Chapter 9

CONVEYANCE SEWER DEVELOPMENT

CHAPTER 9 CONVEYANCE SEWER DEVELOPMENT

9.1 Planning Concept and Design Criteria

(1) Overview of Conveyance Sewer

The conveyance sewer is defined as conduit to transfer wastewater from the proposed intermediate wastewater pumping station to the proposed wastewater treatment plant (WWTP) located in Binh Hung Ward in Binh Chang District. The conveyance sewer route is shown in Fig. 9.1. The conveyance sewer can be installed at the shallow depth due to wastewater lifted up at IWPS.

(2) Design Criteria

[Design Flow]
An hourly maximum discharge including groundwater infiltration is applied as a design flow.

Based on the implementation program, design flow of conveyance sewer is defined as shown below;

Phase	Target Year	Design Flow (m3/day)
Phase I	2005	192,000
Phase II	2010	640,000
Final	2020	699,000

Design flow between Phase I and Phase II is much difference. While design flow of Phase II and Final are almost same. Design flow of Phase I and Final are adopted to study the step-wise construction of conveyance sewer.

9.2 Present Conditions along the Conveyance Sewer Route

The conveyance sewer route is determined based on the existing road alignment and a future road plan. The conveyance sewer route is shown in Fig. 9.2.

(1) Road Alignment

The existing and planned road alignment between IWPS and WWTP are described as follows.

Section No.	Length (m)	Road Condition	Road Width (m)
1	170	Unpaved Road	5
2	816	Paved Road	7
3	59	No Road	- (7)
4	211	No Road	- (7)
5	700	Unpaved Road	3 (7)
6	514	No Road	- (7)
7	600	No Road	- (12.5)
Total	3,070	-	-

Note : Figures in () means a width of planed road.

(2) Land Use along the Conveyance Route

Land use along the conveyance sewer route between IWPS and WWTP is described as follows;

Section No.	Length (m)	Land Use along the Route	
		Existing (2000)	Future (2020)
1	170	Paddy Filed	Residential Area
2	816	Paddy Field	
3	59	Paddy Field	
4	211	Paddy Filed	Saigon South Development Area
5	700	Paddy Field	
6	514	Paddy Field	
7	600	Paddy Field	
Total	3,070	-	-

(3) Soil Condition

Boring logs along the conveyance sewer route shows that Organic Clay lies at the 1st layer from the surface with a thickness ranging from 5 m to 19 m. The laboratory test results that this soil is very soft with N-value of nearly 0. The 2nd layer consists of Sandy Clay, which is relatively stiff with N-value ranging from 5 to 15. The layers below 2nd layer consist of Sand with clay, which are stiff with N-value of greater than 12.

The thickness and characteristic of the 1st and 2nd layers are shown in table and figure below.

Soil Condition along Conveyance Sewer Route

Boring Location	Soil Condition					
	1st Layer : Organic Clay			2nd Layer : Sandy Clay		
	Depth (m)	Thickness (m)	N Value	Depth (m)	Thickness (m)	N Value
6	GL-0.5 - -4.2	3.7	0	GL -4.2 - -6.0	1.8	10-15
7	GL-0.8 - -6.5	5.7	0	GL -6.5 - -9.5	3.0	5-15
8	GL-0.5 - -19.5	19.0	0	GL-19.5 - -22.5	3.0	5-15
9	GL-0.5 - -13.0	12.5	0-2	GL-13.0 - -20.0	7.0	6-10
10	GL-0.5 - -23.0	22.5	0-2	GL-23.0 - -30.0	7.0	10-13

The intermediate wastewater pumping station and the wastewater treatment plant are proposed at the locations as shown in Fig. 9.3 as **PS** and **TP**. The soil condition between the two places, the thickness of Organic Clay layer ranges from 5.0 m to 19.0 m.

Based on the geological profile illustrated in Fig. 9.3, the conveyance sewer route can be classified into 2 zones (Zone **A** and **B**) in accordance with the thickness of the Organic Clay layer. The zones are defined as table below and shown in Fig. 9.3.

Zone	Section	Length	Average Thickness of Organic Clay layer
A	Between Intermediate Pumping Station and 1,113 m distance from Intermediate Pumping Station	1,113 m	5 m
B	Between 1,113 m distance from Intermediate PS and Wastewater Treatment Plant	1,957 m	12 m
Total		3,070 m	

The 1st layer of the Organic Clay layer is unconsolidated soil therefore it must cause land subsidence.

The area along the southern part of the conveyance sewer route is planed to be developed as Saigon South Development Area. The existing ground elevation ranges from EL+0.5 m to EL+0.7 m (Elevation refer to as mean sea level at Mui Nai). If the area is filled up to the planed elevation of EL+2.0 m, the land subsidence along the conveyance sewer route is computed at approximately 9 cm in 10 years and 39 cm in 50 years. The total subsidence at No.9 is computed at 102 cm in 180 years and one at No.10 is computed at 198 cm in 420 years.

9.3 Soil Improvement

Based on the discussion above, the following two auxiliary works are proposed for prevention of land subsidence along the conveyance sewer route.

Vertical Drain Method

To avoid the risk of land subsidence in future, Vertical Drain Method is proposed to hasten the subsidence. If one vertical drain is proposed in 1 m interval, the 95% of the total subsidence will occur in 1 year. The area covered by the vertical drain is proposed along the conveyance sewer route of about 1,957 m for Zone **B**.

Soil Improvement

The Clay layer exists under the Organic layer so that the base of the trench for sewer pipe installation work might be heaved by ground water pressure. According to an analysis, soil improvement under the trench shall be considered along the conveyance sewer route for construction work.

Based on the analysis of heaving at the trench bottom, the soil improvement work is proposed as follows for each zone defined in above.

Zone (Section)	Zone A (Section 1, 2 & 3)		Zone B (Section 4, 5, 6 & 7)	
Excavation Elevation	< GL-4 m	> GL-4 m	< GL-6 m	< GL-6 m
Soil Improvement	No	Necessary (Average Thickness of 2 m)	No	Necessary (Average Thickness of 4 m)

Note : GL means the ground level.

9.4 Alternative Study for Conveyance System

9.4.1 Options of Conveyance Sewer

Based on the condition mentioned above, the following 4 options of conveyance sewer have been studied. The 4 options are presented in Fig. 9.4.

Design capacity and flow system of the conveyance sewer are summarized in table below. **Option 1** aims to install one conveyance sewer with an ultimate capacity of 699,000 m^3/d targeting year 2020 in the Phase I. Other 3 options of **Option 2**, **3** and **4**, a conveyance sewer with a capacity of 192,000 m^3/d for the Phase I and additional conveyance sewer with a capacity of 507,000 m^3/d for the Phase II will be constructed.

Capacity and Flow System of Conveyance Sewer

Option	Phase			
	I		II	
	Capacity	System	Capacity	System
1	699,000 m^3/d = hourly max.)	Pipe & Gravity	No construction Only Instillation of Equipment such as pump	
2	192,000 m^3/d = hourly max.)	Pipe & Gravity	Additional : 507,000 m^3/d = hourly max.)	Pipe & Gravity
3	192,000 m^3/d = hourly max.)	Pipe & Pressurized	Additional : 507,000 m^3/d = hourly max.)	Pipe & Pressurized
4	192,000 m^3/d = hourly max.)	Culvert & Gravity	Additional : 507,000 m^3/d = hourly max.)	Culvert & Gravity

Outline of 4 options are described as follows and illustrated in Fig. 9.4 and Fig. 9.5.

Option 1

(Proposed Facilities)

- Gravity flow by single concrete sewer pipe under the existing road and a planned road.
- Total of 6 units (1 unit for stand-by) of pump installed at the intermediate wastewater pumping station.
- Total of 6 units (1 unit for stand-by) of pump installed at the inflow pumping station in the wastewater treatment plant.

(Construction Plan)

Phase I

- Construct 2,500 mm diameter concrete sewer pipe with a capacity of 699,000 m^3/d targeting Year 2020.
- Excavation depth of the conveyance sewer in Zone A ranges from GL-4.5 m to GL-5.5 m and that in Zone B ranges from GL-6.8 m to GL-8.9 m (refer to Fig. 9.3 (1))
- 3 units of pump installed at the intermediate wastewater pumping station.
- 3 units of pump installed at the inflow pumping station.

Phase II

- No construction of conveyance sewer.
- Additional 3 units of pump installed at the intermediate wastewater pumping station.
- Additional 3 units of pump installed at the inflow pumping station.

Option 2

(Proposed Facilities)

- Gravity flow of 2 concrete sewer pipes with a diameter of 1,500 mm and 2,300 mm under the existing road and a planned road.

- Excavation depth of the 1,500 mm diameter conveyance sewer in Zone A ranges from GL-3.4 m to GL-4.6 m and that in Zone B ranges from GL-5.6 m to GL-8.1 m (refer to Fig. 9.3 (2))
- Excavation depth of the 2,300 mm diameter conveyance sewer in Zone A ranges from GL-4.3 m to GL-5.1 m and that in Zone B ranges from GL-6.6 m to GL-8.2 m (refer to Fig. 9.3 (3)).
- Total of 6 units (1 unit for stand-by) of pump installed at the intermediate wastewater pumping station.
- Total of 6 units (1 unit for stand-by) of pump installed at the inflow pumping station in the wastewater treatment plant.

(Construction Plan)

Phase I

- Construct a concrete sewer pipe with a diameter of 1,500 mm
- Install 3 units of pump at IWPS.
- Install 3 units of pump at the inflow pumping station in WWTP

Phase II

- Construct an additional concrete sewer pipe with a diameter of 2,300 mm
- Install additional 3 units of pump at IWPS
- Install additional 3 units of pump at the inflow pumping station in WWTP

Option 3

(Proposed Facilities)

- Pressurized flow by 4 ductile iron sewer pipes with a diameter of 700 mm (x 2 lines) and 1,200 mm (x 2 lines) beside the existing road and a planned road.
- Total of 6 units (1 unit for stand-by) of pump installed at the intermediate wastewater pumping station.

(Construction Plan)

Phase I

- Construct 2 lines of ductile sewer pipe with a diameter of 700 mm
- Install 3 units of pump at IWPS

Phase II

- Construct additional 2 lines of ductile sewer pipe with a diameter of 1,200 mm
- Install additional 3 units of pump at IWPS

Option 4

(Proposed Facilities)

- Gravity flow by concrete culverts with a dimension of (W) 1,300 mm x (H) 1,200 mm x 2 lanes and (W) 2,000 mm x (H) 1,700 mm x 2 lanes beside the existing road and a planned road.
- Excavation depth of the (W) 1,300 mm x (H) 1,200 mm culvert conveyance sewer in Zone A ranges from GL-1.9 m to GL-2.6 m and that in Zone B ranges from GL-2.7 m to GL-4.0 m (refer to Fig. 9.3 (4)).

- Excavation depth of the (W) 2,000 mm x (H) 1,700 mm culvert conveyance sewer in Zone A ranges from GL-3.4 m to GL-3.6 m and that in Zone B ranges from GL-4.2 m to GL-5.1 m (refer to Fig. 9.3 (5)).
- Total of 6 units (1 unit for stand-by) of pump installed at the intermediate wastewater pumping station.
- Total of 6 units (1 unit for stand-by) of pump installed at the inflow pumping station in the wastewater treatment plant.

(Construction Plan)

Phase I

- Construct 2 lanes of concrete culvert with a dimension of (W) 1,300 mm x (H) 1,200 mm
- Install 3 units of pump at IWPS.
- Install 3 units of pump at the inflow pumping station in WWTP.

Phase II

- Construct additional 2 lanes of concrete culvert with a dimension of (W) 2,000 mm x (H) 1,700 mm
- Install additional 3 units of pump at IWPS
- Install additional 3 units of pump at the inflow pumping station in WWTP.

9.4.2 Project Cost

(1) Construction Cost

The construction cost of 4 options is estimated under the following conditions;

- To avoid unsteady land subsidence for gravity flow system of **Option 1**, **2** and **4**, vertical drain method is proposed under the conveyance sewer pipes and culverts of about 1,950 m long in Zone **B**.
- Based on a comparison of construction cost for conveyance sewer by Trench Method and Pipe Jacking Method, construction cost of conveyance sewer by Trench Method is more economical in case that excavation depth is less than 5 m. While the conveyance sewer construction in case of deeper than 6m, Trench Method requires the supplementary soil improvement works. Then, the construction cost of conveyance sewer deeper than 6m, Pipe Jacking Method is more economical than Trench Method. Consequently, Trench Method is applied to excavation depth of 5 m or less than 5 m and Pipe Jacking Method is applied to excavation depth more than 5 m for conveyance sewer construction.
- 2,084 m length of new road with a width of 7 m is constructed along the conveyance route. The road is also used for maintenance works of the conveyance sewer.
- Pressurized pipe is installed on the ground with thin soil cover.

Construction Cost

Total construction costs of 4 options are estimated as shown in Table 9.1 and are summarized as table below.

Total Construction Cost

(Unit : Billion VND)

Option	1	2	3	4
Phase I	449	348	298	238
Phase II	167	383	288	264
Total	616	731	586	502
Priority	3	4	2	1

Regarding the construction cost for the Phase I, **Option 4** of 238 billion VND is the lowest one, which is 60 billion VND lower than one of **Option 3**.

And for the whole project, **Option 4** is also the most economical scheme among 4 options, which is 84 billion VND lower than that of the second priority scheme of **Option 3**.

O/M Cost

Annual O/M costs of 4 options are estimated as shown below based on the electricity consumption at intermediate and inflow pumping stations.
Annual O/M cost of **Option 3** is the highest and estimated at 9,948 million VND/year for Phase I and 30,794 million VND/year for Phase II, respectively.

Annual O/M costs of **Option 1** and **2** are same. And there is a no significant difference among annual O/M costs of **Option 1**, **2** and **4** because the total required pump head of three options are close.

Annual O/M cost of **Option 3** is about 2.6 times of one of **Option 4** at Phase I and 1.6 times at Phase II.

Annual O/M Cost

(Unit : Million VND)

Option	1	2	3	4
Phase I	4,320	4,320	9,948	3,888
Phase II	19,543	19,543	30,794	19,111

9.4.3 Comparison of Options

Advantages and disadvantages of each option are summarized as follows.

Option 1

(Advantage)

- Land acquisition for pipe installation is not necessary.

- Impact to the surroundings is minimized because Pipe Jacking Method is used and all construction is done at Phase I.

(Disadvantage)

- The initial investment cost is the highest.
- Should be applied a lager slope of 1.0 ‰ to maintain a minimum velocity of 0.7 m/s in case of wastewater discharge of 192,000 m^3/day (2.22 m^3/s) in Phase I.
- Soil Improvement Work is necessary for the whole stretch of the conveyance sewer installation by Trench Method.
- A length of about 1,957 m of Vertical Drain Work in Zone **B** is necessary.

Option 2

(Advantage)

- The invert level at the inflow pumping station is about 70 cm shallower than that of **Option 1**. Because 1,500 mm diameter pipe is installed with a larger slope of 1.2 ‰ but the diameter is 1 m smaller and 2,300 mm diameter pipe is installed with a smaller slope of 0.8 ‰.
- About 800 m length of the conveyance sewer in Zone **A** and **B** can be installed without Soil Improvement Work (refer to Fig. 9.4 (2)).

(Disadvantage)

- The total construction cost is the highest.
- A length of about 1,957 m of Vertical Drain Work in Zone **B** is necessary.

Option 3

(Advantage)

- The initial investment cost is the 2nd lowest.
- Inflow pumping station at wastewater treatment plant is not necessary.
- Soil Improvement Work and Vertical Drain Method are not necessary to settle the ground.

(Disadvantage)

- There is few experience of pressurized pipe for wastewater.
- Practical information on O/M is not available.
- Annual electricity consumption is the highest among other options.
- Pipe is recommended to be made of cast iron. The pipe must be imported.
- Land is required to install the pipes (not under a road)
- The width of area is estimated at about 11 m.
- Special equipment such as Surge Tank or Air Chamber is required to reduce water hammer.
- Operation and maintenance works are more complicated and frequent than gravity system.

Option 4

(Advantage)

- Construction cost of the inflow pumping station is the lowest.
- The initial investment and the total construction costs are the lowest.

- Elevation of inflow pumping station is about 3 m shallower than **Option 1** and **2** because the slope of the culvert is gentler and the height of sewer is smaller.

Soil improvement to excavate by trench method is not necessary because installation depth is shallower than the limit of the stable depth of the trench.

(Disadvantage)

- Land is required to construct the culvert (not under a road)
- The width of area is estimated at about 7.5 m.
- 2 places of Siphon with a total length of 131 m are required for river crossing.
- A length of about 1,957 m of Vertical Drain Work in Zone **B** is necessary.

9.5 Conclusion

As discussed above, **Option 4** is recommended as the optimum conveyance system. The technical and economical reasons are listed below.

<u>Technical Reasons</u>

1) Conventional gravity system
2) Trench Method can be applied for construction.
3) Maintenance work is easy because installation depth ranges from EL-1.2 m to EL-3.5 m.

<u>Economical Reasons</u>

1) Initial Investment cost is the lowest.
2) Annual O/M cost is the lowest.
3) Total project cost is the lowest.

Table 9.1 Construction Cost of Option 1 to 4

(Unit : Million VND)

Option			Unit Price	Quantity	1	2	3	4
1st Phase	Intermediate PS	Civil Work	-	-	66,694	35,799	44,475	35,799
		M/E Work	-	-	105,737	105,737	168,257	105,737
		Sub Total			172,431	141,536	212,732	141,536
	Conveyance Sewer	Trench	-	1,113 m	38,219	35,555	-	-
		Pipe Jacking	-	1,957 m	151,563	91,975	-	-
		Pressurized Pipe	9.42 MVND/m	3,070 m	-	-	57,839	-
		Road	5.761 MVND/m	1,953 m	11,250	11,250	11,250	11,250
		Bridge	121 MVND/m	131 m	15,911	15,911	15,911	15,911
		Culvert	8.83 MVND/m	2,939 m	-	-	-	25,955
		Siphone	13.03 MVND/m	131 m	-	-	-	1,707
		Vertical Drain	0.0553 MVND/m	- m	9,597	9,597	-	6,538
		Land Acquisition	38,600 VND/m2	- m^2	-	-	613	352
		Sub Total			226,540	164,288	85,613	61,713
	Inflow PS	Civil Work			14,977	7,510	-	3,366
		M/E Work			34,700	34,700	-	31,230
		Sub Total			49,677	42,210	0	34,596
	Total of 1st Phase				448,648	348,034	298,345	237,846
2nd Phase	Intermediate PS	Civil Work			-	30,895	40,081	33,812
		M/E Work			129,777	129,777	122,060	129,777
		Sub Total			129,777	160,672	162,140	163,589
	Conveyance Sewer	Trench	-	1,113 m	-	38,495	-	-
		Pipe Jacking	-	1,957 m	-	139,645	-	-
		Pressurized Pipe	20.40 MVND/m	6,140 m	-	-	125,256	-
		Culvert	16.54 MVND/m	2,939 m	-	-	-	48,607
		Siphone	13.73 MVND/m	131 m	-	-	-	1,799
		Vertical Drain	0.0553 MVND/m	- m	-	-	-	9,280
		Land Acquisition	38,600 VND/m2	- m^2	-	-	613	499
		Sub Total			0	178,140	125,869	60,185
	Inflow PS	Civil Work	-	-	-	7,467	-	6,293
		M/E	-	-	37,200	37,200	-	33,480
		Sub Total			37,200	44,667	0	39,773
	Total of 2nd Phase				166,977	383,479	288,009	263,547
Grand Total					615,625	731,513	586,354	501,393

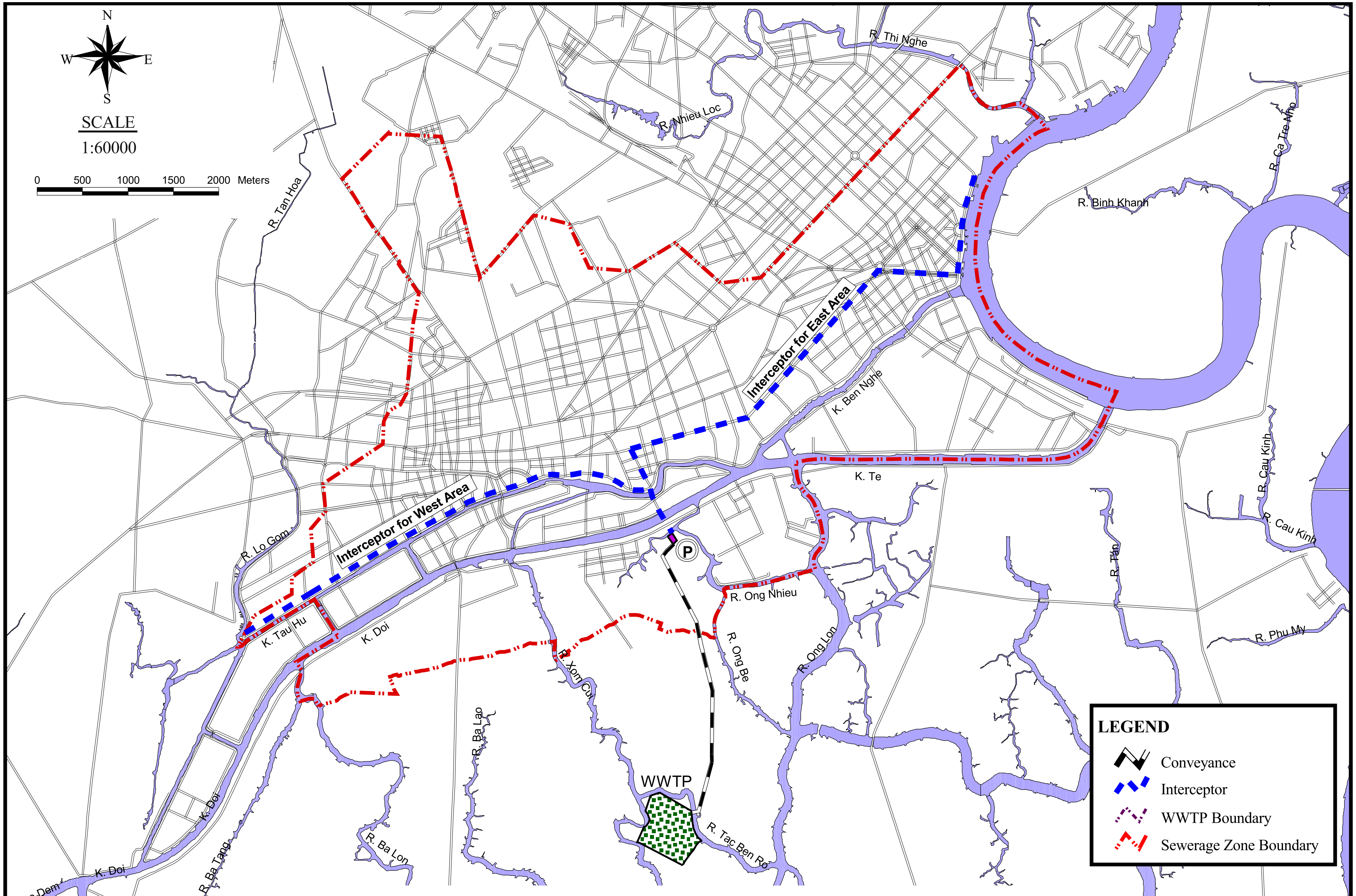


FIG. 9.1 PROPOSED ROUTE OF CONVEYANCE SEWER

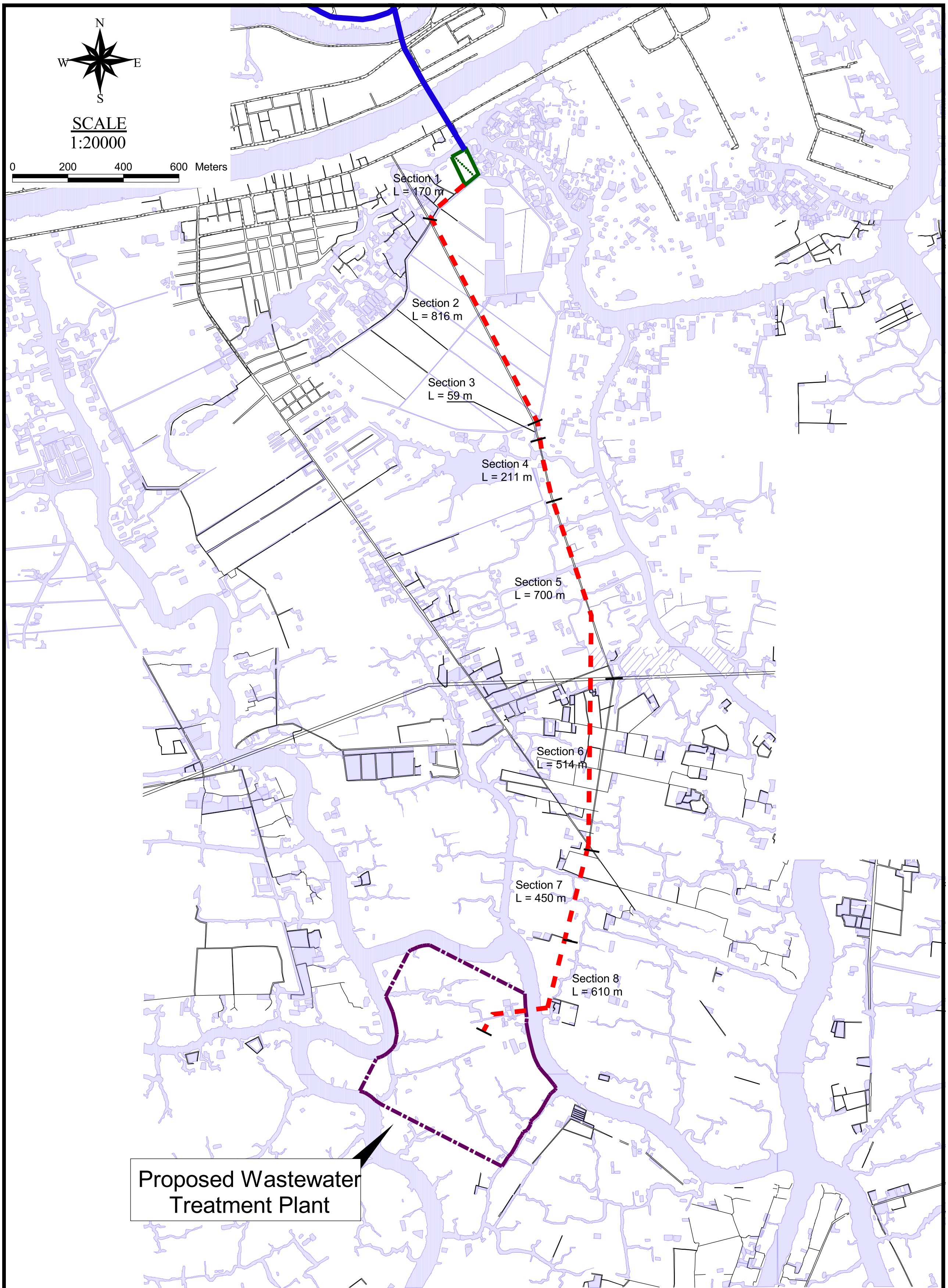
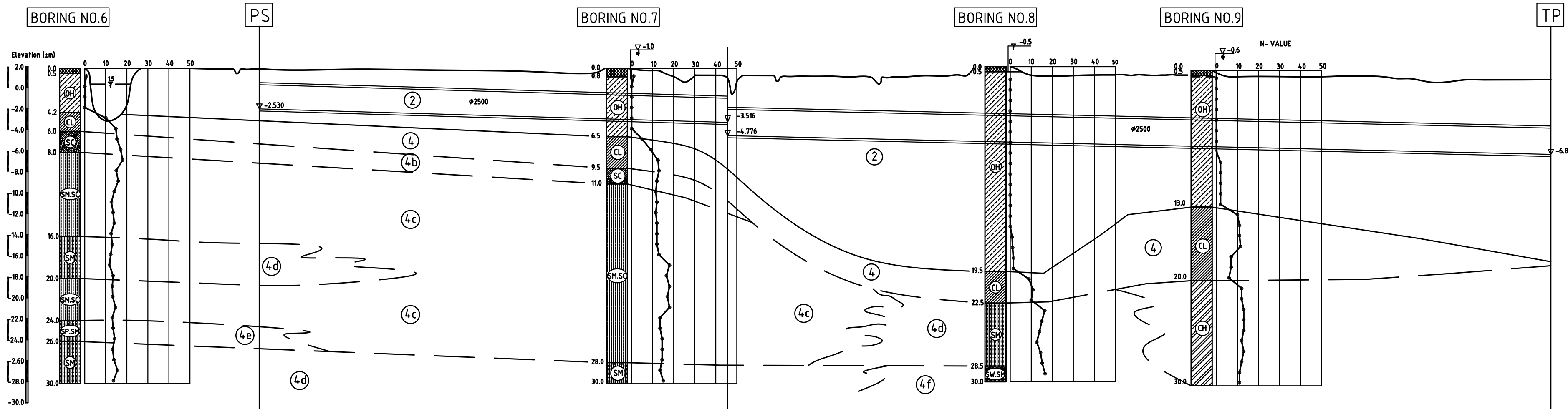


FIG. 9.2 PROPOSED CONVEYANCE SEWER ROUTE



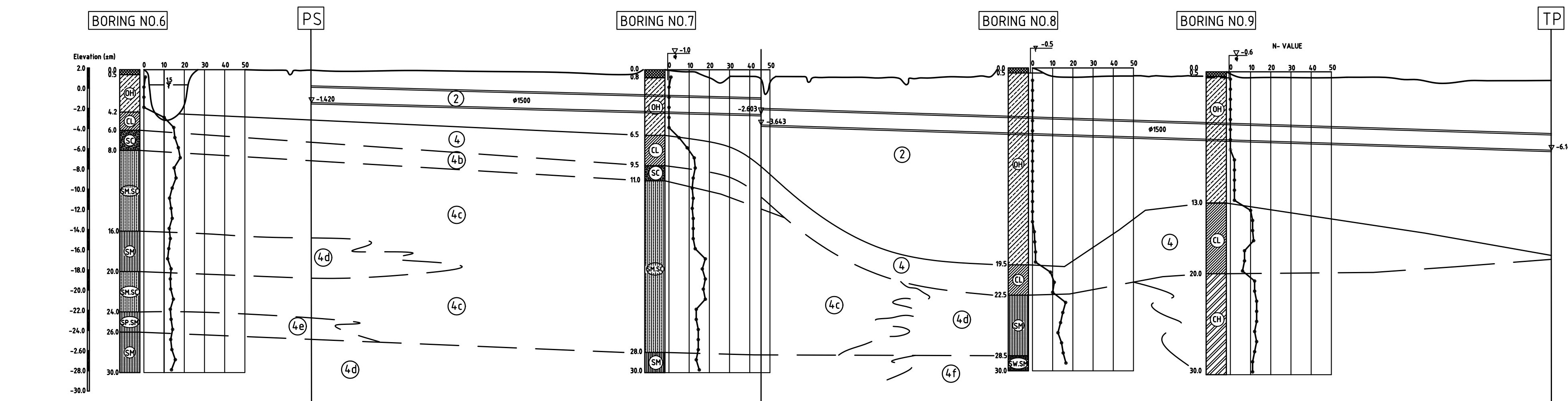
ELEVATION (m)	1.83	2.00		1.82					2.00		1.62	2.00
DISTANCE BETWEEN BORING(m)	1300				900				490		1443	
SECTION NO. (LENGTH)		1 (170m)	2 (816m)		3(59m)	4 (211m)		5 (700m)		6 (514m)		7 (600m)
SOIL CONDITION CLASSIFICATION		ZONE A					ZONE B					
SOIL IMPROVEMENT AREA (m)		3070m										
SEWER LENGTH (m)	450	1113					1957					
EXCAVATION DEPTH (m)		5.03				5.84	7.10					9.36
CONSTRUCTION METHOD		TRENCH					PIPE JACKING					

SCALE : Vertical : 1/600 - Horizontal : 1/15000

LEGEND

- 1 GROUND
- 2 (OH) ORGANIC CLAY
- 3 (CL) SANDY CLAY
- 3a (SC) CLAYEY SAND
- 4 (CL) CLAY with SAND
- 4a (CH) SANDY CLAY
- 4b (SC) CLAYEY SAND
- 4c (SM.SC) SILTY, CLAYEY SAND
- 4d (SM) SILTY SAND
- 4e (SP.SM)SAND with SILT
- 4f (SW.SM) SAND with SILT

FIG. 9.3 (1) SOIL CONDITION AND LONGITUDINAL PROFILE OF CONVEYANCE SEWER (OPTION 1)



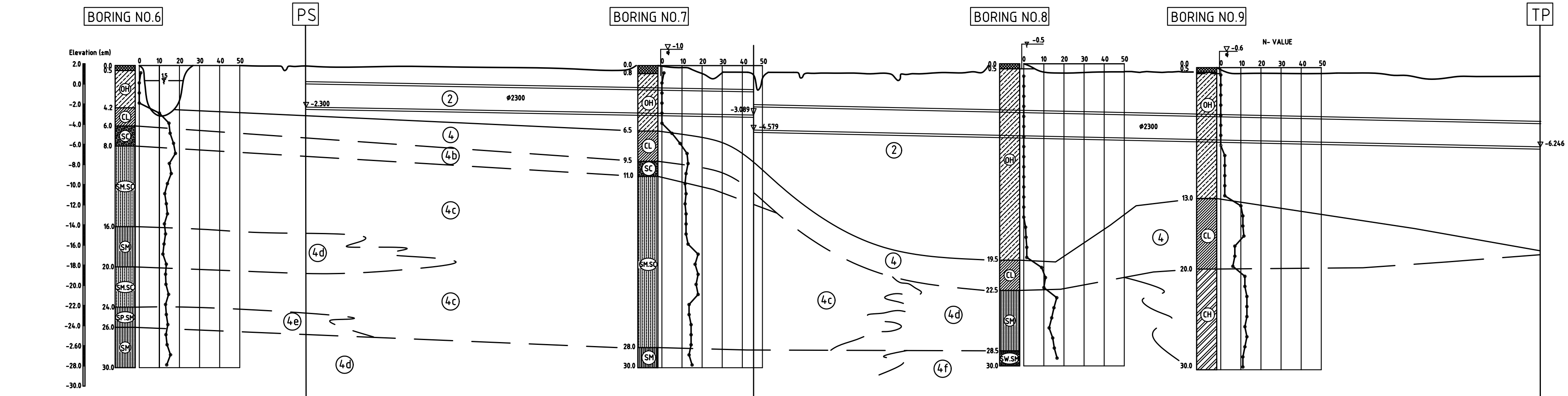
ELEVATION (m)	1.83	2.00		1.82	2.00	1.62	2.00
DISTANCE BETWEEN BORING (m)		1300		900		490	1443
SECTION NO. (LENGTH)		1 (170m)	2 (816m) / 3(59m)	4 (211m)	5 (700m)	6 (514m)	7 (600m)
SOIL CONDITION CLASSIFICATION		ZONE A		ZONE B			
SOIL IMPROVEMENT AREA (m)		NO NEED (500m)	613m	NO NEED (300m)	1657m		
SEWER LENGTH (m)	450	1113		1957			
EXCAVATION DEPTH (m)		3.84	4.82	5.883			8.56
CONSTRUCTION METHOD		TRENCH		PIPE JACKING			

SCALE : Vertical : 1/600 - Horizontal : 1/15000

LEGEND

- 1 GROUND
- 2 (OH) ORGANIC CLAY
- 3 (CL) SANDY CLAY
- 3a (SC) CLAYEY SAND
- 4 (CL) CLAY with SAND
- 4a (CH) SANDY CLAY
- 4b (SC) CLAYEY SAND
- 4c (SM.SC) SILTY, CLAYEY SAND
- 4d (SM) SILTY SAND
- 4e (SP.SM)SAND with SILT
- 4f (SW.SM) SAND with SILT

FIG. 9.3 (2) SOIL CONDITION AND LONGITUDINAL PROFILE OF CONVEYANCE SEWER
(OPTION 2 - 1st PHASE)



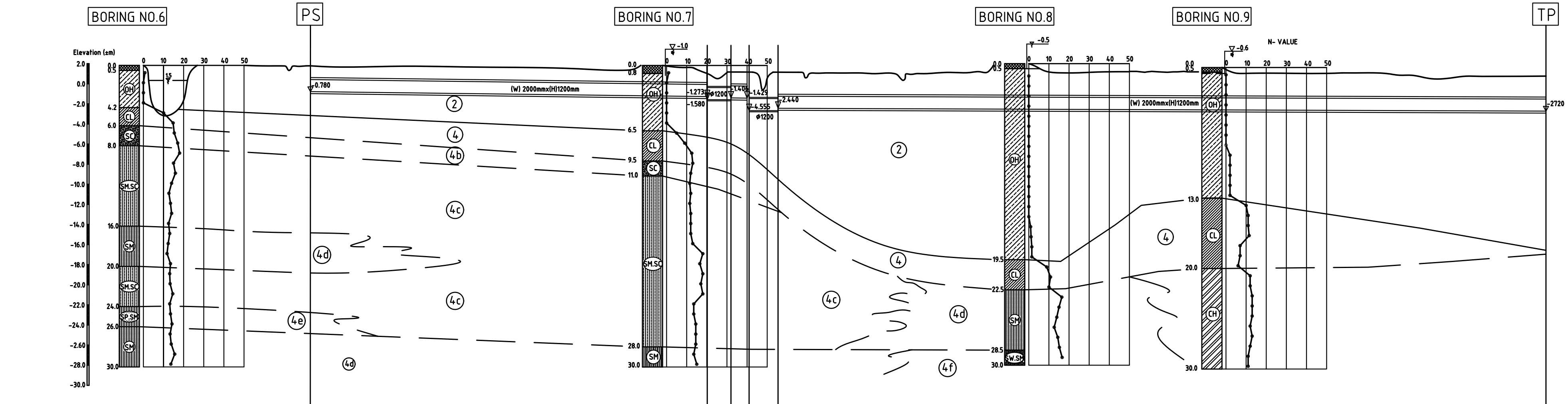
ELEVATION (m)	1.83	2.00	1.82	2.00	1.62	2.00	
DISTANCE BETWEEN BORING (m)	1300		900		490	1443	
SECTION NO. (LENGTH)	1 (170m)	2 (816m)	3(59m)	4 (211m)	5 (700m)	6 (514m)	7 (600m)
SOIL CONDITION CLASSIFICATION	ZONE A			ZONE B			
SOIL IMPROVEMENT AREA (m)	3070m						
SEWER LENGTH (m)	450	1113		1957			
EXCAVATION DEPTH (m)	4.80	5.41		6.80		8.75	
CONSTRUCTION METHOD	TRENCH			PIPE JACKING			

SCALE : Vertical : 1/600 - Horizontal : 1/15000

LEGEND

- 1 GROUND
- 2 (OH) ORGANIC CLAY
- 3 (CL) SANDY CLAY
- 3a (SC) CLAYEY SAND
- 4 (CL) CLAY with SAND
- 4a (CH) SANDY CLAY
- 4b (SC) CLAYEY SAND
- 4c (SM.SC) SILTY, CLAYEY SAND
- 4d (SM) SILTY SAND
- 4e (SP.SM)SAND with SILT
- 4f (SW.SM) SAND with SILT

FIG. 9.3 (3) SOIL CONDITION AND LONGITUDINAL PROFILE OF CONVEYANCE SEWER
(OPTION 2 - 2nd PHASE)



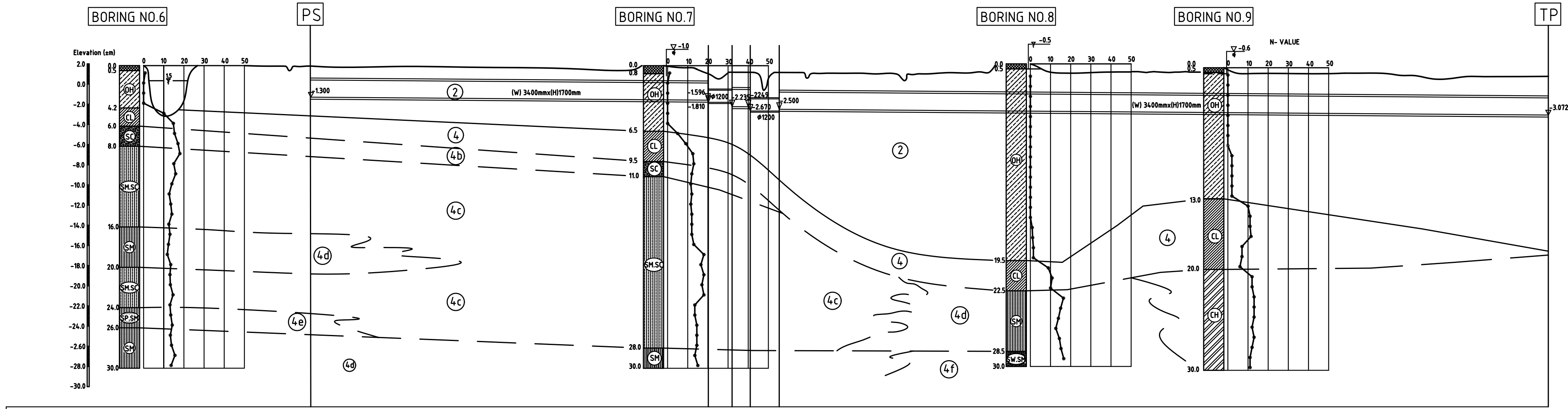
ELEVATION (m)	1.83	2.00	1.82			2.00	1.62	2.00
DISTANCE BETWEEN BORING (m)	1300		900				490	1443
SECTION NO. (LENGTH)	1 (170m)	2 (816m)	3(59m)	4 (211m)	5 (700m)		6 (514m)	7 (600m)
SOIL CONDITION CLASSIFICATION	ZONE A				ZONE B			
SOIL IMPROVEMENT AREA (m)	NO NEED (3070m)							
SEWER LENGTH (m)	450	986	59	45	72	1908		
EXCAVATION DEPTH (m)	3.18							5.32
CONSTRUCTION METHOD	TRENCH							

SCALE : Vertical : 1/600 - Horizontal : 1/15000

LEGEND

- 1 GROUND
- 2 (OH) ORGANIC CLAY
- 3 (CL) SANDY CLAY
- 3a (SC) CLAYEY SAND
- 4 (CL) CLAY with SAND
- 4a (CH) SANDY CLAY
- 4b (SC) CLAYEY SAND
- 4c (SM.SC) SILTY, CLAYEY SAND
- 4d (SM) SILTY SAND
- 4e (SP.SM)SAND with SILT
- 4f (SW.SM) SAND with SILT

FIG. 9.3 (4) SOIL CONDITION AND LONGITUDINAL PROFILE OF CONVEYANCE SEWER
(OPTION 4 - 1st PHASE)



ELEVATION (m)	1.83	2.00	1.82			2.00	1.62	2.00	
DISTANCE BETWEEN BORING (m)	1300		900			490	1443		
SECTION NO. (LENGTH)	1 (170m)	2 (816m)	3(59m)	4 (211m)	5 (700m)	6 (514m)	7 (600m)		
SOIL CONDITION CLASSIFICATION	ZONE A	ZONE B							
SOIL IMPROVEMENT AREA (m)	NO NEED (3070m)								
SEWER LENGTH (m)	450	986	59	45	72	1908			
EXCAVATION DEPTH (m)	3.90	5.67							
CONSTRUCTION METHOD	TRENCH								

SCALE : Vertical : 1/600 - Horizontal : 1/15000

LEGEND

- 1 GROUND
- 2 (OH) ORGANIC CLAY
- 3 (CL) SANDY CLAY
- 3a (SC) CLAYEY SAND
- 4 (CL) CLAY with SAND
- 4a (CH) SANDY CLAY
- 4b (SC) CLAYEY SAND
- 4c (SM.SC) SILTY, CLAYEY SAND
- 4d (SM) SILTY SAND
- 4e (SP.SM)SAND with SILT
- 4f (SW.SM) SAND with SILT

FIG. 9.3(5) SOIL CONDITION AND LONGITUDINAL PROFILE OF CONVEYANCE SEWER
(OPTION 4 - 2nd PHASE)

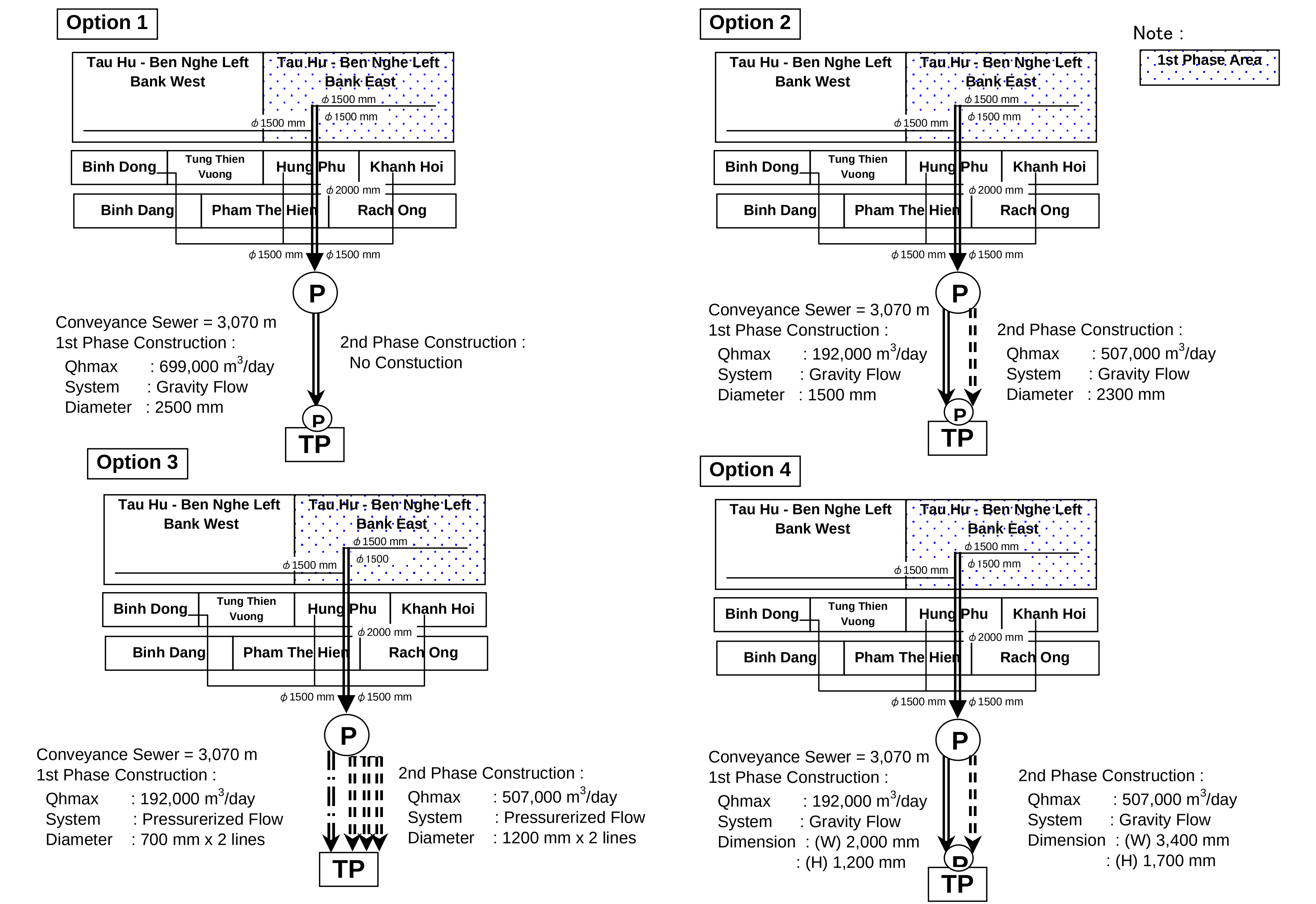
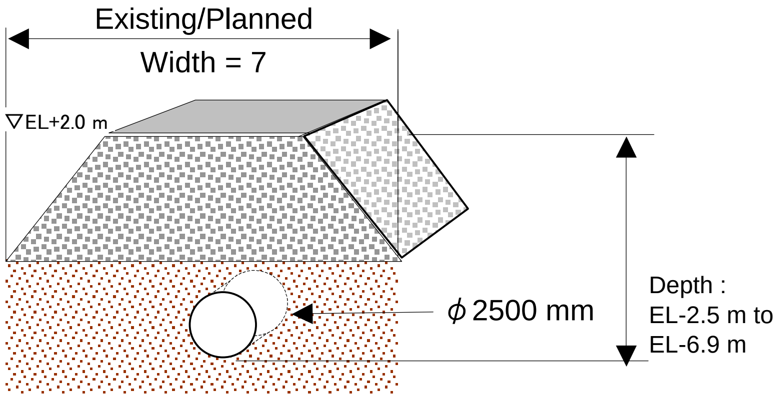
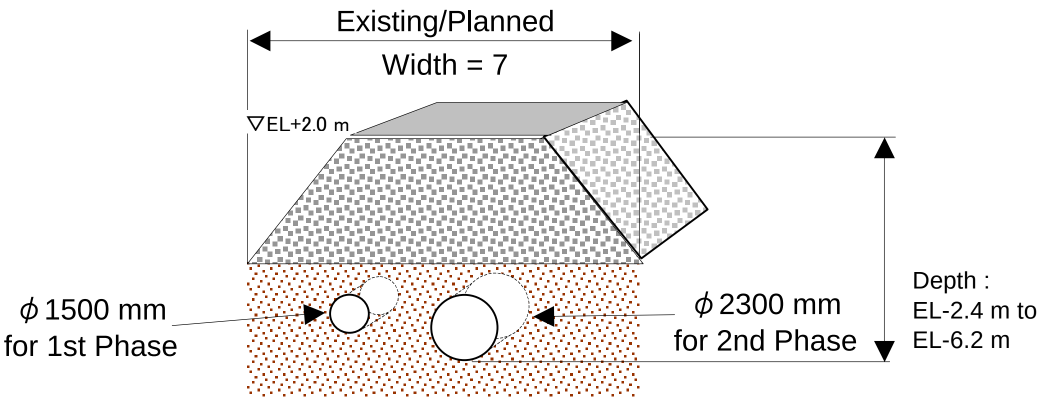


Fig. 9.4 Outline of 4 Options

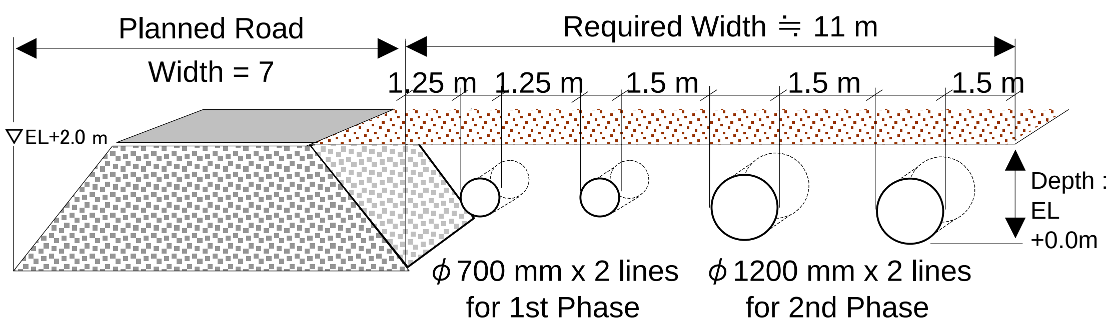
OPTION 1 - 1 Line of Pipe



OPTION 2 - 2 Lines of Pipe



OPTION 3 - Pressurized Pipe Lines



OPTION 4 - CULVERT

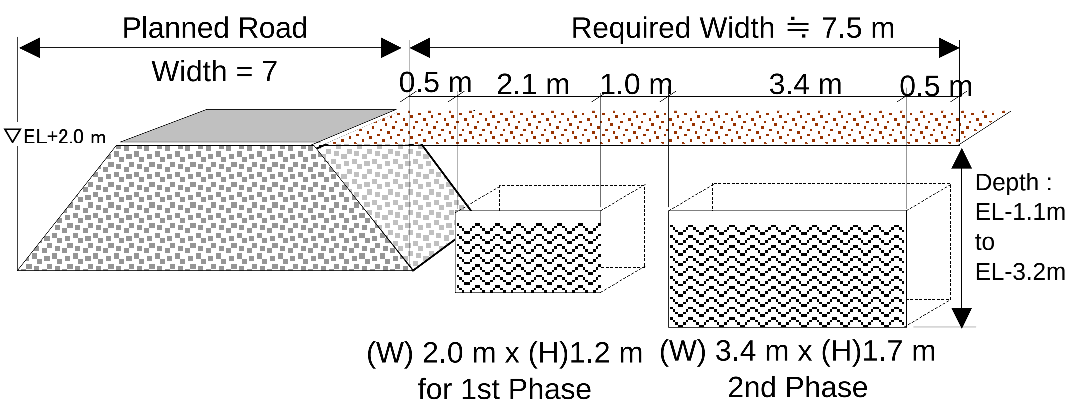


Fig. 9.5 Layout of Sewer Installation

Chapter 10

WASTEWATER TREATMENT PLANT

CHAPTER 10 WASTEWATER TREATMENT PLANT

10.1 Location of Wastewater Treatment Plant Site

10.1.1 Background

PCHCMC and JICA Study Team proposed the THBNDT wastewater treatment plant site at the area enclosed by the Cay Kho Canal and the Go Noi Canal in Phuoc Loc Ward of Nha Be District in the feasibility study. However, the site is located at a distance of about 5.4 km from the sewerage service area. In consequence, a conveyance sewer which transmits the wastewater to the wastewater treatment plant could be longer and it raises the project cost.

JICA mission for the detailed design study requested PCHCMC to reconsider a closer site in order to save the project cost and prepare a more realistic plan.

In response to the request of JICA mission, JICA Study Team for the Detailed Design Study on Ho Chi Minh City Water Environment Improvement Project and PMU conducted the comparative study on wastewater treatment plant site in the definitive plan stage.

10.1.2 Preliminary Comparative Study of Wastewater Treatment Plant Sites

(1) Potential Sites for Wastewater Treatment Plant

PMU studied potential sites more carefully based on the technical aspects and the existing and future land use master plan of Ho Chi Minh City prepared by UPI. Finally, PMU selected 3 potential sites in addition to the wastewater treatment plant site proposed in the F/S.

The following 4 locations are considered as potential sites for the comparative study.

Outline of 4 Potential Sites for Wastewater Treatment Plant

Alternative	*District*	*Ward*	*Location*	*Land Use*	*Remarks*
I	Nha Be	Phuoc Loc	Enclosed by the Cay Kho Canal to the east and the Go Noi Canal to the west and the south	Agricultural	Proposed location in F/S
II	Binh Chanh	Binh Hung	Enclosed by the Ong Lon River to the east and the Tac Ben Ro River to the west	Agricultural	High voltage power supply line is crossing center of the site

II-a	Binh Chanh	Binh Hung	Enclosed by the Tac Ben Ro river to the north and east and the Xom Cui river to the west and	Agricultural	High voltage power supply line is crossing center of the site
III	Binh Chanh	Binh Hung	Along the road of Sai Gon South Development Area	Agricultural (Rice Field)	Located nearby Saigon South Development Area

The location of 4 potential sites are shown in Fig. 10.1.

(2) Outline of Conveyance Sewer

A preliminary design of the conveyance sewer between the intermediate wastewater pumping station and the each potential site of wastewater treatment plant has been done.

Outline of 4 Alternatives for Conveyance Sewer

Alternative	***Diameter (mm)***	***Length (m)***	***Average Excavation Depth (m)***	***Description***
I	2500	1,100	4 to 5	- 2 crossings of river
		4,300	6 to 10	- 5.4 km long
	Total	5,400	-	- Excavation depth ranging from 4 m to 10 m
II	2500	1,100	4 to 5	- 2 crossings of small canal
		2,000	6 to 8	- 3.1 km long
	Total	3,100	-	- Excavation depth ranging from 4 m to 8 m
II-a	2500	1,100	4 to 5	- Crossing of Tac Ben Ro river
		2,430	6 to 8	- 2 crossings of small river
	Total	3,530		- 3.53 km long - Excavation depth ranging from 4 m to 8 m
III	2500	1,100	4 to 5	- No crossing of river/canal
		1,000	6	- 2.1 km long
	Total	2,100	-	- Excavation depth ranging from 4 m to 6 m

(3) Comparison of Construction Cost

The cost estimation of the 4 alternatives for conveyance sewer between the intermediate wastewater pumping station and the wastewater treatment plant has been done under the same conditions of the Feasibility Study.

The construction costs of 4 alternatives are different because of the following reasons;

- Length of conveyance sewer
- Construction method due to installed depth of conveyance sewer
- Pump head of inflow pumping station in the wastewater treatment plant
- Depth of wet well of inflow pumping station

For the cost estimation, the design conditions described below are applied.

- Design wastewater discharge targeting 2020 for conveyance sewer is 699,000 m^3/day (485.4 m^3/min.) as an hourly maximum.
- Design wastewater discharge targeting 2010 for inflow pumping station is 640,000 m^3/day (445.0 m^3/min.) as an hourly maximum.
- Design wastewater discharge targeting 2010 for wastewater treatment plant is 469,000 m^3/day as a daily maximum.
- 2 construction methods are applied to conveyance sewer construction according to the excavation depth
  1) Open Cut Method (excavation depth ≤ 5 m)
  2) Shield Tunneling Methods/Pipe Jacking Method (excavation depth > 5m)
- Pipe Jacking Method is applied to river crossing

Conveyance Sewer

Alternative I needs the highest investment cost for conveyance sewer of 455 billon VND among the 4 alternatives. The conveyance sewer with a length of 4.3 km shall be constructed by Pipe Jacking and Shield Tunneling Methods because the average excavation depth of the conveyance sewer is deeper than 6 m and the soil condition along the route is very weak.

The construction costs of conveyance sewer for Alternatives II, II-a and III are estimated at 189 billion VND, 221billion VND and 115 billion VND, respectively. The construction costs of conveyance sewer for three alternatives of II, II-a and III decrease to less than half of one for Alternative I.

The costs are based on the preliminary design and the construction cost of the JICA feasibility study. The estimated costs are presented in the table below.

Construction Cost of 4 Alternatives for Conveyance Sewer

Alternative	*Diameter (mm)*	*Length (m)*	*Average Excavation Depth (m)*	*Construction Method*	*Construction Cost (Million VND)*
I	2500	1,100	4 to 5	Open Cut	37,773
		2,600	6 to 8	Pipe Jacking	201,361
		1,700	9 to 10	Shield Tunneling	214,452
	Total	**5,400**	**-**	**-**	**454,586**
II	2500	1,100	4 to 5	Open Cut	37,773
		2,000	6 to 8	Pipe Jacking	151,563
	Total	**3,100**	**-**	**-**	**189,336**
II-a	2500	1,100	4 to 5	Open cut	37,773
		2,430	6 to 8	Pipe jacking	184,149
	Total	**3,530**			**221,922**
III	2500	1,100	4 to 5	Open Cut	37,773
		1,000	6	Pipe Jacking	77,447
	Total	**2,100**	**-**	**-**	**115,220**

<u>Wastewater Treatment Plant</u>

As mentioned above, the difference of the construction cost of wastewater treatment plant among the 4 alternatives is raised from the construction cost of inflow pumping station and embankment works, which are necessary to prevent land sliding depending on the location.

Therefore, the construction cost for 4 alternative wastewater treatment plants is compared by the costs of (1) inflow pumping station, (2) embankment work, and (3) wastewater and sludge treatment facilities.

<u>Inflow Pumping Station</u>

The construction costs of inflow pumping station for Alternative I, II, II-a and III are estimated at 94 billion VND, 87 billion VND, 88 billion VND and 83 billion VND, respectively.

The table below itemizes a difference in the costs of civil work and electrical/mechanical work of inflow pumping station. The cost of civil work for Alternative III, which is the lowest option, is estimated at 13 billion VND, or 72 % of one for Alternative I. The cost of electrical/mechanical work for Alternative III is estimated at 70 billion VND, or 93 % of one for Alternative I

Construction Cost of 4 Alternatives for Inflow Pumping Station at WWTP

Alternative	*Diameter (mm)*	*Invert Level of Conveyance Sewer*	*Construction Cost (Million VND)*					
			Civil Work		*Electrical /Mechanical Work*		*Total*	
I	2500	G.L. – 10.5	18,635	100 %	74,895	100 %	93,530	100 %
II	2500	G.L. – 8.2	14,977	80 %	71,900	96 %	86,877	93 %
II-a	2500	G.L. – 8.9	15,600	84%	72,825	97%	88,425	95%
III	2500	G.L. – 6.5	13,462	72 %	69,653	93 %	83,115	89 %

Note : The percentage present a ratio of the cost of each alternative to one of **Alternative I**.

Embankment Work

The construction costs of embankment works for 4 alternatives are estimated as shown in the table below.

Cost of Embankment Work

Alternative	*Required Length (m)*	*Unit Cost (Million VND)*	*Construction Cost (Million VND)*
I	3,100	0.887	2,745
II	1,425		1,263
II-a	2,800		2,484
III	2,600		2,306

Wastewater and Sludge Treatment Facilities

The construction cost of wastewater and sludge treatment facilities is estimated at 3,534 billion VND.

Total Construction Cost

The total construction costs of wastewater treatment plant are estimated as shown in the table below.

Total Construction Cost of Wastewater Treatment Plant (million VND)

Alternative	**Inflow Pumping Station**	**Embankment Work**	**Treatment Facilities**	**Construction Cost**
I	93,530	2,745	3,533,973	3,630,248
II	86,877	1,263		3,622,113
II-a	88,425	2,484		3,624,882
III	83,115	2,306		3,619,394

(4) Comparison of Operation and Maintenance (O/M) Cost

Annual O/M cost of conveyance sewer and inflow pumping station for 4 alternatives are estimated as below:

O/M Cost of 4 Alternatives for Conveyance Sewer and Inflow Pumping Station

Alternative	Conveyance Sewer		Inflow Pumping Station		Total
	Length (m)	Annual O/M (million VND)	Required Power	Annual O/M (million VND)	Annual O/M (million VND)
I	5,400	24	400kw x 4	5,200	5,224
II	3,100	14	330kw x 4	4,200	4,214
II-a	3,530	15	350kw x 4	4,500	4,515
III	2,100	9	280kw x 4	3,600	3,609

(5) Conclusion

Comparison of construction cost of conveyance sewer and wastewater treatment plant for 4 alternatives are estimated as mentioned below:

Construction Cost of 4Alternatives

Alternative	Construction Cost (Million VND)		
	Conveyance Sewer	Wastewater Treatment Plant	Total
I	454,586	3,630,248	4,084,834
II	189,336	3,622,113	3,811,449
II-a	221,922	3,624,882	3,846,804
III	115,220	3,619,394	3,734,614

The evidence from the above table, Alternative III can save the construction cost of 350 billion VND comparing with that of the proposed sewerage system in the feasibility study. And Alternatives II and II-a follow Alternative III.

Annual O/M cost of 1.6 billion VND will be saved by Alternative III comparing with Alternative I, followed by Alternative II with saving of 1.0 billion VND and Alternative II-a with saving of 0.7 billion VND comparing to Alternative I.

While, potential wastewater treatment plant sites of Alternative II and III have the following restrictions;

Alternative II:
This site is enclosed by Tac Ben Ro river to the west and the south and planned road of Chanh Hung to the east. The alignment of planned road of Chanh Hung was already determined. And the high voltage power supply cable exists at the center of the site crossing from east to west. These constrict to design the layout of wastewater treatment plant. Wastewater treatment plant should be divided into four (4) parts of east and west

of Chanh Hung road and north and south of high voltage cable line. It makes the daily operation and maintenance works more difficult and complicated.

Alternative III:
This site is located nearby the future residential area in Saigon South Development Area. Then, the Chief Architect Office of PCHCMC finally did not accept this site for developing the wastewater treatment plant.

After the discussion in Steering Committee Meeting, the third option of **Alternative II-a** was selected and approved by PCHCMC as the optimum location of wastewater treatment plant site for THBNDT Sewerage Development.

10.1.3 Topographic and Soil Conditions of Proposed Wastewater Treatment Plant Site

Proposed wastewater treatment plant site is located in Binh Hung Ward, Binh Chanh district. The area is enclosed by canals and rivers of Tac Ben Ro to the north and the east, Xom Cui to the west and a small canal to the south. The site is about 41 ha with an average ground height of about +0.6 m. The site is occupied by paddy field and fish pond. Some houses are existed in the fringe of the area. High voltage power supply cable is crossing at the center of site from the east to west. The site is divided into two (2) parts of north and south by this high voltage power cable. No access exists to the site except from river.

The soil condition of the site is very weak. Very soft high plasticity organic clay (OH) covers the area with the thickness ranging from 18.5 m to 20.3 m. This OH layer has very small N value of 0 to 2. Stiff low plasticity sandy clay (CL) layer exists under OH layer with the thickness ranging from 0.6 m to 7.3 m. The N value of this CL layer ranges from 13 to 26. The elevation between - 29 and -34.5, medium dense silty sand (SM) layer exists with the thickness of 9 m to 18 m. The N value of this SM layer ranges from 25 to 28. Below SM layer, hard sandy clay (CH) with a N value of more than 45. The thickness of CH layer is more than 11.5 m.

10.2 Planning Concept and Design Criteria

10.2.1 Design Population and Design Wastewater Volume

The project is divided into three (3) phases; target year of Phase I at 2005, Phase II at 2010 and Final Phase at 2020. Design population, design wastewater volume and service area of each phase are summarized below;

	Target Year	Service Area	Population	Unit Wastewater Discharge (l/person/day)	Wastewater Volume (m3/day)	
					Daily Max.	Hourly Max.
Phase I	2005	824.8 ha	425,830	300	141,000	192,000
Phase II	2010	2,791.6 ha	1,421,778	300	469,000	640,000
Final Phase	2020	2,791.6 ha	1,390,282	335	512,000	699,000

In HCMC, fluctuation of water consumption by seasons is not significant. Daily average and daily maximum wastewater discharges are considered the same. Hourly maximum wastewater volume is estimated at 1.4 times as daily maximum wastewater volume including the groundwater infiltration as 10% of daily maximum wastewater volume.

10.2.2 Effluent Quality of Wastewater Treatment Plant (WWTP)

For determination of effluent quality from WWTP, Vietnamese Standard is reviewed. The following is the standard:

<u>Water quality of canal, river and waterway (TCVN 5942 - 1995)</u>
Water supply sources (Upstream of Dong Nai river) : BOD ≤ 4 mg/l., SS≤ 20 mg/l
Other water uses (other river and waterway) : BOD ≤ 25 mg/l., SS ≤ 80 mg/l

<u>Industrial wastewater discharge standard (TCVN 5945 – 1995)</u>
Water supply sources (Upstream of Dong Nai river) : BOD ≤ 20 mg/l., SS ≤ 50 mg/l
Other water uses (other river and canal) : BOD ≤ 50 mg/l.,SS ≤100 mg/l

<u>Urban wastewater discharge standard (TCXD 188 – 1996)</u>
Water supply sources (Upstream of Dong Nai river) : BOD ≤ 20 mg/l., SS ≤ 50 mg/l
Other water uses (other river and canal) : BOD ≤ 50 mg/l.,SS ≤100 mg/l

The Effluent quality should follow the above mentioned industrial wastewater discharge standard (TCVN 5945 – 1995) and urban wastewater discharge standard (TCXD 188-1996). In addition, environmental preservation should be considered for the future. The following effluent quality is proposed for the phases.

- Phase I (year 2001 ~ 2005)
  BOD ≤ 50 mg/l SS ≤ 100 mg/l

- Phase II (year 2006 ~ 2010)
  BOD ≤50 mg/l SS ≤ 100 mg/l

- Final Phase (year 2011 ~ 2020)
  BOD ≤ 20 mg/l SS ≤ 50 mg/l

10.3 Design of Wastewater Treatment Plant

10.3.1 General

Wastewater treatment plant should be designed to meet the different requirements in different phases as shown in the following table.

Phase	Wastewater Volume	Effluent Water Quality
I	141,000 m3/day	BOD= 50mg/l, SS= 100 mg/l
II	469,000 m3/day	BOD = 50 mg/l, SS = 100 mg/l
Final	512,000 m3/day	BOD = 20 mg/l, SS = 50 mg/l

In this report, Basic Design of wastewater treatment plant in the Final Phase and Detailed Design for Phase I were conducted.

10.3.2 Design Ground Elevation

Existing ground elevation is about +0.6 m above mean sea level of Mui Nai. In HCMC, ground elevation of +2.0 m is adopted as the minimum design ground elevation of reclaimed land in swampy area. The design ground elevation of wastewater treatment plant of +2.2 m is determined based on this minimum design ground elevation and allowance of 20 cm for land subsidence. The land subsidence is assumed at 1 cm per annum. All proposed facilities of wastewater treatment plant are supported by concrete piles to prevent imbalanced subsidence. While, roads in treatment plant will be required maintenance works in future.

10.3.3 Basic Design of Wastewater Treatment Plant for Final Phase

(1) Treatment System

Selection of Treatment System

In F/S stage, the following five (5) treatment systems were compared and examined.

1) Stabilization Pond System
2) Aerated Lagoon System
3) Oxidation Ditch System
4) Conventional Activated Sludge System
5) Rotating Biological Contractor System

1), 2) and 3) are suitable for low loading process. The processes have advantage for ease of operation and maintenance. However, a large space is required.
On the other hand, 4) and 5) are suitable for high loading process. Operation and maintenance is not easy as the others. However, the process has been already well

developed. In addition, area of WWTP can be reduced.

The process should be selected by ease of maintenance, land space, and cost for both construction and running. From these point of view, 3) or 4) is appropriate. WWTP site is not enough space for 3). Therefore, 4) Conventional Activated Sludge System is selected as well as F/S.

Proposed sludge treatment system consists of (i) Thickening process, (ii) Storage tank, (iii) Dewatering process and (iv) Composting process. Composted sludge is disposed at landfill site.

Flow and mass balance of wastewater and sludge treatment process are shown in Fig. 10.2 and 10.3 respectively.

(2) Design Standards

Design standard is used “Conventional Activated Sludge Process Design Guideline” published by Japan Sewage Works Agency (JS) and “Sewer Facility Design Guideline and Explanation” published by Japan Sewage Works Association (JA).

The design standards for conventional activated sludge (AS) system for Final Phase are reviewed and proposed as followings:

Design Standards for Conventional Activated Sludge

Primary Sedimentation Tank

Item	Standards	Reference
Surface loading (m3/m2/d)	50	JS
Effective water depth (m)	3.0	JS
Effluent weir loading (m3/m/d)	250	JS

Aeration Tank

Item	Standards	Reference
HRT (hr)	6.0	JA
MLSS (mg/l)	1,500 ~ 2,000	JS
Return sludge ratio (%)	50 ~ 100[*1]	JS
Effective water depth (m)	5.5	JS
Concentration of return sludge (mg/l)	3,000 ~ 6,000	JS
BOD-SS Loading (kg-BOD/SS-kg/day)	0.2 – 0.4	JS

Final Sedimentation Tank

Item	Standards	Reference
Surface loading (m3/m2/d)	25	JS
Effective water depth (m)	3.5	JS
Effluent weir loading (m3/m/d)	120	JS
Capacity of Sludge Hopper	Q max. 30 min	JS

Disinfection Tank

Item	Standards	Reference
HRT (min)	> 15	JS

(3) Design Influent Quality and Removal Efficiency of WWTP

Influent wastewater quality of BOD and SS to WWTP is reviewed as shown below.

BOD = 60 g/person/d * 1,390,282 person ÷ 512,000 m^3/d
= 163 mg/l
SS = 60 g/person/d * 1,390,282 person ÷ 512,000 m^3/d
= 163 mg/l

Design water quality of treatment plant is determined from design influent wastewater quality and wringed water quality from sludge treatment plant. Wringed water quality from sludge treatment plant of BOD and SS are assumed at 20% and 30% of influent water quality respectively.

Design water quality of treatment plant are as follows:

BOD = 163 mg/l x 120 % = 195.6 mg/l say 200 mg/l
SS = 163 mg/l x 130 % = 211.9 mg/l say 210 mg/l

The removal efficiency at each facility in WWTP is designed to achieve effluent water quality as follows:

(WWTP Designed Removal Efficiency)

Item	Design (mg/l)		Removal Efficiency (%)		
	Influent	Effluent	PST*1	AT + FST*2	Total
BOD	200	20	40	83.3	90.0
SS	210	30	50	71.4	85.7

*1: primary sedimentation tank
*2: aeration tank + final sedimentation tank

Effluent water quality of SS is required 50 mg/l by Vietnamese effluent water quality standards of TCVN5945-1995 and TCXD188-1996. While the conventional activated sludge process can remove SS of at least 85% under the normal operation condition. Then the design removal efficiency of SS is estimated based on the design effluent water quality of SS at 30 mg/l. The capacity of treatment facility is designed under this condition.

(4) Number of Train for Treatment Process

Proposed WWTP is to treat a large capacity of wastewater. It should be designed several trains. Each train has primary sedimentation tanks (PST), aeration tanks (AT), and final sedimentation tanks (FST). Wastewater is separated at the distribution tank and delivered to each train by open channel.

A number of trains are determined by the least cost for the extension from Phase I to Final Phase in 2020. When a number of trains increase, a number of tanks, pumps and measurement equipment also increase. In general, construction cost including mechanical facilities increases when a number of trains increase.

For maintenance reason, a number of trains are required more than 2. If possible, desirable number of 2, 4, 8, or 16 so on should be selected because of many advantages for operation and maintenance. With this consideration, 8 trains are proposed.

Each train has 10 PSTs, ATs, and FSTs. Each PST and FST separates 2 waterways. The characteristic of PST, AT, and FST are summarized below.

- Number of train: 8
- Number of tanks in each train
  PST: 10 tanks (Each tank is separated into 2 waterway.)
  AT: 10 tanks
  FST: 10 tanks (Each tank is separated into 2 waterway.)
- Capacity of 8 trains, Q_{max} : 512,000 m3/d (in 2020)
- Capacity of each train: 64,000 m3/d (in 2020)

For sludge treatment process is design under the following conditions;

Sludge density

- Raw sludge: 2.0 %
- Excess sludge: 0.6%
- Density of return sludge: 3,000 – 6,000 mg/l
- Combined sludge: 1.0%
- Gravity thickened sludge: 2.5% (combined sludge)
- : 3.0% (raw sludge)

- Centrifugal thickened sludge: 4.0%
- Centrifugal dewatered sludge: 20%
- Composted sludge: 30-40% (without dosing of chaff)
- : 40-50% (with dosing of chaff)

Solid capture ratio

- Gravity thickened sludge: 80 – 90%
- Centrifugal thickened sludge: 85 – 95%
- Centrifugal dewatered sludge: 90 – 95%

Sludge generation rate: 100%

(5) Basic Design

Primary sedimentation tank is designed as follows;
5.0 m ^{w} x 13.0 m ^{l} x 3.0 m ^{h} x 80 tanks (160 waterways)
Surface loading: 512,000 m^3/day / (5.0 m x 13.0 m x 160) = 49.2 m^3/m^2/day

Aeration tank is as follows;
10.5 m ^{w} x 28.0 m ^{l} x 5.5 m ^{h} x 80 tanks
HRT (hr) = (10.5 x 28.0 x 5.5 x 80) / 512,000 m^3/day x 24 = 6.06 hrs

Final sedimentation tank;
5.0 m ^{w} x 26.0 m ^{l} x 3.5 m ^{h} x 80 tanks (160 waterways)
Surface loading : 512,000 m^3/day / (5.0 x 21.0 x 160) = 24.6 m^3/m^2/day

Disinfection tank;
5.0 m ^{w} x 54.0 m ^{l} x 5.0 m ^{h} x 4 waterways
HRT: (5.0 x 54.0 x 5.0 x 4) / 512,000 x 24 x 60 = 15.2 min.

Gravity thickener;

The characteristic of gravity thickening is described:

number of tanks:	4
diameter:	14 m
height:	3.5 m

The number of tanks is determined that one tank takes sludge from 2 trains of PST.

JA standard describes 4m high for gravity thickening tank. However, higher temperature such as Ho Chi Minh City causes inappropriate thickening. Longer retention time occurs putrefaction of sludge. With this reason, dimension of tank is not determined by JA standard.

Settling and consolidation of sludge is needed from 3.0 to 3.5 m. Therefore, height for gravity thickening is designed as 3.5 m instead of 4m.

Centrifugal Thickener

number of units: 6 (includes 2 stand-by)
capacity: 70 m^3/hr.

As well as gravity thickener, one centrifugal thickener is designed to take sludge from 2 trains of FST. In addition, the operation is continuous.

Centrifugal Dewatering

number of units: 6 (includes 2 stand-by)
capacity: 30 m^3/hr.

Equipment of dewatering is compared belt filter press and centrifugation. Both has advantages and disadvantages. For this study, centrifugation is proposed. The reason is less problem of order, ease of maintenance, and less total cost of initial and running.
A number of sludge dewatering equipment is designed as well as centrifugal thickeners. Therefore, six sludge dewatering are proposed.

Composting Plant;

Composting facility consists of (1) Fermentation vessel, (2) Curing yard, (3) Storage vessel and (4) Deodorizing filter. Treatment capacity of composting plant is 92.145 ton /day of sludge (461 m3/day with sludge density of 20%).

(6) Hydraulic Profile of Wastewater Treatment Plant

Water level of whole system is indicated in Fig. 10.4.

(7) Layout of Wastewater Treatment Plant

For designing the layout of the wastewater treatment plant, the proposed site the following restrictions.

1) There is a high voltage power line crossing over the middle of the WWTP site. So, the site is divided into 2 parts of the north and the south. It is necessary to be set up 25 m apart both sides from the center of power line.
2) The site is enclosed by Tac Ben Ro river to the north and the east, Xom Cui canal to the west and the small canal to the south.
3) The site is located at the low lying area with the existing ground level of + 0.6

m which is occupied by paddy field and fish ponds.

4) The geological condition of the site is very weak with N value of almost 0.

The layout of treatment plant is determined with the following considerations;

- From the limited space of the site and required space for treatment facilities, wastewater treatment facilities are proposed to construct in the south area and sludge treatment facilities in the north area,
- The facilities are designed to be located inland of the isolated area as much as possible to keep the buffer zone along rivers and canals from environmental aspect and to prevent the landslide occurring,
- Smooth distribution of wastewater and sludge to each facility,
- Efficient operation and maintenance,
- Flexibility of stepwise construction and future expansion,
- Effluent point is determined to down stream of Tac Ben Ro river from its sufficient dilution capacity,
- Easy access to the facilities and hauling the compost and
- Landscape with storm water drainage and lighting, etc.

Proposed layout of treatment plant for Final Phase is shown in Fig. 10.5.

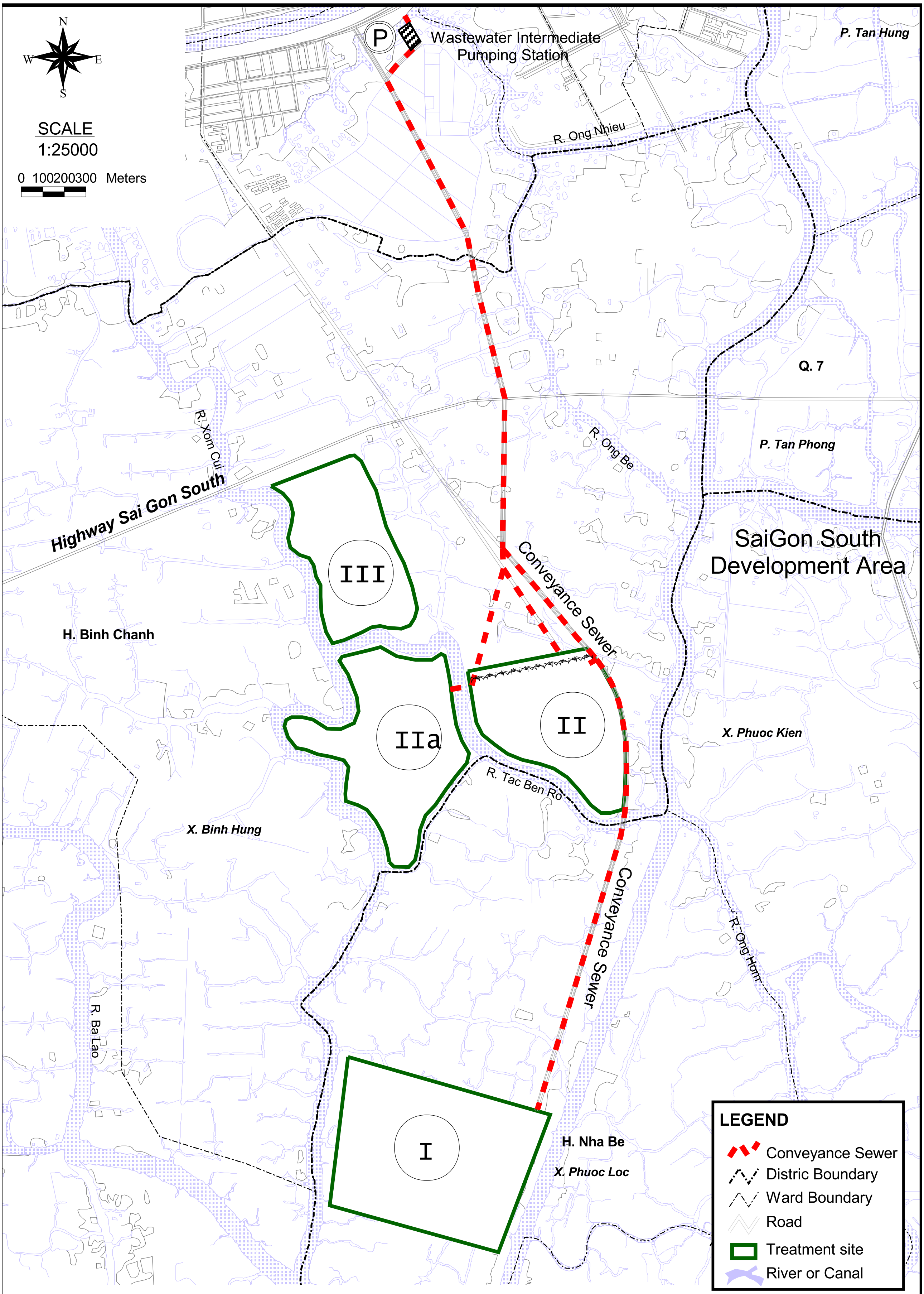


FIG. 10.1 POTENTIAL SITES OF WWTP

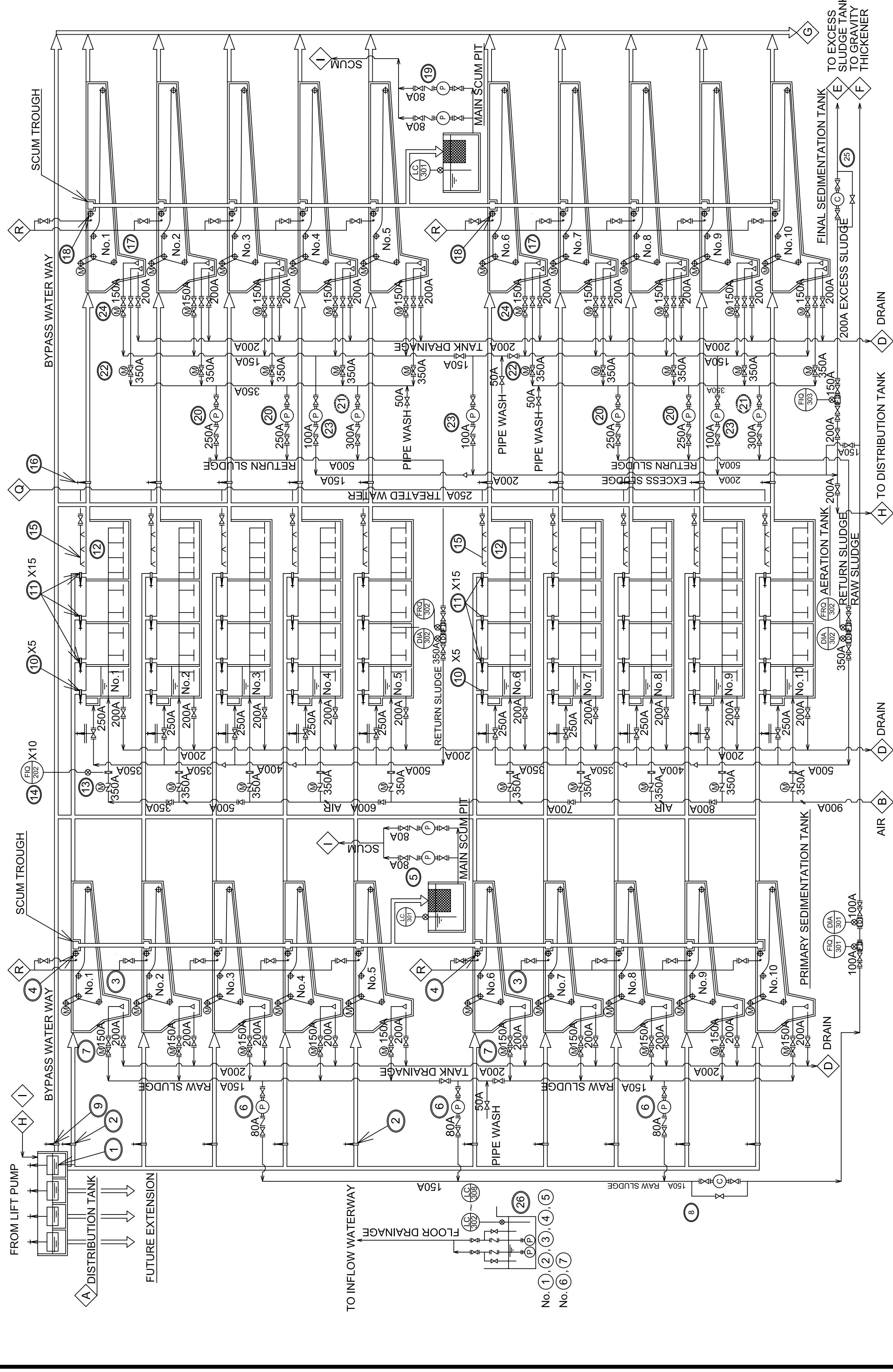


FIG. 10.2 FLOW SHEET OF WATER TREATMENT FACILITY

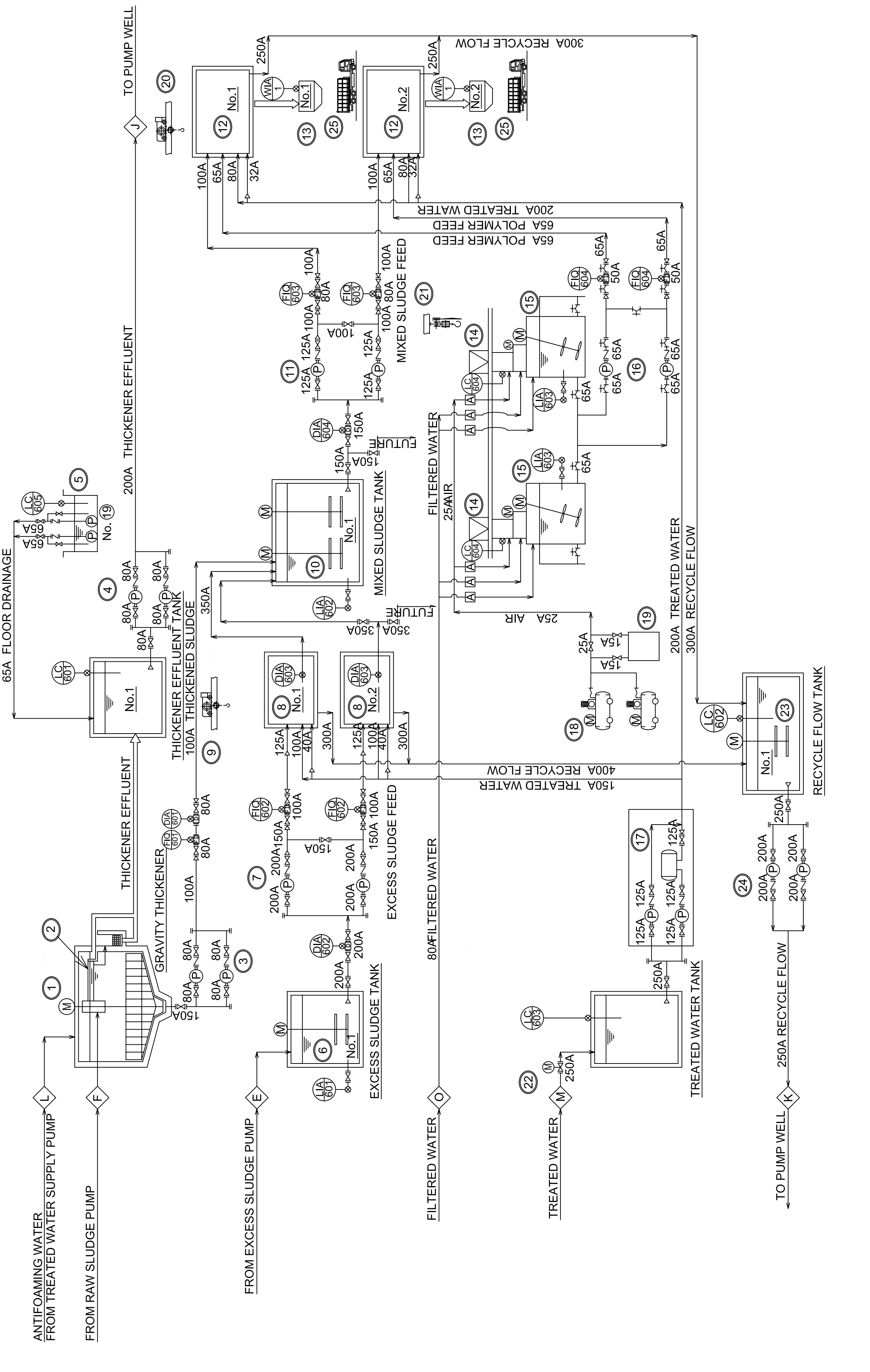


FIG. 10.3 FLOW SHEET OF SLUDGE TREATMENT FACILITY

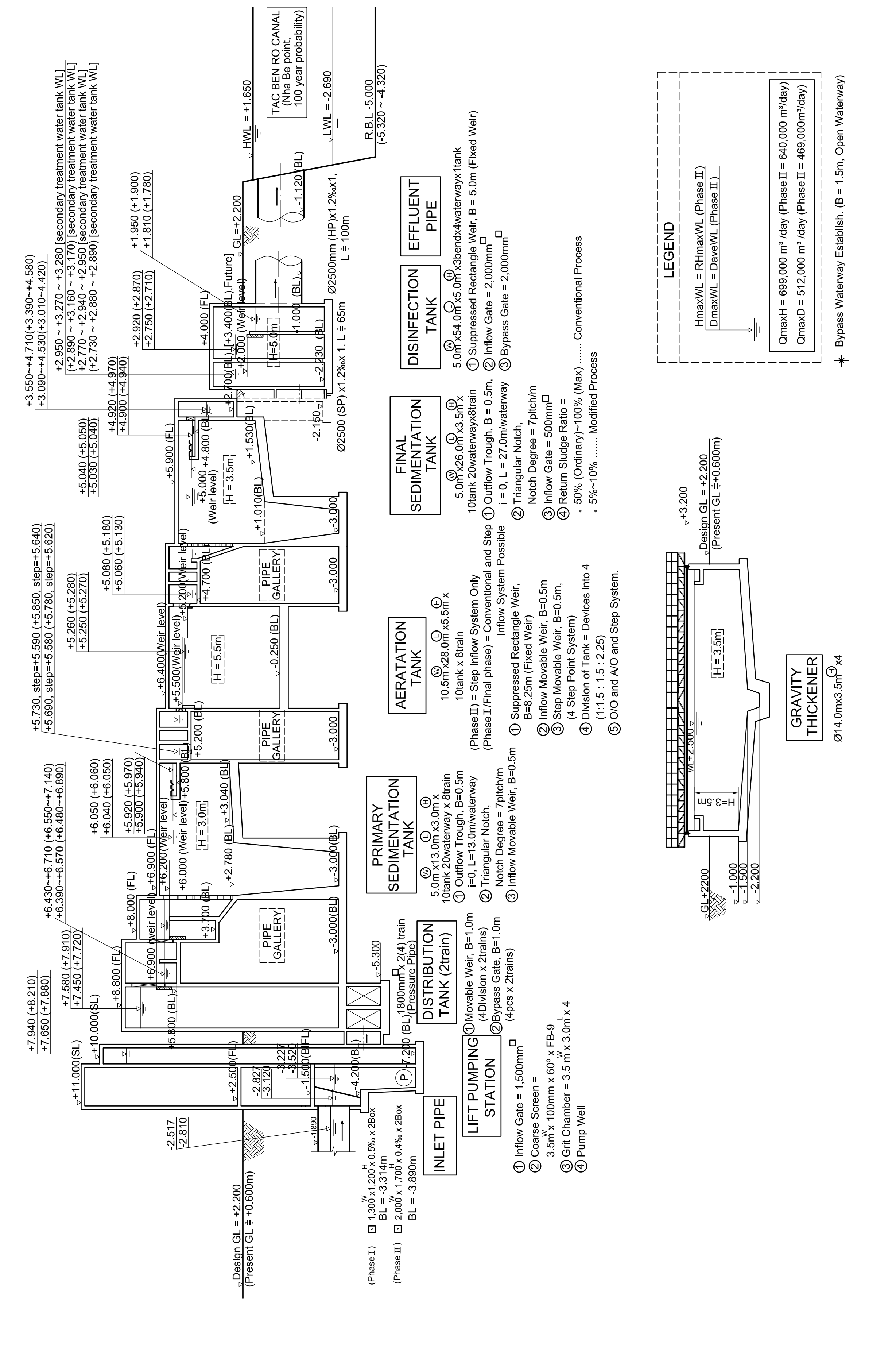
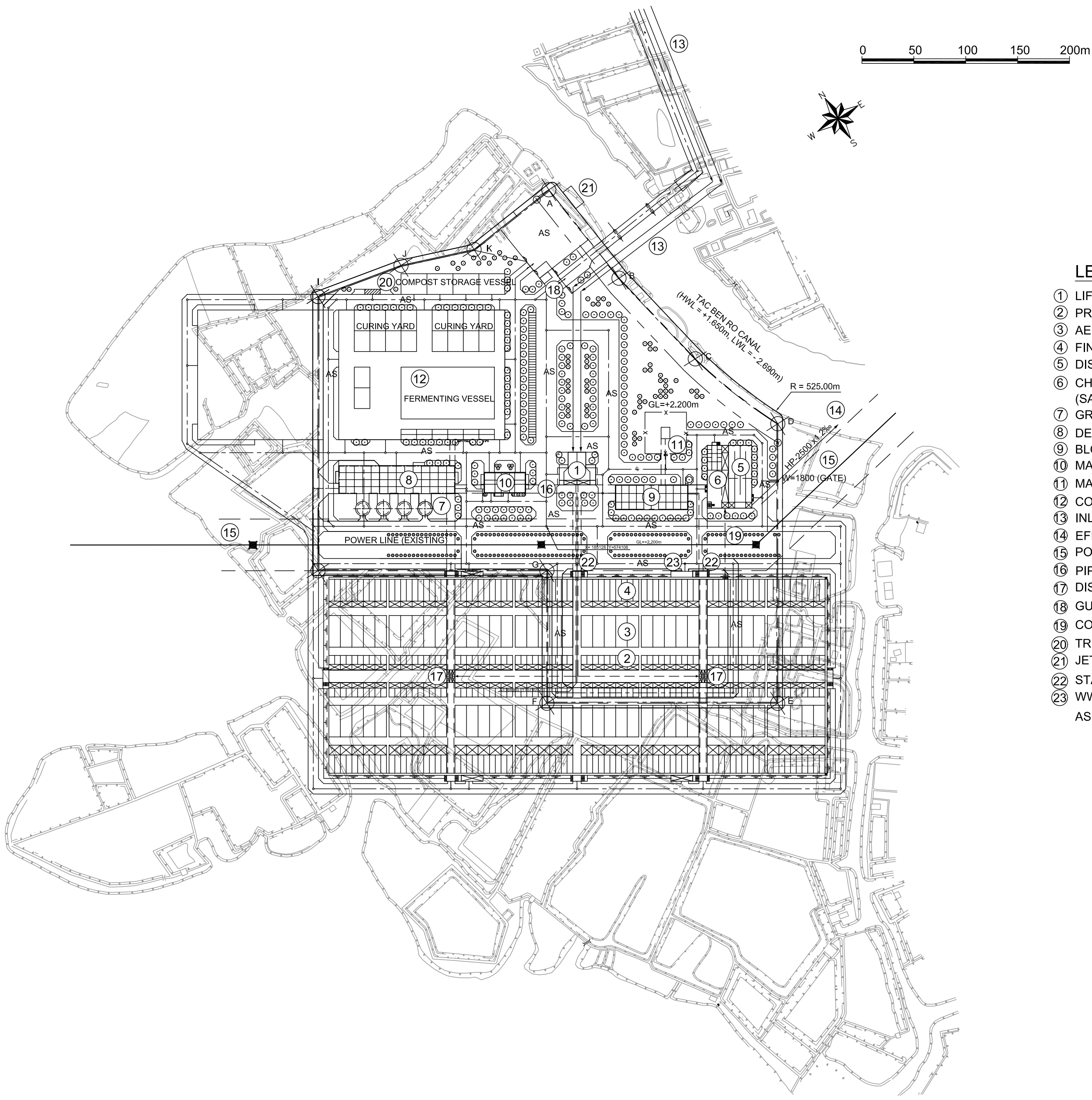


FIG. 10.4 HYDRAULIC PROFILE OF THBNDT WASTEWATER TREATMENT PLANT



LEGEND

1. LIFT PUMPING STATION
2. PRIMARY SEDIMENTATION TANK (5.0m^W x13.0m^L x3.0m x160 waterway 80 tank)
3. AERATION TANK (10.5m^W x28.0m^L x5.5m x80 tank)
4. FINAL SEDIMENTATION TANK (5.0m^W x26.0m^L x3.5m x160 waterway 80 tank)
5. DISINFECTION TANK (5.0m^W x54.0m^L x5.0m x3 bend 4 waterway 1 tank)
6. CHLORINATION STORAGE BUILDING (SAND FILTRATION EFFLUENT TANK, SECONDARY TREATMENT TANK)
7. GRAVITY THICKENER (14.0m^Ø x3.5m x4 tank)
8. DEWATERING & CENTRIFUGAL THICKENER BUILDING
9. BLOWER BUILDING
10. MAIN BUILDING (Control Room, Electrical Room, etc.)
11. MAIN SUBSTATION
12. COMPOST PLANT FACILITY
13. INLET PIPE (⊡ 1,300^W x1,200 x0.5‰ x2Box,⊡2,000^W x1,700 x 0.4‰ x2Box)
14. EFFLUENT PIPE (Ø2,500mmx1.2‰, HP)
15. POWER LINE (EXISTING)
16. PIPE GALLERY
17. DISTRIBUTION TANK
18. GUARD ROOM
19. CONECTION PIPE (Ø2,500mm x1.2‰, SP)
20. TRUCK SCALE
21. JETTY
22. STAIRCASE
23. WWTP ELECTRICAL ROOM

AS : ASPHALT CONCRETE

FIG. 10.5 GENERAL LAYOUT OF THBNDT WASTEWATER TREATMENT PLAN FINAL PHASE