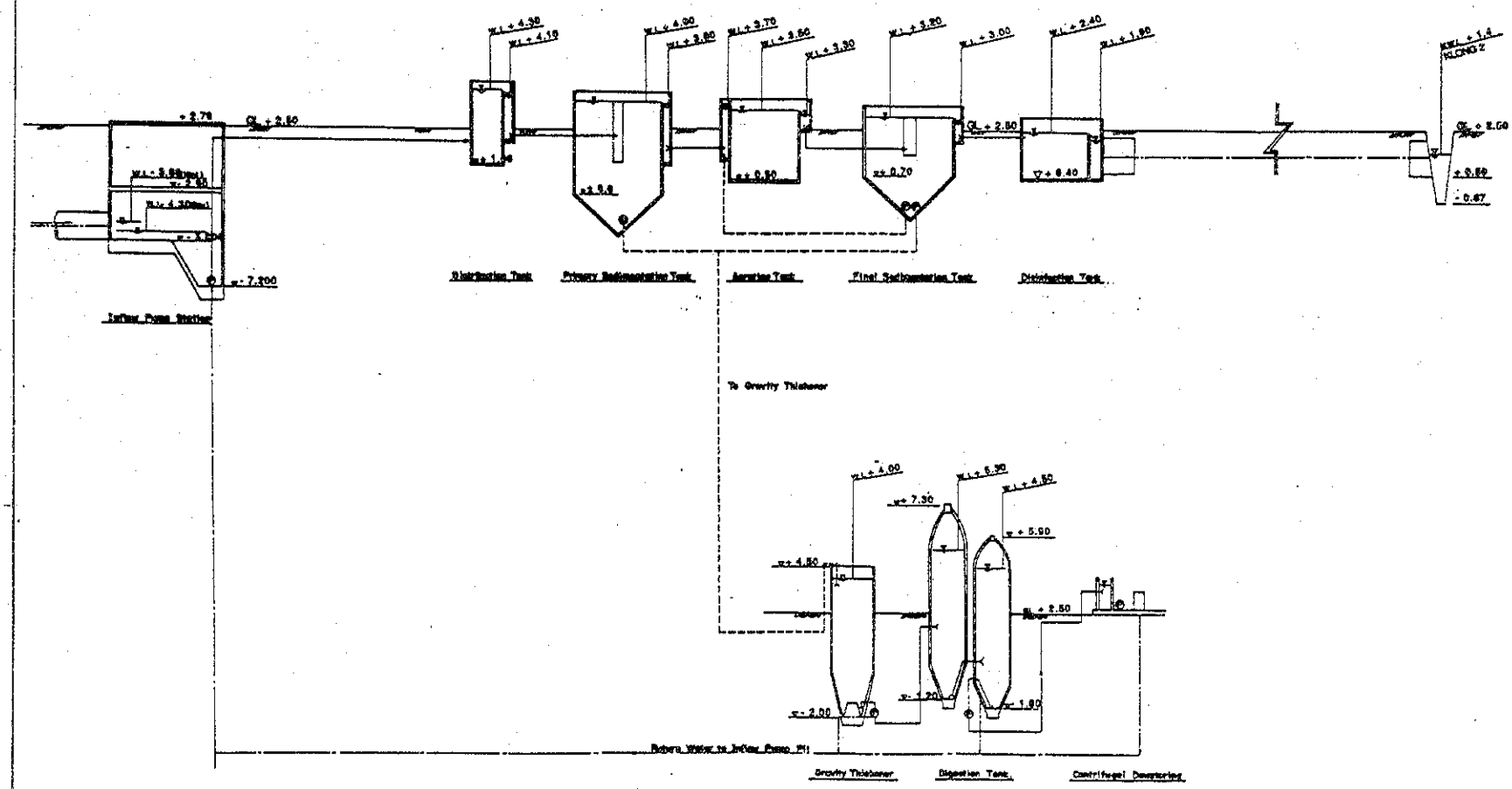


Figure 7.6.4 Hydraulic Profile of Sewage Treatment Plant (Rangait)

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JAPAN INTERNATIONAL COOPERATION AGENCY

7.7 Cost Estimates

7.7.1 Construction Cost

In the previous chapter, cost functions for interceptors, pump stations (more than $5m^3/min.$) and wastewater treatment plants are developed. Land acquisition cost is also considered to come up with the total construction cost. The following are cost requirements (million Baht) broken down into priority area (F/S) and remaining area for the design year 2011.

Cost Item	Priority Area(F/S)	Remaining Area	Total
(1) Direct Cost			
1) Interceptor	167.3	261.2	428.5
2) Pump Station	58.5	91.3	149.8
3) W.W.T.P.	223.74	365.01	598.75
Total of Direct Cost	459.54	717.51	1,177.05
(2) Contingency (20% of Direct Cost)	91.9	143.5	235.4
(3) Total of Construction ((1)+(2))	551.44	861.01	1,412.45
(4) Engineering & Construction Supervision (17% of (3))	93.7	146.4	240.1
(5) Land Acquisition			
1) Pump Station	0.42	0.65	1.07
2) W.W.T.P.	36.62	57.13	93.75
Total of Land Acquisition	37.04	57.78	94.82
Grand Total (million Baht)	682.18	1,065.19	1,747.37

7.7.2 Operation and Maintenance Cost

Annual Operation and Maintenance cost (thousand Baht) is estimated using cost functions/unit cost studied in the previous chapter.

Cost Item	Priority Area(F/S)	Remaining Area	Total
(1) Interceptor	506	791	1,297
(2) Pump Station	3,502	5,468	8,970
(3) W.W.T.P.	15,115	23,595	38,710
Total of O&M Cost	19,123	29,854	48,977

7.8 Implementation Plan

The provision of a complete sewerage system for the entire study area with its expanding population, will require a great investments of capital Fund as estimated in the previous section. Some areas within the study are is presently undeveloped land and environmental conditions of such area are different from built-up area. Although the study area needs to be sewered in early stage, the urgency of sewerage requirements is different depending on the features of areas.

Staged construction will have advantages to minimize the excessive initial investment and capital expenditures.

Implementation program is prepared for the first 20 years, dividing into 4 stages of five year each, taking the design period up to the year 2011 into account. The schedule is assumed giving priority to developed/being developed areas.

Stage	Period	Work with Priority
1st	1991-1995	Preparatory work & design of facilities
2nd	1996-2001	Construction for western and southern portions (F/S area)
3rd	2002-2006	Construction for north-eastern portion
4th	2007-2011	Construction for remaining southern and Western portions

7.9 Administrative and Financial Study

7.9.1 General

Rang Sit Area consists of two S.Ds: Khu Kot and Prachatipat. The sanitary district is the lowest unit of local government. They are scheduled to merge into one municipality in the near future. Therefore the proposed sewerage system shall be considered as one unit.

Thailand's political system is highly centralized under the monarchy. The

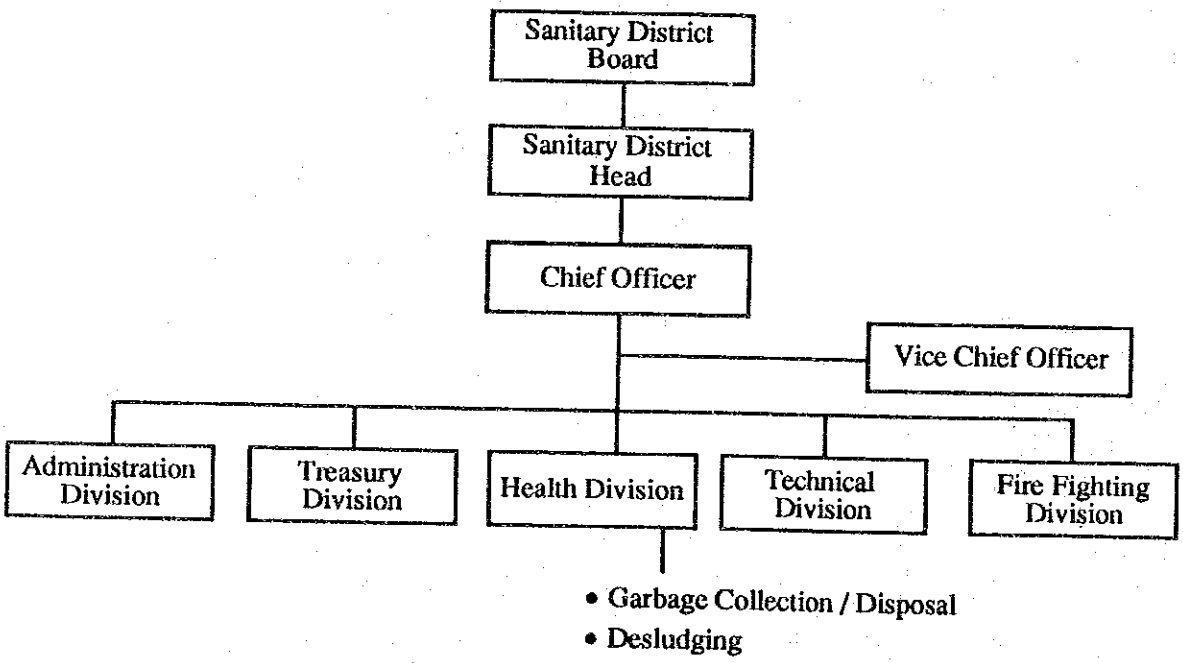
administrative set-up is decided by the regulations of Ministry of Interior. Now the existing staffing and their assigments are on a minimum level. The Study Team examined the administrative of the two S.Ds, and found that their capacity would be too limited to operate and maintain the proposed sewerage system.

7.9.2 Existing Administrative System

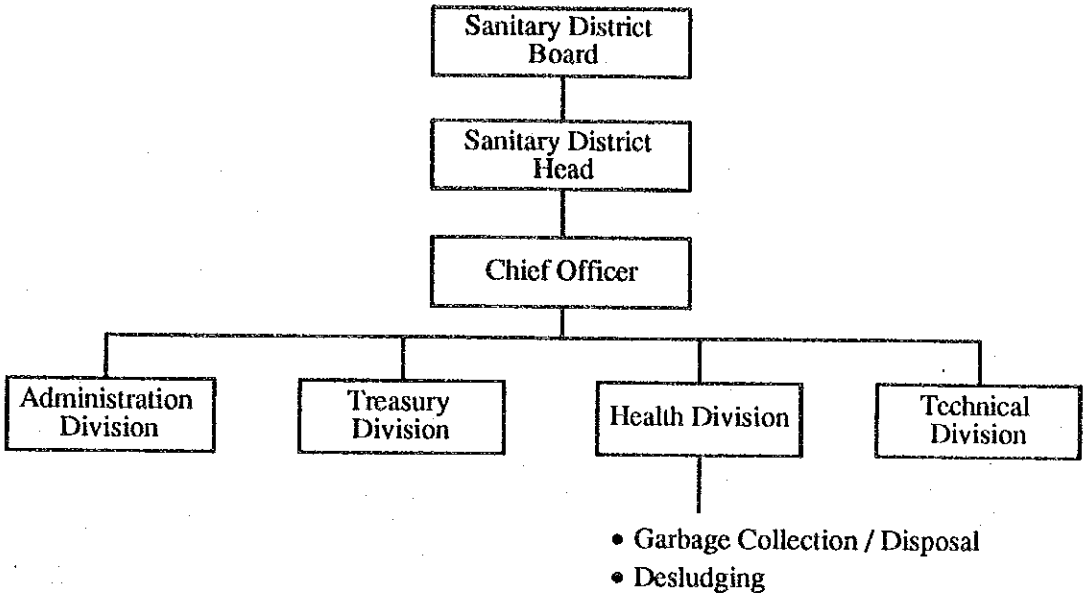
The Rangsit area consists of two sanitary districts: Prachatipat and Khu Kot. They are now independent organizations, shown in Figure 7.9.1, which are to be converted in the future.

The both administrations are headed by Sanitary District Head. The Board is the legislative body consisting of several representatives. The head is selected among the representatie to administer the sanitary district. But their functions are very limited.

The only difference is that Prechatipat S.D. has Fire Fighiting division, beside four divisions. This seems to have come from social and historical back ground. Khu Kot S.D has the same function under TEchnical division. This means that the regulations of Ministry of Interior allow this much of freedom for local administration.



<Sanitary District of Prachatipat>



<Sanitary District of Khu Khot>

Figure 7.9.1 Administrative Structure of Rang Sit Area

The area of Prachatipat and Khu Khot is 33.3 km^2 at present. No increase is foreseen. The populations of Prachatipat and Ku Khot are now 45,786 and 76,600 respectively. The administrative organizations are almost the same; under the S.D board the head is in charge of the sanitary district of Prachatipat and Ku Khot are 62 and 81 respectively.

In Prachatipat there are 28 officials and 36 employees, while there are 15 officials and 66 employees in Ku Khot. This means that Prachatipat has almost twice as many as officials, though it has only a smaller population than the other.

The main functions of the sanitary districts are almost the same as those of municipalities:

- Administration
- Tax collection
- Health affairs
- Technical/maintenance of basic infrastructures
- Fire fighting

One of the characteristics of sanitary districts is that they lack education division because of the regulation. This decreases the number of teachers, who might be counted otherwise.

7.9.3 Existing Relevant Regulations

At present the two sanitary districts are independent from each other. But the Rang Sit Area is considered to have a large potential of industrial and residential development. They will be merged in the future to form a new municipality. Then the Rangsit Area will be regulated by the Municipal Government Act (1953).

7.9.4 Recommendations

The two Sanitary Districts of Prachatipat and Khu Kot are considered to merge for a new municipality. It will have the following divisions:

- Administration division
- Treasury division
- Health division
- Technical division
- Education division

After establishment of the municpality, Rangsit Area (equivalent to municipality) have two options to manage the proposed sewerage system:

- (A) to attach the sewerage division to the municipal organization (see Figure 7.9.2)
- (B) to create the local sewerage authority (see Figure 7.9.3)

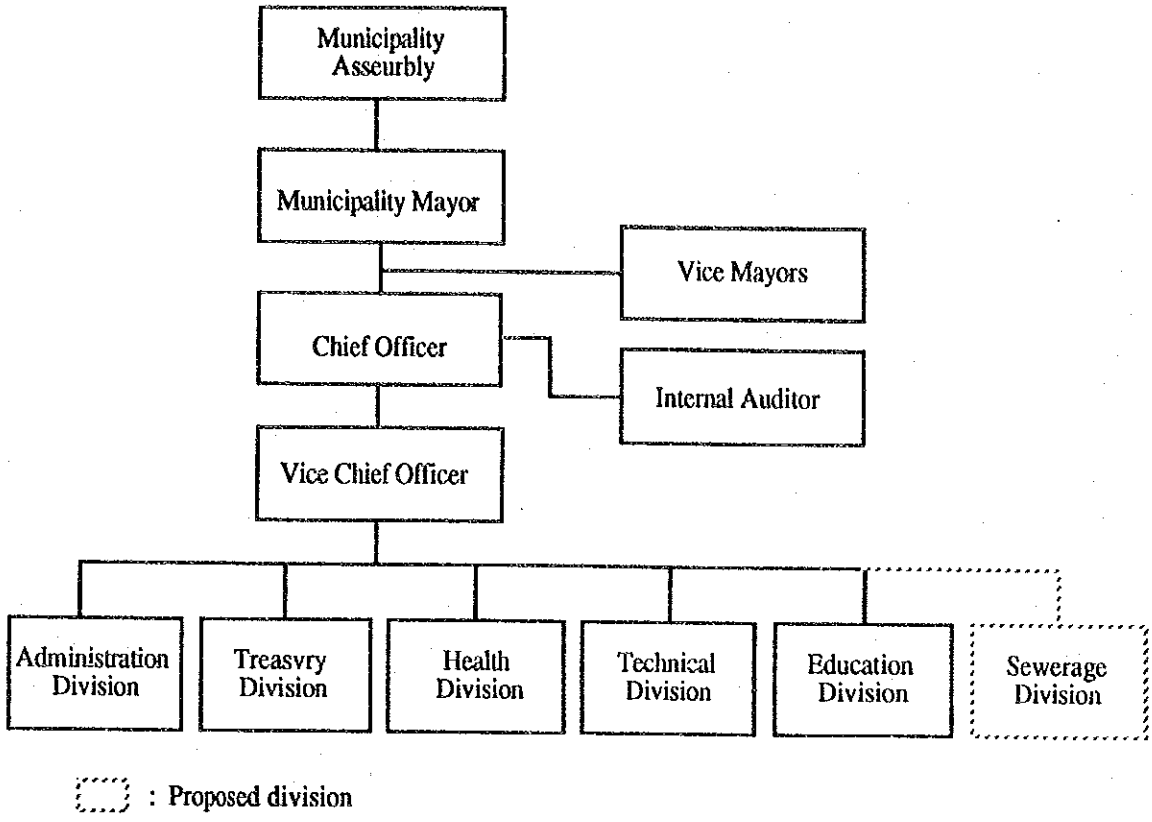


Figure 7.9.2 Option (A) for Rang Sit Area

In this option the Sewerage division will be limited in many aspects such as staff recruitment, budgeting and training. But this is in a meaning stable solution, because the municpal administration already exists. There will be no need to create new regulations, except minor amendments of the local ones.

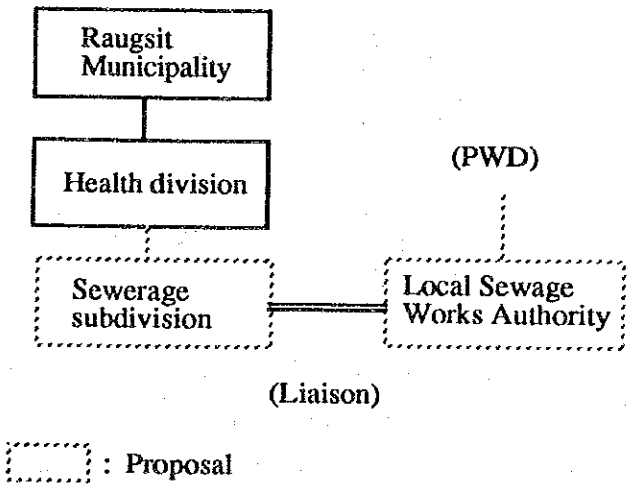


Figure 7.9.3 Option (B) for Rang Sit Area

Option (B) has many advantages over Option (A). It can be more flexible in management : staff recruitment, budgeting, planning, construction, oepration and training. But for the purpose a large scale of legislative actions will be required to establish the national and local sewerage authorities. At the initial stage PWD (OSW) should play a leading role for local sewerage authorities. However this is all dependent upon the Government's decision. Ince it considers the nationwide sewerage as important and high priority amongh the policies, it will not be difficult.

This implementation plan is summarized in section 7.8 with rough staff requirement as follows:

Stage	Period	Staffing requirement
1st	1991 - 1995	15
2nd	1995 - 2001	33
3rd	2002 - 2006	50
4th	2007 - 2011	70

7.9.5 Financial Considerations

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 40%. While the amount of fixed investment varies with fiscal year, this figure of 40% was not high among eight municipalities.

Rang Sit has not yet developed social infrastructure, compared with that of Rangsit and Bang Bua Thong. The proportion of public fixed investment to total expenditures was only 25% in 1991. This appears to reflect that the greater the portion of public fixed investment, the smaller the relative burden of land acquisition cost. For example, when public fixed investment increases to, say, 30% of total expenditures, the relative burden of land acquisition cost becomes also 30%. Thus, the relative burden of 39% while a little high, should be interpreted in a frame work not only of fixed investment but also of total expenditures.

Nevertheless, when the relative burden exceeds a certain figure, say, 10%, it will add substantial burden on local municipality. This is due to limited capability of increasing local revenues in financing a large public investment project as the sewerage project.
Rang Sit is no exception. Financing options that are available are (1)

municipality development fund, (2) environment fund, or (3) increasing local revenues.

Environmental fund is available to local agencies in the form of grant and/or loan. It is recommended that Rang Sit explore loan financing to allocate financial burden into the future, compared to raising local revenues or utilizing municipality development fund whose objectives are more general than those of environmental fund.

The average household user cost in item 4.3 of Table 7.9.1 is well below one percent of low household income in 2011 for Ang Thong. The user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Rang Sit would transfer to the user, and the other, the loss of the sewerage revenue collection that could be compensated for and would be included as part of the user charge.

The household users were estimated on the basis of the project service area in 2011. The household is assumed to have 4.1 persons on the average. We have also assumed that household users as sewerage users for simplicity. The average sewerage user cost was calculated on O&M cost divided by [(0.7+0.2x1.2+0.1x2)(number of household users)].

The average rate of non household users could be assumed to pay as high as the highest progressive rate of the household user rate structure. The progressive rate structure is 1.0 to 1.3 to 2.0 for low, medium, and high household income group respectively. A summary is shown in 4.4 of Table 7.9.1.

Finally, affordability will be considered. The affordability level is defined as the ratio of the average household user cost to low household income level of 96,571 Baht in 2011 in the Central Region. With available data on household income by Ang Thong, the figure indicated in 4.5 of Table 7.9.1 would then be updated and could also be modified with allocation of loan cost among the users.

Table 7.9.1 Selected indicators for Rang Sit

1.1	Service Pop in 2011	154,000
1.2	Household Users in 2011	37,560
2.1	Total Expenditures, 1991 (Thousand Baht)	19,136
2.2	Investment on Land & Const., 1991 (Thousand Baht)	12,288
2.3	Land Acquisition Cost (Thousand Baht)	4,862
2.4	Relative Burden (2.3/2.2) in %	39
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	na
3.1	Total Revenues, 1991 (Thousand Baht)	26,406
3.2	Central Government Support, 1991 (Thousand Baht)	2,620
4.1	Treatment capacity (m3/d), in 2011	62,500
4.2	Unit O&M Cost of 4.1, in 2011	2.07
4.3	Household Users Cost/Year, in 2011 without loan	1258
4.4	Progressive Rates: 1:1.3:2.0 in 2011	1084 1410 2169
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	11
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	1.32%

SECTION 8

BANG BUA THONG MUNICIPALITY

SECTION 8 BANG BUA THONG MUNICIPALITY

8.1 Description of the Study Area

The Bang Bua Thong municipality was a part of Tambol Bang Bua Thong about ten years ago (1983) with a population of about 2,000. However, rapid urbanization has been achieved in recent years, affected by the expansion of Metropolitan Bangkok.

The development has been extended beyond present municipality area as revealed in the field work that presently resided area is over the DTCP area prepared in 1985, especially in the western portion of the municipality. The center of the municipality is extended at the both sides of Khlong Pra Pimol. Infrastructures are located in the densely populated area as typical local municipality.

The climate is warm and humid with the maximum temperature of 32.5°C, the minimum temperature of 24.2°C and average temperature of 28.8°C through the year. The average humidity in the area is 76.3%. The topographic characteristic of the area is generally flat with an average elevation of 2 m amsl.

The study area is abundant of water with the Chao Phraya river as the main source. The Khlong Pra Pimol is the main natural river which diverts from a khlong in Nakorn Pathom Province and distributes water to some other khlongs in the municipality. The electricity supply comes directly from EGAT in Bangkok. A slaughterhouse is existing in the area with an area of 4 rai in Moo 4. About 18 pigs, a cow and a buffalo are slaughtered per day. Water from the well is used and about 10 m^3 is consumed per day. The wastewater is drained to the septic tank. There is a fresh market located in Moo 5 near Khlong Praminol.

8.2 Existing Sanitation and Sewerage Systems

8.2.1 Existing Sanitation Facilities

The municipality operates some trucks to collect 100 tons of refuse per day and dispose them at a dumping site with an area of about 4 rai.

On-site treatment and disposal of nightsoil is practiced as mentioned in Section 3, Chapter 2.

8.2.2 Existing Sewerage Facilities

Sewerage facilities are existing in the urbanized area facing Khlong Pra Pimol in the form of combined system. The pipeline with a diameter of ϕ600 mm and about 5,500 m long is installed to collect wastewater from fresh market and highly populated area. The discharge point is connected to Khlong Pra Pimol. Composition of existing drainage facilities is summarized in Table 8.2.1. Area coverage and location of sewers are shown in Figure 8.2.1.

Table 8.2.1 Existing Drainage Facilities

Size (mm)	Length (m)	Type	Drainage Area (ha)
dia. 400	130	RC. Pipe	
600	5,491	RC. Pipe	
Total	5,621		56.2

8.3 Water Supply

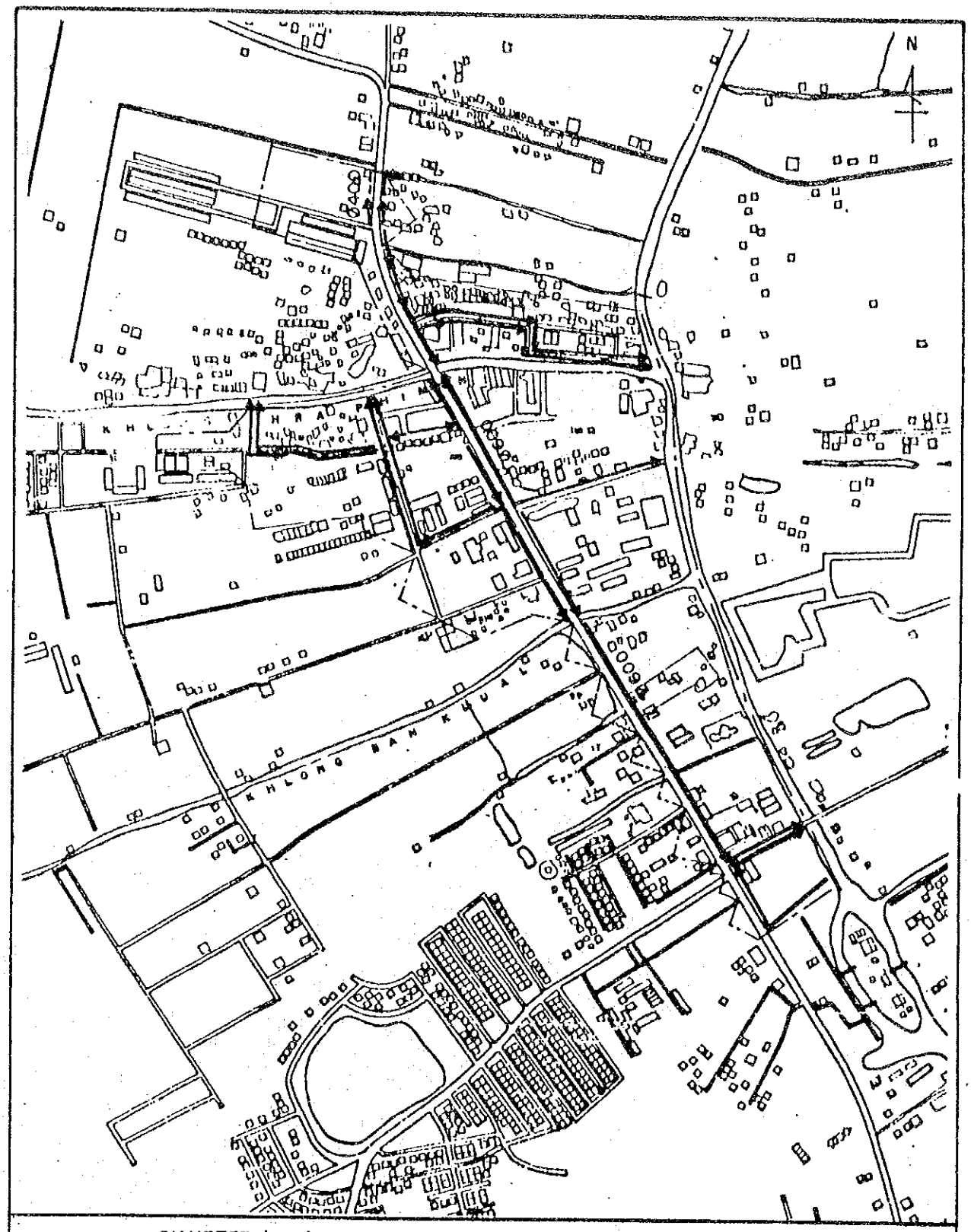
Water supply in the study area is provided by PWD and MWA. As of 1991, the annual supply rate is 5,475,000 m^3/year to a population of 17,000.

8.4 Population and Land Use

Land use at present and in the future (2011) is referred to in Section 3, Chapter 2 and Figure 8.4.1 presents the projection in the year 2011.

Study area and population are as follows:

Area & Population	Present Municipality	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
Area (km^2)	1.60	14.04	15.64	0.00	9.85
Pop. in 1991	45,786	-	45,786		
Pop. in 2011	76,600	3,000	79,600		



LEGEND: 600 DIAMETER (mm.)
DRAINAGE PIPE —→ OUTFALL ——·—DRAINAGE AREA BOUNDARY SCALE 1 : 10000

FIGURE 8.2.1 EXISTING DRAINAGE SYSTEM BANG BUA THONG MUNICIPALITY

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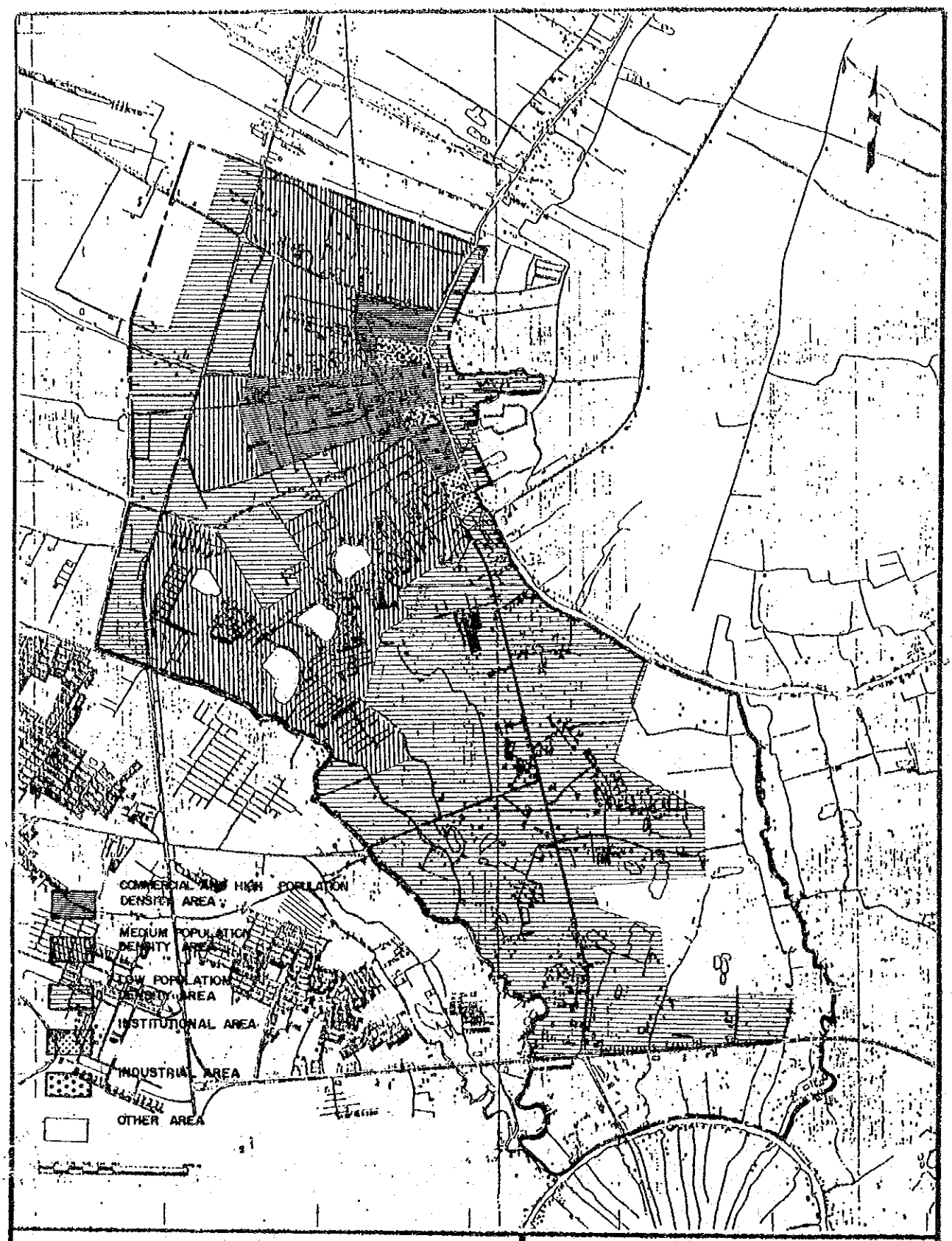

FIGURE 8.4.1 FUTURE LAND USE – YEAR 2011 (BANG BUA THONG)

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8.5 Quality and Quantity of Wastewater

8.5.1 Unit Wastewater and Pollution Load on a Generation Basis

(1) Domestic Wastewater

Unit quality (BOD) and quantity on the daily average basis at present and in design year are tabulated breaking down into sullage and toilet waste.

Domestic wastewater discharge is assumed at 80% of water consumption. Toilet waste is treated by septic tank with assumed treatment efficiency of 50%.

Year	Unit Wastewater (lpcd)			Unit BOD Load (gpcd)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Present	136	24	160	33.6	5.5	39.1
Design Year (2011)	170	24	194	35.1	5.5	40.6

(2) Business Wastewater

Those for business wastewater (commercial and institutional) is assumed to be 30% and 40% of domestic wastewater for the present and design year (2011), respectively.

	Unit Wastewater (lpcd)	Unit Pollution Load (BOD gpcd)
Present	64	10.1
Design Year (2011)	94	11.4

8.5.2 Discharged Wastewater and BOD Load

(1) Domestic Wastewater

Wastewater quantity and BOD load based on a discharge basis are estimated for the present and design year (2011) multiplying service population by unit wastewater quantity/BOD load. The following are the estimation results.

Bang Bua Thong North Area

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	4,452	786	5,238	9,673	1,366	11,039
BOD Load (kg/d)	1,099.8	180.0	1,279.8	1,997.2	313.0	2,310.2

Bang Bua Thong South Area

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	1,776	313	2,089	3,859	545	4,404
BOD Load (kg/d)	438.7	71.8	510.5	796.8	124.9	921.7

(2) Business Wastewater

Discharged wastewater quantity and BOD load are estimated in the same procedure as domestic wastewater as shown below.

Bang Bua Thong North Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	2,095	5,349
BOD Load (kg/d)	330.6	648.7

Bang Bua Thong South Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	836	2,134
BOD Load (kg/d)	131.9	258.8

(3) Total Wastewater Quantity and BOD Load

Total discharged wastewater quantity and BOD load (daily average basis) at present and in the design year (2011) for Bang Bua Thong Sewerage Development are figured out as shown below.

Bang Bua Thong North Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	7,333	16,388
BOD Load (kg/d)	1,610.4	2,958.9

Bang Bua Thong South Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	2,925	6,538
BOD Load (kg/d)	642.4	1,180.5

8.6 Proposed Sewerage System

8.6.1 Service Area

The service area covers 1,564 ha with present population of about 45,800. The total area is divided into two service areas, north and south areas due to land availability for the wastewater treatment plant, as shown in Figure 8.6.1. Information on the two areas is enumerated below.

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station			
Dia. by Material (mm)		Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)		More than 5m^3/m Capacity (m^3/m)	
RCP	300	6,175	No.1	329	No.3	2.10	No.1	12.84
RCP	400	4,280	No.2	55	No.4	3.72	No.2	43.56
RCP	500	2,305	No.3	35	No.5	1.86	No.6	5.52
RCP	600	2,412	No.4	3	No.6	1.02	No.8	12.90
RCP	800	2,090	Special	3				
RCP	1,000	1,240			Table	4		4
RCP	1,200	50	Total	425				
Total		18,252						

Siphon (Parallel pipes)

Dia. (mm)	Length (m)
RC 400 x 2	38

Note ; RCP; Reinforced Concrete Pipe

LEGEND

- SEWERAGE SERVICE APEA
- DRAINAGE BASIN
- MAIN AND SUB MAIN SEWER
- NO OF MAIN SEWER / NO OF SECTIONS
- DIA METER: φ300; SLOPE: 2.0‰; LENGTH: 500m
- T TREATMENT PLANT
- CP COMMON TYPE PUMP STATION
- MP MANHOLE TYPE PUMP STATION
- INVERTED SIPHON

DESIGN CONDITIONS, FUNDAMENTALS for SEWERAGE MASTER PLANNING

	Present Year 1991			Target Year 2011		
	North Area	South Area	Total	North Area	South Area	Total
Area (Km^2)	1.55	0.05	1.6	6.70	8.94	15.64
Population (persons)	32,700	13,086	45,786	56,900	22,700	79,600
Unit Wastewater (lpcd)						
Unit Domestic		160			194	
Unit Business		64			94	
Unit BOD Load (gpcd)						
Unit Domestic		39.1			40.6	
Unit Business		10.1			11.4	
Total Wastewater Quantity (m^3/d)	7,333	2,925	10,258	16,388	6,538	22,926
Total Wastewater BOD(kg/d)	1,610.4	642.4	2,252.8	2,858.9	1,180.5	4,139.4

FIG. 8.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (BANG BUA THONG MUNICIPALITY)

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

JAPAN INTERNATIONAL COOPERATION AGENCY