JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PEOPLE'S COMMITTEE OF HO CHI MINH CITY (PCHCMC)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE DETAILED DESIGN STUDY
ON
HO CHI MINH CITY
WATER ENVIRONMENT IMPROVEMENT PROJECT
IN
THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

SUMMARY

JUNE 2001

PACIFIC CONSULTANTS INTERNATIONAL

Foreign Currency Exchange Rate Applied in this Report

Currency	Exchange Rate/US$
Vietnamese Dong（VND）	14,500
Japanese Yen（JPY）	110.00

(As of December, 2000)

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a detailed design study on Ho Chi Minh City Water Environment Improvement Project in the Socialist Republic of Viet Nam and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Masami Kondo of Pacific Consultants International (PCI) to the Socialist Republic of Viet Nam, several times between April 2000 and May 2001.

The team held discussions with the officials concerned of the Government of the Socialist Republic of Viet Nam and conducted field surveys at the study area, and continually conducted further studies in Ho Chi Minh City and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Socialist Republic of Viet Nam for their close cooperation extended to the study.

June 2001

Kunihiko Saito
President
Japan International Cooperation Agency

June 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir:

We are pleased to submit herewith the Final Report of Detailed Design Study on Ho Chi Minh City Water Environment Improvement Project in the Socialist Republic of Viet Nam.

The report presents of detailed design of the Ho Chi Minh City Water Environment Improvement Project in the Socialist Republic of Viet Nam conducted by the Study Team in accordance with the contracts signed between the Japan International Cooperation Agency and the Pacific Consultants International in the period of April 2000 and June 2001.

The report concludes a detailed design for construction of canal improvement, drainage pumping stations, sewers, wastewater pumping station and wastewater treatment plant in the central part of Ho Chi Minh City. The report consists of the Summary, Main Report, Design Report, Data Book and Draft Tender Documents. The Summary summarizes the results of entire study. The Main Report contains the results of the detailed design. The Design Report includes the results of the structure design for the related facilities of drainage and sewerage development and The Data Book includes the data for design. The Draft Tender Documents including all documents necessary for tendering including drawings have been prepared for each package.

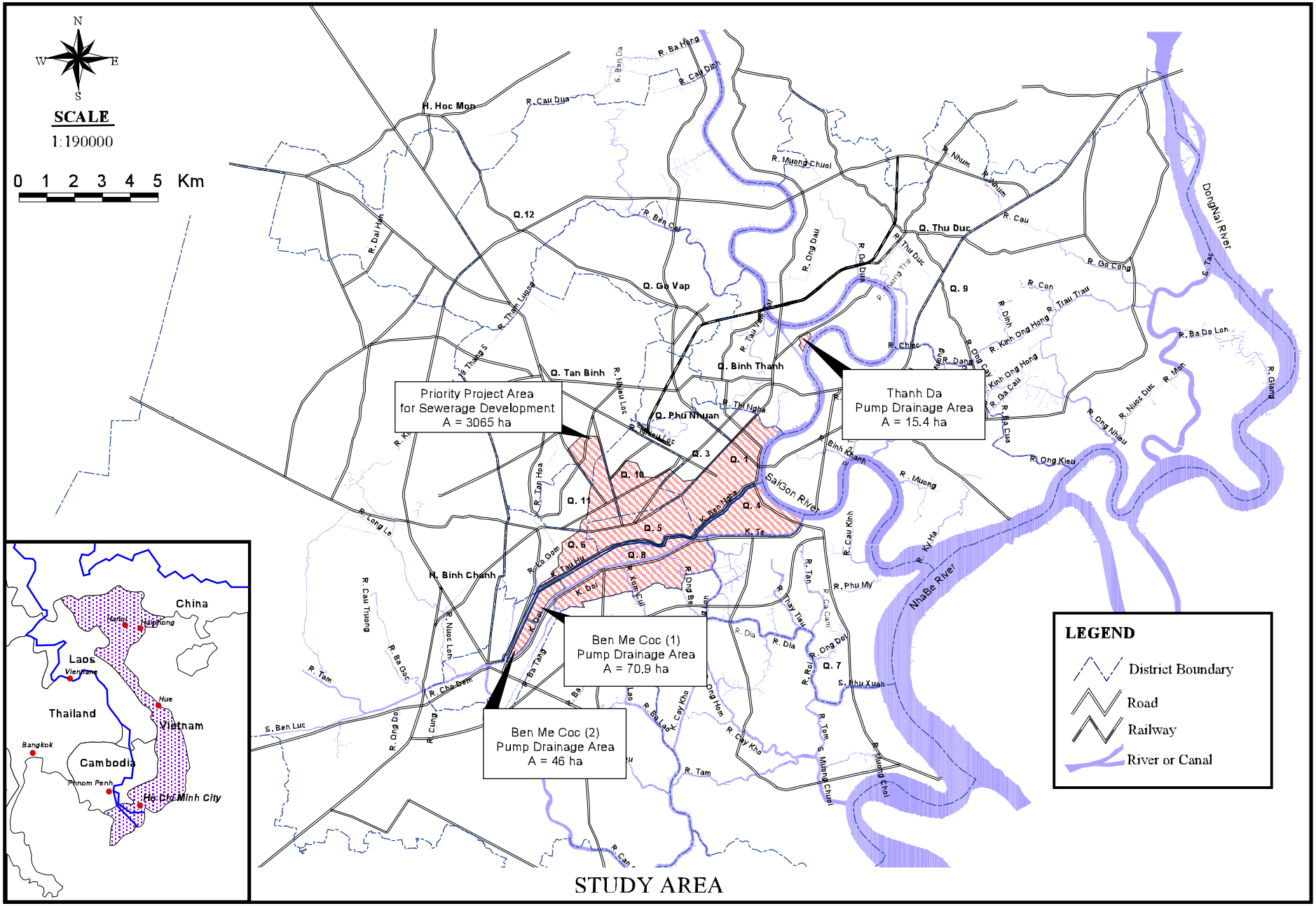
We would like to express our deep gratitude to the officials concerned of the Government of the Socialist Republic of Viet Nam, especially, the People's Committee of Ho Chi Minh City for close cooperation and assistance extended to us during our investigation and design.

We also wish to express our grateful acknowledgement to your agency and the Ministry of Foreign Affairs, the Embassy of Japan in the Socialist Republic of Viet Nam

Finally, we sincerely hope that the results of the study will contribute to Ho Chi Minh City and to the future of Socialist Republic of Viet Nam.

Very truly yours,

Masami Kondo
Team Leader
The Detailed Design Study on Ho Chi Minh City Water Environment Improvement Project
in the Socialist Republic of Viet Nam



STUDY AREA

JICA - The Detailed Design Study on HCMC Water Environment Improvement Project

ABSTRACT

Introduction

The objectives of the Study are to conduct a detailed design and to prepare draft tender documents of Ho Chi Minh City Water Environment Improvement Project Phase I, and to pursuer technology transfer to the counterpart personnel of Government of the Socialist Republic of Viet Nam (hereinafter referred to as "GOV") in the course of the Study.

The Study, which commenced on April 2000, was conducted in co-operation with People's Committee of Ho Chi Minh City (hereinafter referred to as "PCHCMC"), the executing agency of GOV.

Detailed Design

The construction works of the Project consists of five (5) packages as follows:

(1) Package A : Tau Hu - Ben Nghe canal improvement
(2) Package B : Pump drainage improvement
(3) Package C : Interceptor sewer construction, intermediate wastewater pumping station construction and procurement of sewer cleaning equipment
(4) Package D : Conveyance sewer construction, existing combined sewer improvement
(5) Package E : Wastewater treatment plant construction

The detailed design and draft tender documents were prepared in each package. In addition to these five (5) packages of construction work, terms of reference for consulting supervision services for all construction works and required experts were also proposed.

Institutional Development

New organization of Sewerage and Drainage Company (hereinafter referred to as "SDC") by strengthening the existing Urban Drainage Company (hereinafter referred to as "UDC") was proposed to meet the additional works including management of revenue generated from the sewerage charge and expenditure for O/M of the newly constructed drainage and sewerage facilities by the three (3) on-going projects. Along with the existing UDC's functions, SDC should have the following new functions;

(1) Operate and maintain the new facilities,
(2) Prepare the expansion plan of the facility capacity,
(3) Supervise the maintenance works for Level 4 and smaller sewer system,
(4) Perform related commercial activities, and
(5) Handle the financial matters.

Project Cost

The project cost for HCMC Water Environment Improvement Project Phase I is estimated at 3,951.0 billion VND under the economic condition in December 2000.

The project cost of each package and the consulting services cost are summarized and shown in the following table.

Project Cost for Phase I

(Unit : Million VND)

Item	F.C.	L.C.	Total
Package A	100,241.68	707,443.53	807,685.20
Package B	42,595.65	220,744.18	263,339.83
Package C	345,301.50	219,262.25	564,563.75
Package D	69,306.90	186292.70	255,599.59
Package E	1,026,336.22	773,335.35	1,799,671.57
Consulting Services	191,726.22	68,404.20	260,131.02
Total	1,775,508.77	2,175,482.21	3,950,990.98

Financial Analysis

PCHCMC stipulated the Decision No. 10/2001/QD-UB to introduce a sewerage charge collection from residents who receive public water supply services from WSC covering the whole HCMC area. Collection of the sewerage charge will commence on July 1st, 2001. Sewerage charge is set at 264 VND/m^3 for public water consumption which is equivalent to 12% of the existing water supply charge.

This sewerage charge will cover the O/M cost of SDC and the cost for the regional urban drainage improvement in HCMC. This sewerage tariff will be remained until 2003. In the year 2004, sewerage tariff will be revised to meet the future requirement of additional O/M cost for three (3) urban drainage and sewerage development projects currently being conducted by PCHCMC.

(VND/m^3)

Year	2001-2003	2004	2005	2006	2007
Sewerage Tariff	264	837	1,163	2,094	2,513
Year	2008-2010	2011	2012	2013	2014-2020
Sewerage Tariff	2,714	3,691	4,097	4,547	5,229

In principle, the required sewerage charge will be kept combined with costs of water supply, wastewater and solid waste services below the affordable limit of 5 % of the average monthly income of the low-income inhabitants in HCMC.

The proposed sewerage tariff will reflect the sound operation of the SDC.

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1. INTRODUCTION

Master Plan and Feasibility Study on Urban Drainage and Sewerage Development for Ho Chi Minh City were conducted by Japan International Cooperation Agency (hereinafter referred to as "JICA") from July 1998 to January 2000. In these studies, Tau Hu - Ben Nghe, Doi - Te Basin (hereinafter referred to as "THBNDT Basin"), located in the central part of Ho Chi Minh City (hereinafter referred to as "HCMC") was selected and identified as the objective area for a water environment improvement project.

In parallel with the Feasibility Study, Government of the Socialist Republic of Viet Nam (hereinafter referred to as "GOV") requested the Government of Japan (hereinafter referred to as "GOJ") to conduct the Detailed Design Study on HCMC Water Environment Improvement Project (hereinafter referred as to "the Project" and "the Study"), which was formulated through the master plan and the feasibility study.

In response to the request of GOV, GOJ decided to implement the Study and JICA signed the Scope of Work of the Study in January 2000. JICA dispatched the study team in April 2000.

The Detailed Design Study was divided into two (2) stages: (i) Definitive Plan Stage and (ii) Detailed Design Stage. The definitive plan covers the entire project area selected by the Feasibility Study and has a target year 2010. The definitive plan study consists of (a) Review of the feasibility study (F/S) by JICA and (b) basic design. The detailed design covers the Phase I project, which was selected from the Project, has a target year 2005.

2. OBJECTIVES OF THE STUDY

The objectives of the Study are;

(i) to conduct a definitive plan study, which includes review of the JICA F/S for the Project, and confirmation of the optimum plan of drainage and sewerage development project for THBNDT Basin;,
(ii) to prepare a detailed design, a cost estimate, a construction plan, an operation and maintenance program and draft tender documents of the Phase I project; and
(iii) to pursue technology transfer to the counterpart personnel of GOV in the course of the Study.

3. DEFINITIVE PLAN STUDY

3.1 Study Area

The Study Area for the Definitive Plan covers the central part of Ho Chi Minh City with an area of 3,065.4 ha, defined as the THBNDT Basin for sewerage development, and the isolated areas of Thanh Da of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha for pump drainage improvement areas as shown in **Fig. 1**. The Study Area encompasses 10 districts with a total population of 1.5 million in 1997.

3.2 Tau Hu – Ben Nghe Canal Improvement

The Tau Hu - Ben Nghe Canal with a total length of about 12.2 km has three (3) functions, namely, urban drainage for eight (8) districts of about 61.7 km^2, waterway transportation between Mekong Delta and HCMC and water open space including landscape for the city life. Garbage sedimentation, encroachment of illegal houses on/along the canal and direct discharge of domestic wastewater into the canal have caused a serious living environmental issue and the canal improvement is considered essential to regain its natural functions.

The canal improvement has been designed to meet the requirements of the year 2020 with 10 years frequency flood for urban drainage and 100 - 300 tonnage boat navigation for waterway transportation.

Alignment of the canal has been proposed to coincide as far as possible with the existing canal alignment and to harmonize with the proposed alignment of the future East - West Highway.

3.3 Pump Drainage Improvement

Pump drainage improvement has been proposed for three (3) small low-lying areas, Thanh Da of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha, which are located on the fringes of inner city and which have been flooded about 10 times per year during periods of high tides.

In order to economize on total pump drainage cost, it is proposed to allow a short duration of inundation with no flood damage and to provide retarding ponds in combination with pumping stations. Pump drainage improvement has been designed for 5-year frequency flood for pumps and 2-year frequency flood for sewers under the conditions for the year 2020.

3.4 Existing Combined Sewer Improvement

To mitigate the inundation of regions of District 5, 10 and 11 caused by insufficient sewer capacity, the existing main combined sewer, having a total length of about 9.5 km, is proposed to be improved.

3.5 Sewer System in Southern New Urban Area

A separate sewer system has been proposed in the southern new urban area of Rach Ong (133 ha), Pham The Hien (196 ha) and Binh Dang (208 ha). A stormwater sewer of 26.5 km with diameters ranging from ϕ1000 mm to ϕ2500 mm and a sanitary sewer of 51.5 km with diameters from ϕ300 mm to ϕ600 mm are proposed to be developed concurrently with the future development of this area.

3.6 Interceptor Sewer Construction

To minimize the initial investment cost for sewerage development an interceptor sewer, utilizing the existing combined sewer, is proposed for collection of wastewater. Principally, the interceptor sewer is proposed to be located along the river and canal just before the existing system discharges wastewater into public water bodies. However, Ton Duc Thang - Ham Nghi - Tran Hung Dao roads were selected for the location of the interceptor sewer instead of the Ben Chuong Duong road along the Ben Nghe Canal because it is winding and narrow and to avoid future disturbance of East - West Highway construction. The interceptor sewer of the west zone at the left bank side of the Tau Hu Canal is proposed to be located between the proposed East - West Highway and the Tau Hu Canal. This construction will be implemented simultaneously with East - West Highway project.

Main and secondary interceptor sewers, with a total length of 12.2 km and diameters ranging from ϕ225 mm to ϕ2200 mm, are proposed in the east zone at the left bank of the Tau Hu - Ben Nghe Canal. For the west zone, at the left bank of the Tau Hu Canal, interceptor sewers of 3.8 km with diameters ranging from ϕ500 mm to ϕ2000 mm are proposed.

Interceptor sewers with a total length of 18.5 km with diameters from ϕ300 mm to ϕ1200 mm have been proposed for isolated areas of about 558 ha between the Tau Hu - Ben Nghe Canal and the Doi - Te Canal.

3.7 Intermediate Wastewater Pumping Station Construction

An intermediate wastewater pumping station (IWPS) with a design capacity of 444.4 m^3/min. has been proposed in Ward 4 in District 8. The site of about 0.6 ha is located in a swampy area enclosed by the Dong Dieu road and the Ong Nho Canal.

Submersible-type pumps comprising three (3) units of 700 mm diameter and three (3) units of 1000 mm diameter are required. One (1) pump unit will serve as a stand-by unit for each diameter. A grit chamber and bar screens are proposed after lift pumping.

3.8 Conveyance Sewer Construction

The proposed site of the wastewater treatment plant is located about 3.5 km from the project area. To transfer the wastewater from IWPS to the treatment plant site, two (2) lines of conveyance sewer are proposed to be constructed under the existing Dong Dieu road and through a paddy field area. The total length is 3,535 m and comprises two (2) lines of double cell box culvert section with a dimension of 1300 mm (W) x 1200 mm (H) for Phase I and 2000 mm (W) x 1700 mm (H) for Phase II.

3.9 Wastewater Treatment Plant Construction

The proposed treatment plant site is located in Binh Hung Ward in Binh Chanh District. The area of about 41.3 ha has been allocated as the treatment plant site by PC HCMC.

The area is bordered by the Tac Ben Ro River to the north and the east and the Xom Cui Canal to the west and the small canal to the south. A high voltage overhead power supply cable crosses from east to west through the center of the site. Under these constraints, the layout of the treatment plant has been designed with wastewater treatment facilities located south of the site and sludge treatment facilities and main control building located to the north.

The wastewater treatment plant has been designed to meet the requirements as listed in **Table 1**.

Table 1 Requirements of Wastewater Treatment Plant Design

Phase	Year	Wastewater Volume	Required Effluent Quality
I	2005	141,000 m^3/day	BOD=less than 50 mg/l, SS= less than 100 mg/l
II	2010	469,000 m^3/day	BOD= less than 50 mg/l, SS= less than 100 mg/l
Final	2020	512,000 m^3/day	BOD= less than 20 mg/l, SS= less than 50 mg/l

In principle, the treatment plant has been designed for the final condition using a conventional activated sludge treatment process. However for Phase I, in order to minimize the initial investment cost and to achieve the required effluent quality of BOD = 50 mg/l, a modified aeration process with shorter retention time in the system has been adopted. The design allows for a simple conversion to the conventional activated sludge process in the final phase.

In order to meet the required wastewater discharge capacity of 469,000 m^3/day for the year 2010, modified activated sludge treatment consisting of (i) inflow pump, (ii) primary sedimentation tank, (iii) aeration tank, (iv) secondary sedimentation tank, and (v) disinfection tank is proposed for the wastewater treatment, while sludge treatment, consisting of (i) gravity thickener, (ii) centrifugal thickener, (iii) centrifugal dewatering, and (iv) composting plant is proposed.

3.10 Project Cost

The total project cost of urban drainage improvement and sewerage development for the Project comprising of Phase I and II is estimated at 8,625.4 billion VND under the economic condition in December 2000 as given in **Table 2**.

Table 2 Total Cost of the Project

(Unit: Billion VND)

Item	F.C.	L.C.	Total
A. Construction Cost			
A.1 Urban Drainage Improvement			
(i) Tau Hu – Ben Nghe Canal improvement	130.3	304.1	434.4
(ii) Pump drainage improvement	38.5	89.4	127.9
(iii) Existing combined sewer improvement	38.7	90.3	129.0
(iv) New drainage system development in southern new urban area	44.6	104.0	148.6
(v) Procurement of sewer cleaning equipment	92.2	0.0	92.2

A.2 Sewerage Development			
(i) Interceptor sewer construction	408.4	277.3	685.7
(ii) Conveyance sewer construction	37.6	82.3	119.9
(iii) Intermediate wastewater pumping station	149.2	122.1	271.3
(iv) Wastewater treatment plant	2,015.5	1,627.4	3,642.9
(v) Wastewater collection system in southern new urban area	63.0	51.6	114.6
Sub-Total	3,018.0	2,748.5	5,766.5
B. Administration Cost	0	287.3	287.3
C. Engineering Cost	340.3	119.6	459.9
D. Land Acquisition and Compensation Cost	0	736.9	736.9
E. Physical Contingency	301.8	303.8	605.6
Total of A, B, C, D and E	3,660.1	4,196.1	7,856.2
F. Price Escalation	249.1	520.1	769.2
Grand Total	3,909.2	4,716.2	8,625.4

Note : Exchange rate : US$ 1 = VND 14,500 = ¥ 110.0
Administration cost : 3% of construction cost, land acquisition and compensation cost
Physical contingency : 10% of construction cost
Price escalation : Foreign Currency (F.C.) =1.2 % per annum,
Local Currency (L.C.) = 2.5% per annum

Annual operation/maintenance (O/M) cost in the year 2011 is estimated at 155.2 billion VND consisting of 16.7 billion VND for the urban drainage system and 138.5 billion VND for the sewerage system.

Project implementation is divided into two (2) phases; Phase I from 2001 to 2005 and Phase II from 2006 and 2010. Each component of the Project will be executed in Phase I and Phase II as shown in the following table and the proposed implementation schedule is shown in **Fig. 2**.

Item	Phase I	Phase II
1.Urban Drainage Development		
(1) Tau Hu -Ben Nghe canal improvement		
Ben Nghe canal	○	-
Tau Hu canal（down stream）	○	-
Tau Hu canal（upper stream）	-	○
(2) Pump drainage improvement		
Thanh Da area	○	-
Ben Me Coc (1) area	○	-
Ben Me Coc (2) area	Sewer/Embankment	○
(3) Existing combined sewer improvement	○	-
(4) New drainage system development in southern new urban area	-	○
(5) Procurement of dredging equipment	○	○
2. Sewerage Development		
(1) Interceptor sewer		
East area	○	-
West area	-	○
Other area	-	○
(2) Conveyance sewer	○	○
(3) Intermediate Wastewater Pumping Station	○	○

(4) Wastewater Treatment Plant	○	○
(5) Sewage collection system in southern new urban area	-	○

3.11 Project Evaluation

3.11.1 Economic Evaluation of Urban Drainage Improvement Project

Table 3 shows a summary of economic benefit of urban drainage improvement project.

Table 3 Average Annual Benefit for The Project Area

(Million VND)

Direct benefit			Indirect benefit		
Benefit items	1997	2020	Benefit items	1997	2020
Buildings/movables	74,008	144,319	Business suspension losses	16,909	15,442
Public facilities	1,143	2,189	Income losses of workers	555	1,035
Agricultural crops	512	256	Saving amount of medical	556	1,092
			Navigation benefit	13,060	21,980
Total	75,663	146,764	Total	31,080	39,549

Economic annual O/M cost including replacement cost is at sum of 12.1 billion VND for Phase I and 4.6 billion VND for Phase II. Net present value, EIRR and B/C of urban drainage project are shown in **Table 4**.

Table 4 EIRR and B/C of Urban Drainage Improvement Project

Net Present Value (billion VND)	EIRR (%)	B/C
330.1	15.54	1.43

3.11.2 Economic Evaluation for Sewerage Development Project

From the socio-economic point of view, the benefits of the sewerage development project are expected to be very significant, though difficult to quantify. The main foreseen benefits will be:

- **Improvement of water environment of the Tau Hu - Ben Nghe, Doi - Te Canal**
  The canal improvement aims to recover the amenity of water environment along the canal. Flowerbeds, some low shrub and canopy tree planting have been designed to develop the landscape along the canal and provide a place of recreation and relaxation for the citizens after completion of the canal improvement. To that end, it is essential to prevent the wastewater discharging into the canal and to improve the water quality of the canal which emanates offensive odour.
- **Improvement of water quality of the Saigon River**
  The Saigon River is an important base of the waterway transportation between Mekong Delta and HCMC. A large number of tourists also use the river as a means of transportation so that the river becomes important tourist attractions. Consequently, it is important to preserve the water quality of the Saigon River for the tourist industry.
- **A contribution to a reduction of waterborne diseases contraction ratio**
  The statistics issued by Department of Health of HCMC shows that the total number of patients was 1.087 million and the total medical cost was 364 billion VND in 1997.

The share ratio of the patients suffered by water-borne diseases to the total patients was estimated at about 28 % and therefore the improvement of living environment by sewerage development will contribute reduction of the contraction rate of the water-borne diseases.

3.11.3 Water Quality Simulation

Water quality simulation and analysis of rivers and canals was conducted to evaluate the effects of sewerage development and canal improvement projects under the following six (6) conditions as shown in **Table 5**.

Table 5 Conditions of Water Quality Simulation

Case	Year	THBNDT Sewerage Development	Tau Hu Canal Improvement	Tan Hoa Lo Gom Project
1	2005	without	without	without
2	2010	without	without	without
3	2005	Phase I	without	without
4	2005	Phase I	Phase I	without
5	2010	Phase II	Phase II	without
6	2010	Phase II	Phase II	BOD= 25 mg/l

The objective water bodies for water quality simulation and analysis are shown in **Fig. 3**. The simulation results are illustrated in **Fig. 4**.

As a result of reduction of pollution load by sewerage development in Phase I, water quality of the Ben Nghe, Doi - Te Canal will be improved. However, the water quality of the canal in terms of BOD is computed at from 70 to 107 mg/l due to the pollution load discharge from the Lo Gom Canal and does not satisfy the requirement of BOD level. Even if the sewerage system would be fully developed in the THBNDT Basin along with the canal improvement in Phase II, the water quality of the canal will still not be sufficiently improved without implementation of Tan Hoa - Lo Gom project currently being conducted with Belgian assistance. Implementing the Tan Hoa - Lo Gom project simultaneously with this project is essential in order to achieve the target levels of water quality in the of Tau Hu - Ben Nghe, Doi - Te canals.

4. DETAILED DESIGN STUDY

4.1 General

Phase I project consists of five (5) packages as follows:

(1) Package A : Tau Hu - Ben Nghe canal improvement
(2) Package B : Pump drainage improvement
(3) Package C : Interceptor sewer construction, intermediate wastewater pumping station construction and procurement of sewer cleaning equipment
(4) Package D : Conveyance sewer construction, existing combined sewer improvement

(5) Package E : Wastewater treatment plant construction

In addition to those five (5) packages of construction work, consulting supervision services for all construction works will be conducted.

4.2 Study Area

Detailed design study covers the Phase I project area of about 914.7 ha which has a population of 442,000 for sewerage development and three (3) pump drainage improvement areas at Thanh Da of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha. In addition to those areas, intermediate wastewater pumping station of 0.6 ha, wastewater treatment plant of 41.3 ha, the Tau Hu - Ben Nghe Canal improvement of 7.3 km, existing main combined sewer improvement route of 9.7 km, main and secondary interceptor sewer routes of 12.2 km and conveyance sewer route of 3.5 km are also included (**Fig. 1**).

4.3 Tau Hu - Ben Nghe Canal Improvement (Package A)

Package A project consists of improvement of two (2) canals, which are the Ben Nghe Canal of 3,158 m long from the Saigon River to the Chu Y Bridge and the Tau Hu Canal (downstream) of 4,128 m from the Chu Y Bridge to the junction with the Ngang No.1 Canal.

Channel alignment of the objective courses of the Tau Hu - Ben Nghe Canal has been designed to coincide with the existing one as much as possible, to satisfy the waterway transport requirement, and to harmonize with the road alignment proposed for the HCMC East - West Highway Project. **Fig. 5** shows the proposed alignment of the Tau Hu - Ben Nghe Canal. Canal bed slope has been designed at 1/20,000, which is the same slope as that proposed in the definitive plan, as shown in **Fig. 6**.

The following two (2) types of single cross section, each with stone masonry revetments to protect the both banks from scouring and erosion by floodwater, have been designed.

(i) Type A : Trapezoidal shape channel with 1:1.5 slope lined by stone masonry
(ii) Type B : Trapezoidal shape channel with 1:0.5 slope lined by stone masonry

However, there is a possibility that these revetments will need to be reviewed and revised, for some specific sections, if the road alignment of the East - West Highway project changes during its future detail design stage.

There are 96 sewer outlets connecting with the canal at present. Of these, 82 sewer outlets, consisting of RC pipe, RC box culvert and brick construction, have been designed to be reconstructed.

The East - West Highway and the existing road, which are located on the north and the south of the canal respectively, are planed to be utilized as O/M roads. In order to

revive the amenity of water environment, open space of max. 5.0 m width has been provided as a sidewalk along both banks of the canal, in which some low shrub and canopy tree planting, lighting and other facilities for relaxation have been designed. The proposed landscape development scheme is shown in **Fig. 7**.

Main features of the canal improvement are shown in **Table 6**.

Table 6 Main Features of Canal Improvement

Name of Canal	Length (m)	Top Width (m)	Depth (m)	Open Space (m)	Revetment (m)		Sewer Outlet (No.)
					Type A	Type B	
Ben Nghe	3,158	59.7 - 91.6	5.50 - 5.64	5.00	(L): 2,910 (R): 2,777	- -	(L): 15 (R): 20
Tau Hu (downstream)	4,128	44.7 - 62.0	5.50 - 5.70	2.60 – 5.00	(L): 2,654 (R): 2,539	(L): 1,343 (R): 1,389	(L): 30 (R): 17

Note : The length of revetments and sewer outlets shown in the above table does not include 15 sewer outlets and 223 m of revetments to be constructed by other projects such as the East - West Highway Project, Hang Bang Drainage Improvement Project and Package D in this Project.

4.4 Pump Drainage Improvement (Package B)

Pump drainage improvement works for Thanh Da, Ben Me Coc (1) and (2) areas consist of three (3) components, (i) construction of dikes, (ii) construction of sewers, and (iii) construction of stormwater drainage pumping stations with retarding ponds. **Fig. 8** shows the proposed pump drainage systems for three (3) drainage areas in Phase I project.

In the Thanh Da area, a permanent dike consisting of RC pile, beam and slab, which is of the same type as the existing revetment, has been designed for the specific section of 75 m along the Saigon River. For Ben Me Coc (1) and (2) areas, temporary stone masonry dikes with lengths of 4,329 m and 3,630 m respectively and with top elevation of EL +2.00 m to protect the areas from external flood have been designed to be constructed along the canal side of existing ring road. Permanent revetment are planned to replace the temporary dikes in Phase II when detailed design of the surrounding canals will be carried out.

New sewer lines consisting of ϕ400 mm to ϕ1800 mm RC pipe have been designed for three (3) drainage areas to reduce internal flooding, to reduce the number of outlets and to provide outlets with flap gate in order to protect the area from external floods. Total length of sewers is estimated at 751 m for Thanh Da, 4,436 m for Ben Me Coc (1) and 3,940 m for Ben Me Coc (2) areas, respectively

Two (2) stormwater drainage pumping stations, each with two (2) sets of submersible pumps of ϕ400 mm diameter (Q = 42 m^3/min.), have been designed for Thanh Da area and for the eastern part of Ben Me Coc (1) area. In order to economize on total pump drainage cost, each pumping station has been designed allowing for retarding ponds by utilizing existing ponds. **Figs. 9** and **10** show a general layout of Thanh Da and Ben Me Coc (1) pumping stations respectively.

Main features of the respective pump drainage improvement are shown in **Table 7**.

Table 7 Main Features of Pump Drainage Improvement

Location / Item	Thanh Da	Ben Me Coc (1)	Ben Me Coc (2)
Drainage Area	15.4 ha	70.9 ha	46.0 ha
Dike Construction	Extension of existing revetment: L = 75 m	Temporary stone masonry dike: L = 4,329 m	Temporary stone masonry dike: L = 3,630 m
Construction of Drainage Pipe	ϕ 800 – ϕ 1200mm, L = 751 m Outlet flap gate: 5 No.	ϕ 400 – ϕ 1800 mm, L = 4,436 m Outlet flap gate: 10 No.	ϕ 400 – ϕ 1800 mm, L = 3,940 m Outlet flap gate: 9 No.
Construction of Pumping Station	Submersible Pump: ϕ 400 0.35 m^3/s x 2 units Total cap. = 42 m^3/min	Submersible Pump: ϕ 400 0.35 m^3/s x 2 units Total cap. = 42 m^3/min	-
Construction of Retarding Pond	Pond area : 2,100 m^2 Effective depth : 2.0 m Capacity : 4,200 m^3	Pond area : 19,000 m^2 Effective depth : 1.1 m Capacity : 20,900 m^3	-

4.5 Construction of Interceptor Sewer and Intermediate Wastewater Pumping Station, and Procurement of Sewer Cleaning Equipment (Package C)

4.5.1 Interceptor Sewer Construction

Interceptor sewer construction consists of main and secondary interceptor sewers (**Fig. 11**). From technical and economical points of view, two (2) construction methods are proposed according to excavation depth; (i) open cut method for depths less than 10 m and (ii) pipe jacking method for depths over 10 m (**Fig. 12**). Length of sewers and the number of manholes and diversion chambers are summarized in **Table 8**.

Table 8 Main Feature of Interceptor Sewer Construction

Sewer	Diameter (mm)	Length (m)	Manhole (no.)	Diversion Chamber (no.)
Main Interceptor	300 – 2200	6,538	48	10
- Open Cut Method	300 – 1200	2,671	31	10
- Pipe Jacking Method	1200 – 2200	3,867	17	0
Secondary Interceptor	225 – 800	5,642	92	18
Total		12,180	140	28

Diversion chambers will be installed for the main and the secondary interceptor sewers to control the wastewater discharge volume into the interceptor sewers mainly during rain. Typical structure of a diversion chamber for the main interceptor sewer is shown in **Fig. 13**. For the secondary interceptor sewer, sluice valves are installed at nine (9) locations of diversion chamber to give additional control of inflow into the interceptor sewers.

Four (4) types of pipe bedding are proposed depending on the installation depth. The proposed pipe beddings are (i) sand bedding, (ii) concrete cradle with 120° support, (iii) concrete cradle with 180° support and (iv) concrete encasement (360°).

4.5.2 Construction of Intermediate Wastewater Pumping Station

The Intermediate Wastewater Pumping Station (IWSP) consists of a lift pumping station and a grit chamber. Design capacity of IWSP for Phase I is 192,000 m3/day (133.3 m3/min.).

Considering the subsoil conditions of the site (loose sand) and the very deep substructure (about 20 m), it was concluded that the substructure of pumping station should be constructed by the diaphragm wall method and the pumping station covering the requirements of the priority project in the civil and architectural works be designed and constructed in the Phase I stage. The exteriors of pump house and O/M office have been designed to harmonize with the surrounding area. Three (3) units of submersible motor pump with a diameter of 700 mm and with volute casing have been selected as the most economical type. Two (2) different power supply transmission lines of 22 kV are proposed to connect to a sub-station installed in the site to reduce the risk of power failure.

The grit chamber has been limited in size to half the future requirement of 444.4 m3/min. on consideration of reduced initial investment cost and the ease of making future expansion. Grit removal equipment selected is a grab bucket type with 0.25 m3 capacity. **Figs. 14** and **15** show general layout of IWSP. Main features of IWSP are shown in **Table 9**.

Table 9 Main Features of IWSP Construction

Item	Pumping Station	Grit Chamber
Civil works 1. Structure type 2. Outside dimension 3. Foundation type	 * Diaphragm wall and RC structure * (W) 27.2 m x (L) 32.8 m x (H) 20.5 m * No pile foundation	 * RC structure * (W) 12.0 m x (L) 36.5 m x (H) 4.2 m * Wooden pile
Architectural works 1. Structural type 2. Outside dimension	(Pump house and O/M office) * RC structure * (W) 25.8 m x (L) 27.2 m x (H) 11.0 m	-
Mechanical works 1. Main equipment	 * Pump: ϕ 700mm x 3 units (133.3 m^3/min) * Automatic fine screen with conveyor * Emergency gate	 * Grit removal with grab bucket * Inlet sluice gate
Electrical works 1. Main equipment	 * 22 kV Substation, 750 kVA Generator * 1500 kVA Transformer * Electrical and control panels	 * Switch box and panels

4.5.3 Procurement of Sewer Cleaning Equipment

To conduct periodic sewer cleaning works efficiently, sewer cleaning equipment has been specified. Cleaning of sewers with diameters greater than ϕ1200 mm can be done by manually easily. Sewers with diameters ranging from ϕ500 mm to ϕ1100 mm will be cleaned by mechanical devices such as water jet cleaner and vacuum cleaner. The length of sewers in the project area is about 78 km and the diameters range from ϕ500 mm to ϕ2500 mm. They are expected to be cleaned once every two (2) years. The required main sewer cleaning equipment are 4-ton water jet cleaner x 1 unit, 8-ton

water jet cleaner x 1 unit, 4-ton vacuum truck x 1 unit, 8-ton vacuum truck x 1 unit, 4-ton water tank x 6 units, 4-ton sludge hauling dump truck x 15 units, 4-ton truck for equipment transport x 3 units and other minor equipment.

4.6 Conveyance Sewer Construction and Existing Combined Sewer Improvement (Package D)

4.6.1 Conveyance Sewer Construction

This portion of the project consists of the construction of the conveyance sewer and the inspection/maintenance road.

Conveyance sewer construction comprises the construction of approximately 3,535 m of double-cell (each (W) 1300 mm x (H) 1200 mm) reinforced concrete box culvert, supported on timber piles of 25 piles per m^2 density or concrete piles having an average length of 30 m, between the proposed IWPS and the proposed WWTP. The sewer has been designed for the hourly maximum wastewater discharge of 192,000 m^3/day (2.222 m^3/s).

The box culvert has joints at 30 m intervals and is to be constructed in-situ. The sewer includes a siphon, comprising two (2) conduits with a diameter of ϕ1200 mm to be constructed by pipe jacking method, where it passes beneath the Tac Ben Ro Canal. The layout of the conveyance sewer is shown in **Fig. 11**.

The inspection/maintenance road will be constructed along the conveyance sewer route. The road reaches the WWTP via a bridge over the Tac Ben Ro Canal to be constructed in Package E.

In consideration of good interfacing with the construction of the IWPS and the WWTP, construction of the conveyance sewer is divided into three (3) portions which are included in Packages C, D and E as shown below.

Package C : Between IWPS and the connection with the Dong Dieu road, L = 242 m
Package D : Between the connection with the Dong Dieu road and the maintenance chamber installed before the Tac Ben Ro Canal, L = 3,003 m
Package E : Between the maintenance chamber installed before the Tac Ben Ro Canal and the inflow pumping station at WWTP, L = 290 m

4.6.2 Existing Combined Sewer Improvement

This portion of the project consists of construction of additional and replacement combined sewers for six (6) lines in the C and D catchment as shown in **Fig. 16**. The total length of the proposed sewer is 9,521 m, which comprises additional sewers of 7,125 m long and replacement sewers of 2,396 m long. Four (4) outlets will be reconstructed. The sewers are designed for 3-year frequency flood and 2-year frequency rainfall

The dimensions and lengths of sewer improvement are shown in **Table 10**.

Table 10 Dimensions and Lengths of Existing Combined Sewer Improvement

Catchment Name	Line No.	Additional /Replacement	Dimension (mm)	Length (m)
C	1	Additional	Ø1000	722
	2	Additional	Ø1500	677
	3	Replacement	□2000 x 2000,□2500 x 2000	1,361
	4	Additional	Ø1500,□2000 x 2000	1,723
	5	Additional	Ø1000, Ø1500, Ø1800, Ø2000 □2000 x 2000	2,326
		Sub total	–	6,809
D	6	Additional	Ø2000,□2500 x 2000	1,677
		Replacement	□2500 x 2000	1,035
		Sub total	–	2,712
Total		Additional	–	7,125
		Replacement	–	2,396
				9,521

4.7 Wastewater Treatment Plant Construction (Package E)

Wastewater treatment plant (WWTP) has been designed for the following conditions;

Wastewater volume : 141,000 m^3/day
Influent quality : BOD = 165 mg/l, SS = 165 mg/l
Effluent quality : BOD = less than 50 mg/l, SS = less than 100 mg/l

A modified aeration process utilizing the facilities described in **Table 11** has been proposed to meet the criteria mentioned above.

Table 11 Main Features of WWTP Facilities

Wastewater Treatment Plant Facilities

Facility	Main Features
Inflow Pump	Capacity : Ø 700 mm x 66.7 m^3/min x 14 m x 3 units
Primary Sedimentation Tank	Dimensions : 5 m (W) x 13 m (L) x 3.0 m (D) x 20 units Flight chain type sludge collector : 2 chain x 1.5 kW x 10 units Sludge drawing pump : Ø 80 mm x 0.5 m^3/min x 14 m x 3 units
Aeration Tank	Dimensions : 10.5 m (W) x 28 m (L) x 5.5 m (D) x 10 tanks Blower: Ø 600 mm x 360 m^3/min. x 6.8 mAq x 480 kW x 2 units
Final Sedimentation Tank	Dimensions : 5 m (W) x 26 m (L) x 3.5 m (D) x 20 units Flight chain type sludge collector : 2 chain x 2.2 kW x 10 units Sludge drawing pump: Ø 100 mm x 1.2 m^3/min x 13 m x 3 units Return Sludge pump : Ø 250 mm x 5.6 m^3/min x 6 m x 4 units
Disinfection Tank	Dimensions : 5 m (W) x 27 (54) m (L) x 5 m (D): 4 waterways

Sludge Treatment Plant Facilities

Facility	Main Features
Gravity Thickener	Dimensions : Thickener Ø 14 m x 3.5 m (D) x 1 unit
Centrifugal Thickener	Capacity : 70 m^3/hr/unit x 112.75 kW x 2 units

Dewatering	Centrifugal type Capacity : 30 m^3/hr/unit x 147.4 kW x 2 units
Composting Plant	Chaff addition type Dewatering sludge (Density of sludge =20%) : 70.3 ton/day 1st Fermentation Facility : 45.8 m x 88.8 m 2nd Fermentation Facility : 40.0 m x 135.0 m

The proposed layout and hydraulic profile of the WWTP are shown in **Figs. 17** and **18**, respectively. The flow sheets of the WWTP are shown in **Figs. 19**, **20** and **21**.

Due to the very soft soil conditions at the treatment plant site, soil improvement by soil-cement mixing method for an area of 15 m wide and 318 m long along the Tac Ben Ro Canal has been adopted to prevent the land sliding. All facilities, buildings and pipes in the treatment plant site are supported on concrete pile foundations with an average length of 35 m.

Mechanical and electrical design has been based on the Vietnamese and the Japanese standards or their equivalent. Power supply to the treatment plant is to be fed from two (2) different power sources, namely, the Saigon South 4 sub-station and the Chanh Hung sub-station to minimize the risk of power supply failure. An engine generator with a capacity of 750 kVA is also included to meet the requirement of operating the inflow pumps in an emergency.

4.8 Environmental Impact Assessment

An environmental impact assessment (EIA) survey for the Phase I project was carried out based on the EIA for the Project which had previously been approved by Ministry of Science, Technology and Environment (hereinafter referred to as "MOSTE"). The EIA for the Phase I project was prepared in accordance with the Vietnamese law and legal requirements and was approved by MOSTE in January 2001.

4.9 Consulting Services

Consulting services for construction supervision consists of two (2) stages, which are (i) pre-construction stage, (ii) construction supervision stage.

In the pre-construction stage, firstly, a review of the detailed design and finalization of tender documents for all five (5) packages of construction works shall be conducted to meet the requirement of GOV. Secondly, assistance will be given to PMU to proceed with the pre-qualification and tendering for five (5) packages of construction.

The Consultant shall conduct all the necessary works to smoothly implement five (5) packages of construction works. Study on institutional development of operation and management for urban drainage and sewerage system, consisting (i) preparation of O/M plan, (ii) financial plan and (iii) institutional strengthening plan, shall be conducted.

The Consultant shall monitor the implementation of the resettlement action plan and

public involvement works which shall be carried out on a sub-contract basis.

The above-mentioned consulting services including preparation of all necessary documents and reports will be conducted within 59 months with foreign experts of 422 man/months (M/M) and local experts of 1,013.5 M/M.

4.10 Institutional Development and Legal Framework

Based on the decision No. 10/2001/QD-UB stipulated by PCHCMC, Water Supply Company (hereinafter referred to as "WSC") has the responsibility for collection of both sewerage and water supply charges which will be charged on the same bill. It is required to establish a new organization of Sewerage and Drainage Company (hereinafter referred to as "SDC") by strengthening the existing UDC to meet the additional works including management of revenue generated from the sewerage charge and expenditure for O/M of the newly constructed drainage and sewerage facilities by the three (3) on-going projects of THBNDT, NLTN and Hang Bang. Along with the existing UDC's functions, SDC should have the following new functions;

(1) Operate and maintain the new facilities,
(2) Prepare the expansion plan of the facility capacity,
(3) Supervise the maintenance works for Level 4 and smaller sewer system,
(4) Perform related commercial activities, and
(5) Handle the financial matters.

SDC is proposed to have the following five (5) departments under the control of the managing director: (i) Technical operation, (ii) Commercial operation, (iii) Planning, (iv) Financial control and (v) Administration support.

In order to operate and maintain the existing and future developed drainage and sewerage facilities efficiently, the following offices and facilities would come under the jurisdiction of SDC;

(1) Head office,
(2) THBNDT wastewater treatment plant,
(3) Intermediate wastewater pumping station for THBNDT and wastewater pumping station for NLTN,
(4) Two (2) drainage pumping stations at Thanh Da and Ben Me Coc (1), and
(5) Monitoring kiosks for controlling inflow into the interceptor sewers.

Public relations and education are required for the people in HCMC to understand the necessity of sewerage development, evocation of willingness to pay for better environment, enlightenment on the importance of conservation and protection of the valuable facilities and system of the Project, and education of the next generation for recognizing importance on city-wide care for the environment.

GOV stipulated several legislations as laws, decrees, regulations and decisions related to sewerage and drainage development. However, the following issues need to be further addressed in detail in the future.

(1) Effluent standards to the public sewer system
(2) Stipulation on connection between private sewers and public sewer system
(3) Monitoring and inspection of the wastewater discharge
(4) Punishment or penalties for the non-payment
(5) Punishment or penalties for damages caused to the facilities of SDC

4.11 Project Cost

The project cost for HCMC Water Environment Improvement Project Phase I is estimated at 3,951.0 billion VND under the economic condition in December 2000.

The project cost of each package for construction works consists of (i) construction cost, (ii) price escalation, (iii) physical contingency, (iv) land acquisition cost and (v) administration cost. The consulting service cost consists of (i) consulting service cost, (ii) price escalation, (iii) physical contingency and (iv) administration cost.

The project cost of each package and the consulting service cost are summarized and shown in **Table 12**.

Table 12 Project Cost for Phase I

(Unit : Million VND)

Item	F.C.	L.C.	Total
Package A	100,241.68	707,443.53	807,685.20
Package B	42,595.65	220,744.18	263,339.83
Package C	345,301.50	219,262.25	564,563.75
Package D	69,306.90	186292.70	255,599.59
Package E	1,026,336.22	773,335.35	1,799,671.57
Consulting Services	191,726.22	68,404.20	260,131.02
Total	1,775,508.77	2,175,482.21	3,950,990.98

Note : Exchange rate : US$ 1.0 = VND 14,500 = ¥ 110.0
Administration cost : 5% of construction cost and consulting service cost including price escalation, physical contingency and land acquisition cost
Physical contingency : 10% of construction cost and consulting service cost
Price escalation : Foreign Currency (F.C.) = 0.8 % per annum,
Local Currency (L.C.) = 0.1 % per annum

4.12 Financial Analysis

PCHCMC stipulated the Decision No. 10/2001/QD-UB to introduce a sewerage charge collection from residents who receive public water supply services from WSC covering the whole HCMC area. Collection of the sewerage charge will commence on July 1st, 2001. Sewerage charge is set at 264 VND/m^3 for public water consumption which is equivalent to 12% of the existing water supply charge.

This sewerage charge will cover the O/M cost of SDC and the cost for the regional

urban drainage improvement in HCMC. This sewerage tariff will be remain until 2003. In the year 2004, sewerage tariff will be revised to meet the future requirement of additional O/M cost for three (3) urban drainage and sewerage development projects currently being conducted by PCHCMC. The followings are the main items to be covered by sewerage charge after 2004;

(1) OM cost of SDC
(2) OMR cost of urban drainage and sewerage system in THBNDT project proposed by JICA
(3) OMR cost of urban drainage and sewerage system in NLTN project proposed by WB
(4) OMR cost of drainage system in Hang Bang project by ADB
(5) Repayment of sewerage development portion proposed by WB

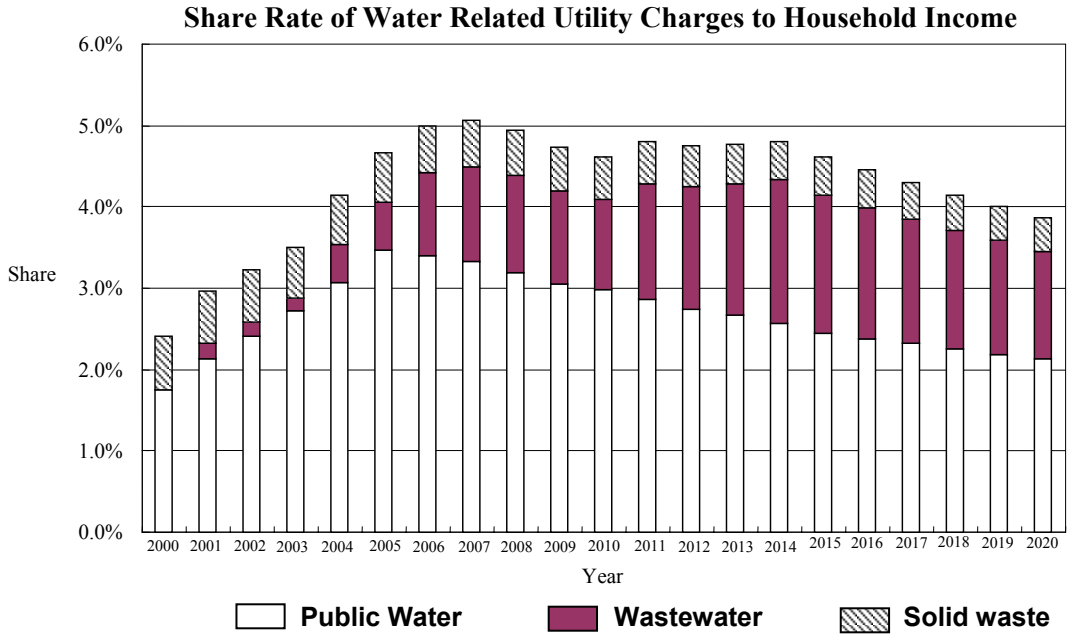
Based on the conditions mentioned above, the required sewerage tariff in each year is revised as shown in **Table 13**.

Table 13 Sewerage Tariff

(VND/m^3)

Year	2001-2003	2004	2005	2006	2007
Sewerage Tariff	264	837	1,163	2,094	2,513
Year	2008-2010	2011	2012	2013	2014-2020
Sewerage Tariff	2,714	3,691	4,097	4,547	5,229

In principle, the required sewerage charge will be kept combined with costs of water supply, wastewater and solid waste services below the affordable limit of 5 % of the average monthly income of the low-income inhabitants in HCMC. The proportion of three (3) combined costs to the average income is illustrated as shown below.



4.13 Recommendations

(1) Immediate Project Implementation

The existing combined sewerage system fully covers the central area of HCMC, however it discharges untreated sewage directly into rivers and canals. This results in the waterways acting as open sewers with the problem being most acute in the canals which emanate offensive odour and aggravate the environmental conditions. Furthermore, low-lying areas along rivers and canals suffer frequent inundation caused by high tides and heavy rain.

As the Phase I project is essential for the improvement of the river and canal environment and for the mitigation of flood damage, and as GOV and Japan Bank for International Cooperation (JBIC) have signed the Loan Agreement (L/A) dated March 30,2001, it is recommended that implementation proceed immediately and that the consultant be employed to assist PMU in the implementation.

(2) Simultaneous Development of Sewerage System in Tan Hoa-Lo Gom Basin

The Tan Hoa - Lo Gom (THLG) Canal, which receives wastewater from the THLG basin, flows into the Tau Hu - Ben Nghe Canal causing a significant adverse effect on its water quality. Without improvement of the water quality of the Tan Hoa - Lo Gom Canal, this project will not be able to achieve the required improvement of water quality in the Tau Hu - Ben Nghe Canal.

Hence it is recommended to develop the sewerage system for the Tan Hoa - Lo Gom basin simultaneously with this project to improve water quality of both the Tau Hu - Ben Nghe canal and the Tan Hoa - Lo Gom canal effectively.

(3) Cooperation with East-West Highway Project for Interceptor Sewer Construction

The interceptor sewer in the west zone has been designed to be constructed in the Phase II along the route of the proposed East-West Highway. The detailed design of the East-West Highway will commence from the middle of 2001 and its construction is expected to start mid 2003. The interceptor sewer has been designed to be constructed without any disturbance to the East-West Highway project even though the highway is to be constructed before the Phase II stage of this project. Furthermore, the construction schedule of the East-West Highway is subject to the completion of a relocation program of more than 5,200 houses along the Tau Hu - Ben Nghe Canal.

Hence it is recommended to closely monitor the construction schedule of the East-West Highway project and to maintain close cooperation with PMU of the East-West Highway project in order to ensure smooth implementation of that project and of Phase II of the interceptor sewer.

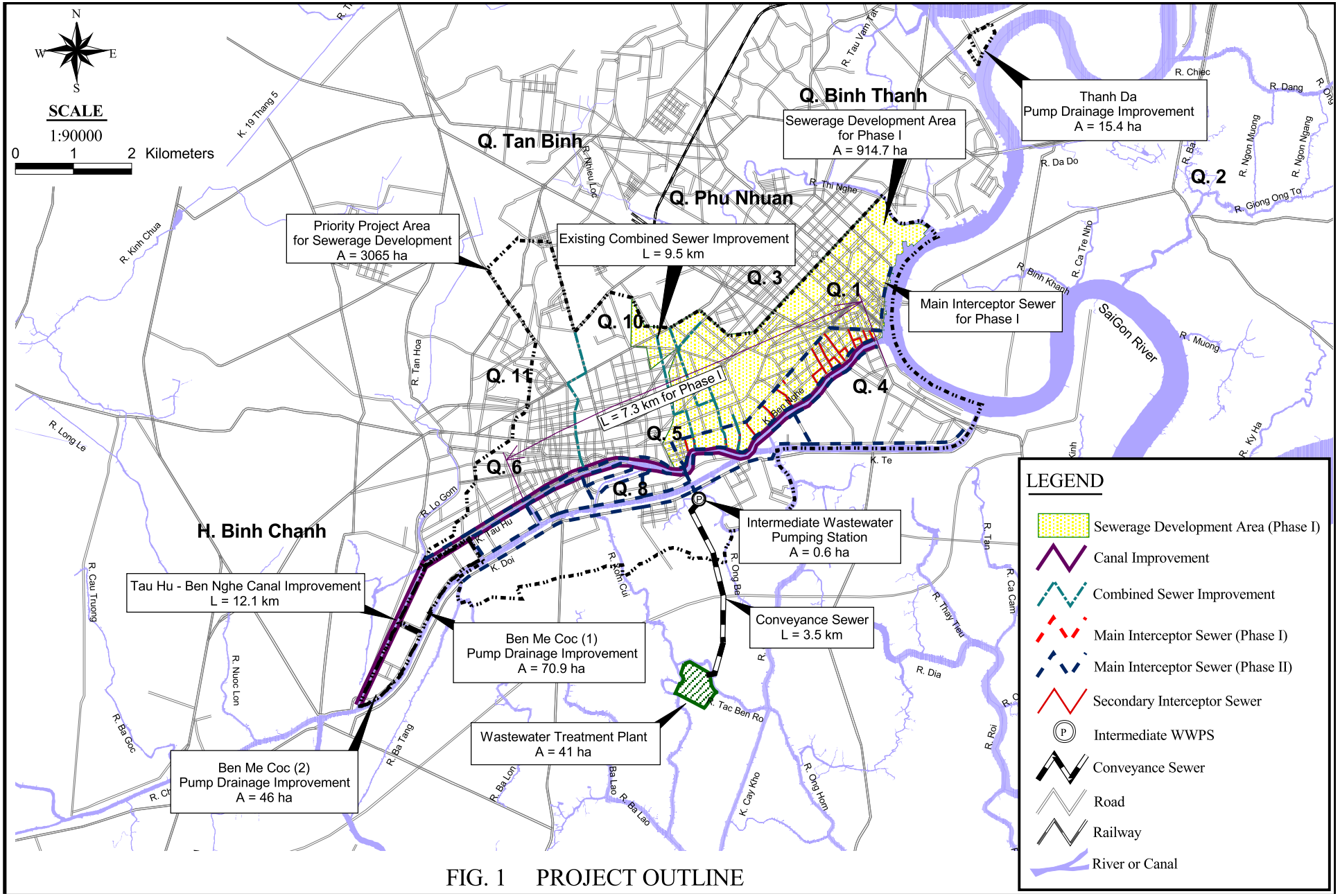
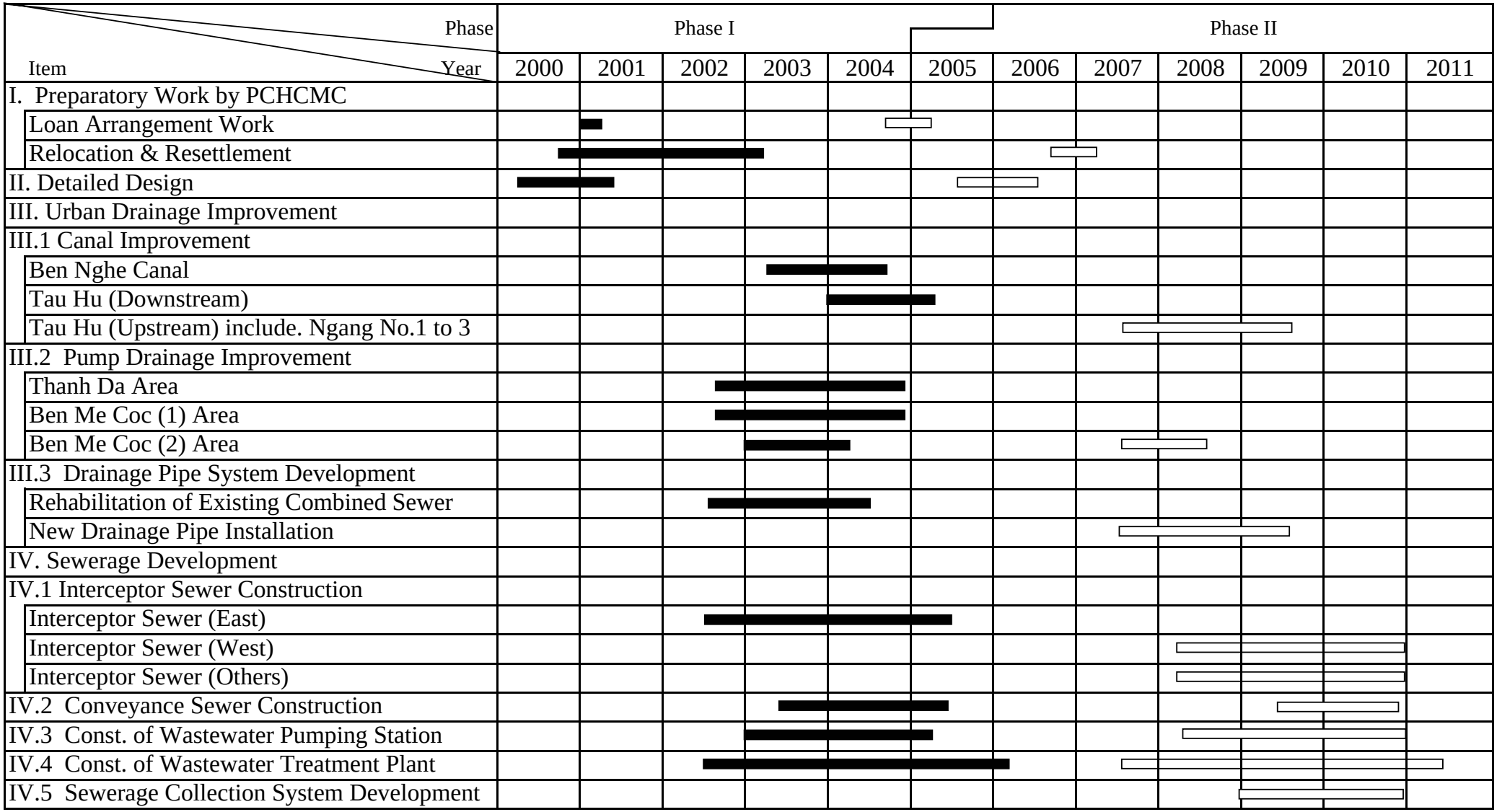


FIG. 1 PROJECT OUTLINE

FIG. 2 IMPLEMENTATION SCHEDULE OF THE PROJECT



Note : Phase I Project
: Phase II Project

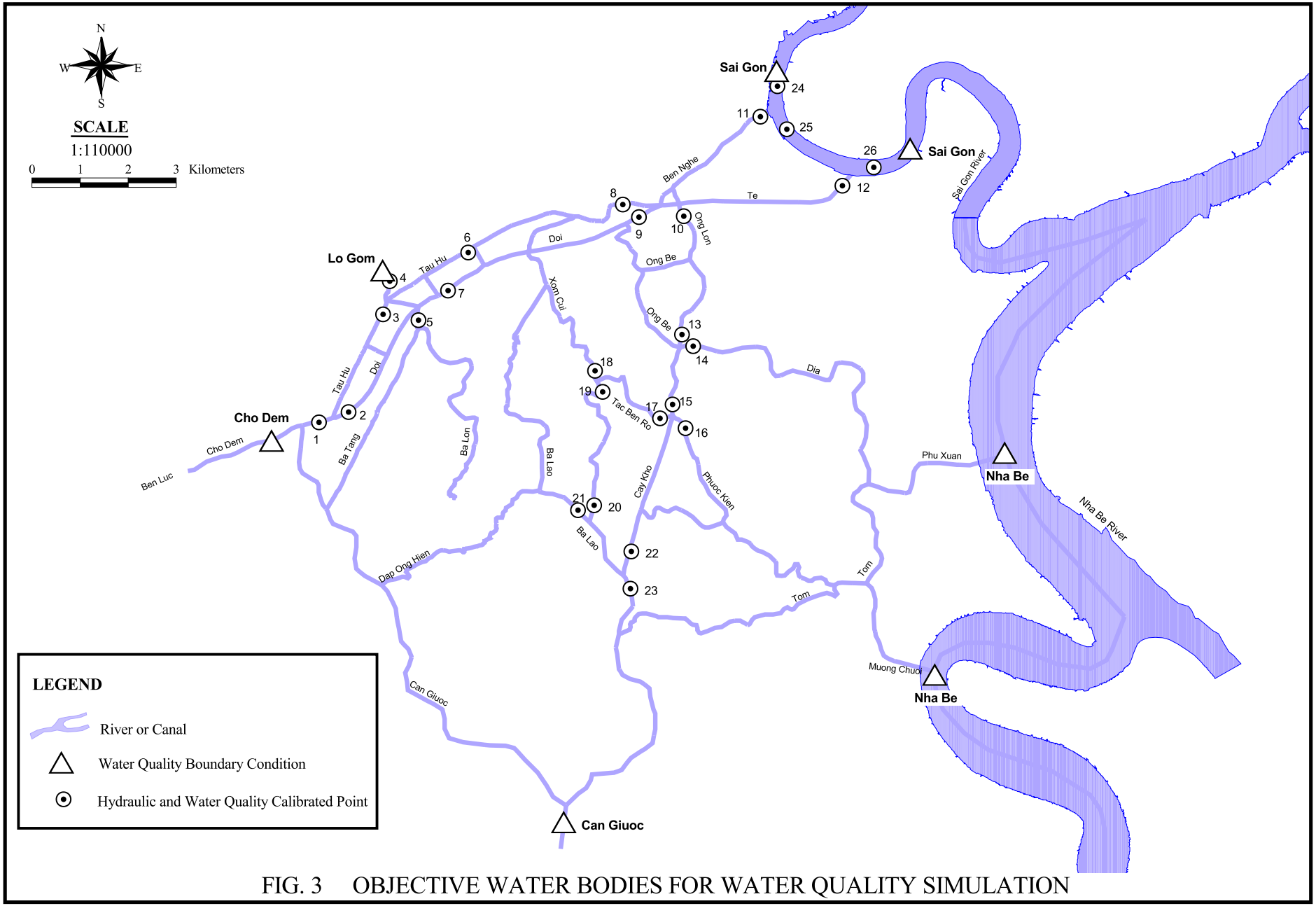


FIG. 3 OBJECTIVE WATER BODIES FOR WATER QUALITY SIMULATION

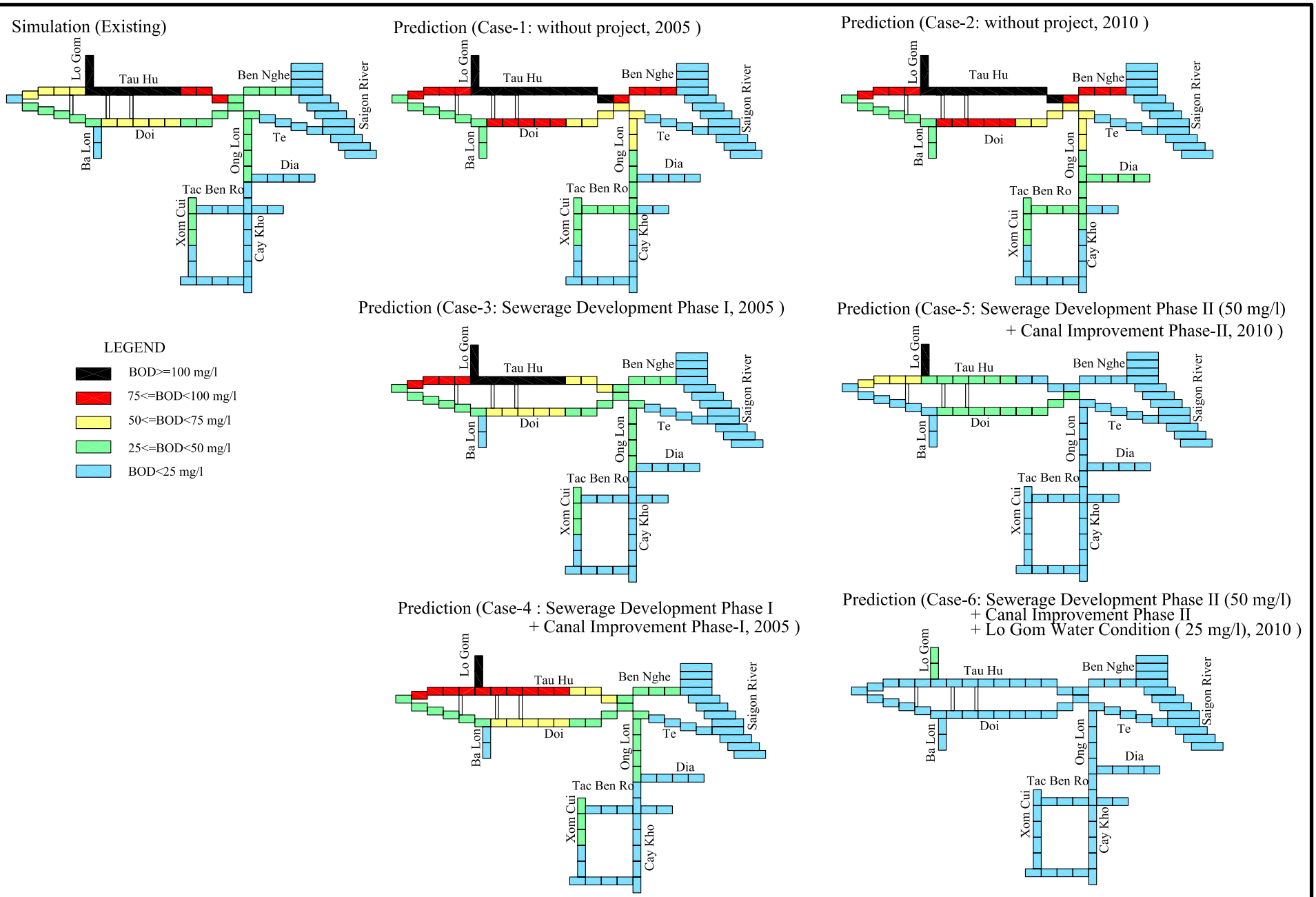


FIG. 4 RESULT OF SIMULATION OF WATER QUALITY WITH/WITHOUT PROJECT

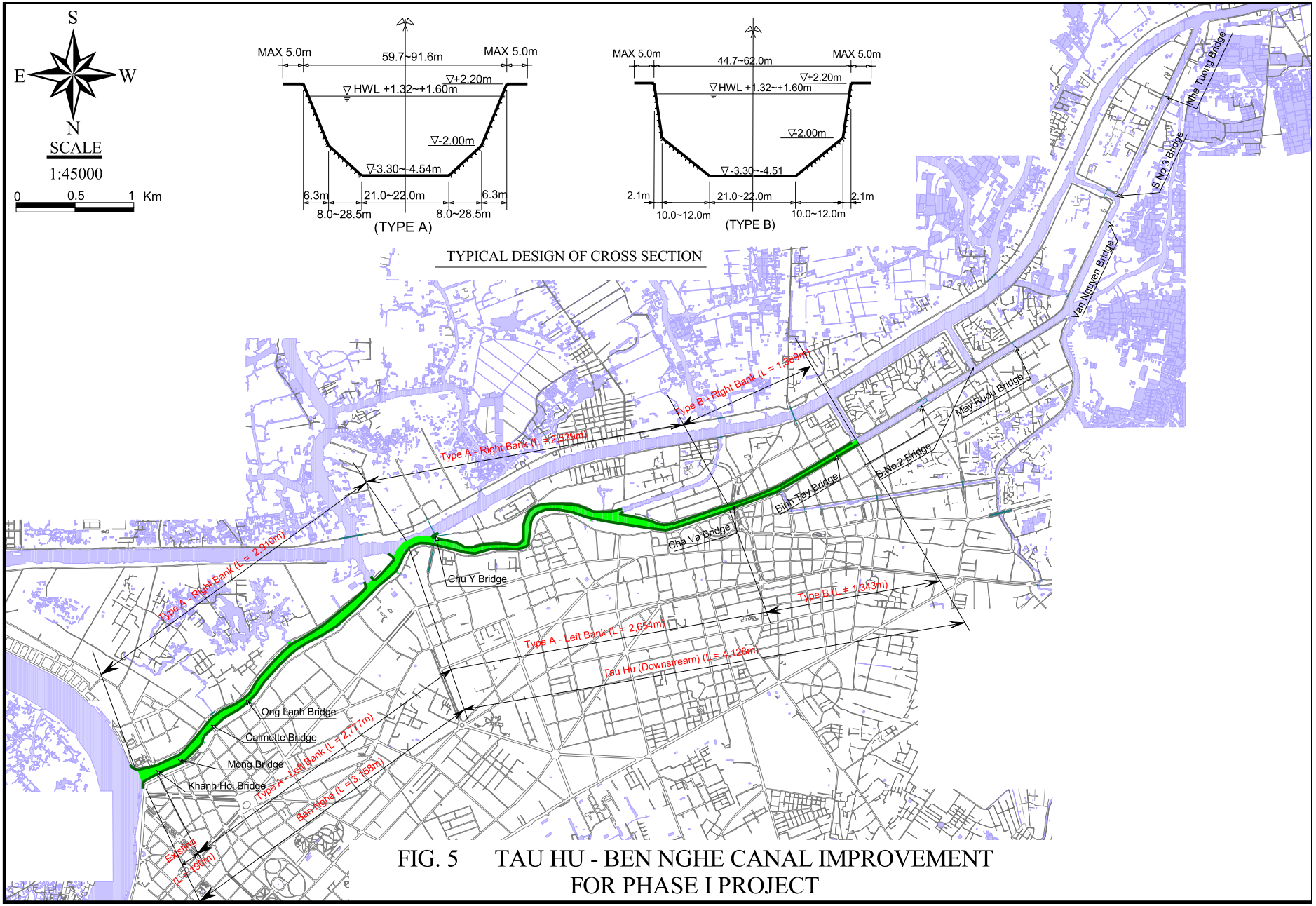


FIG. 5 TAU HU - BEN NGHE CANAL IMPROVEMENT FOR PHASE I PROJECT

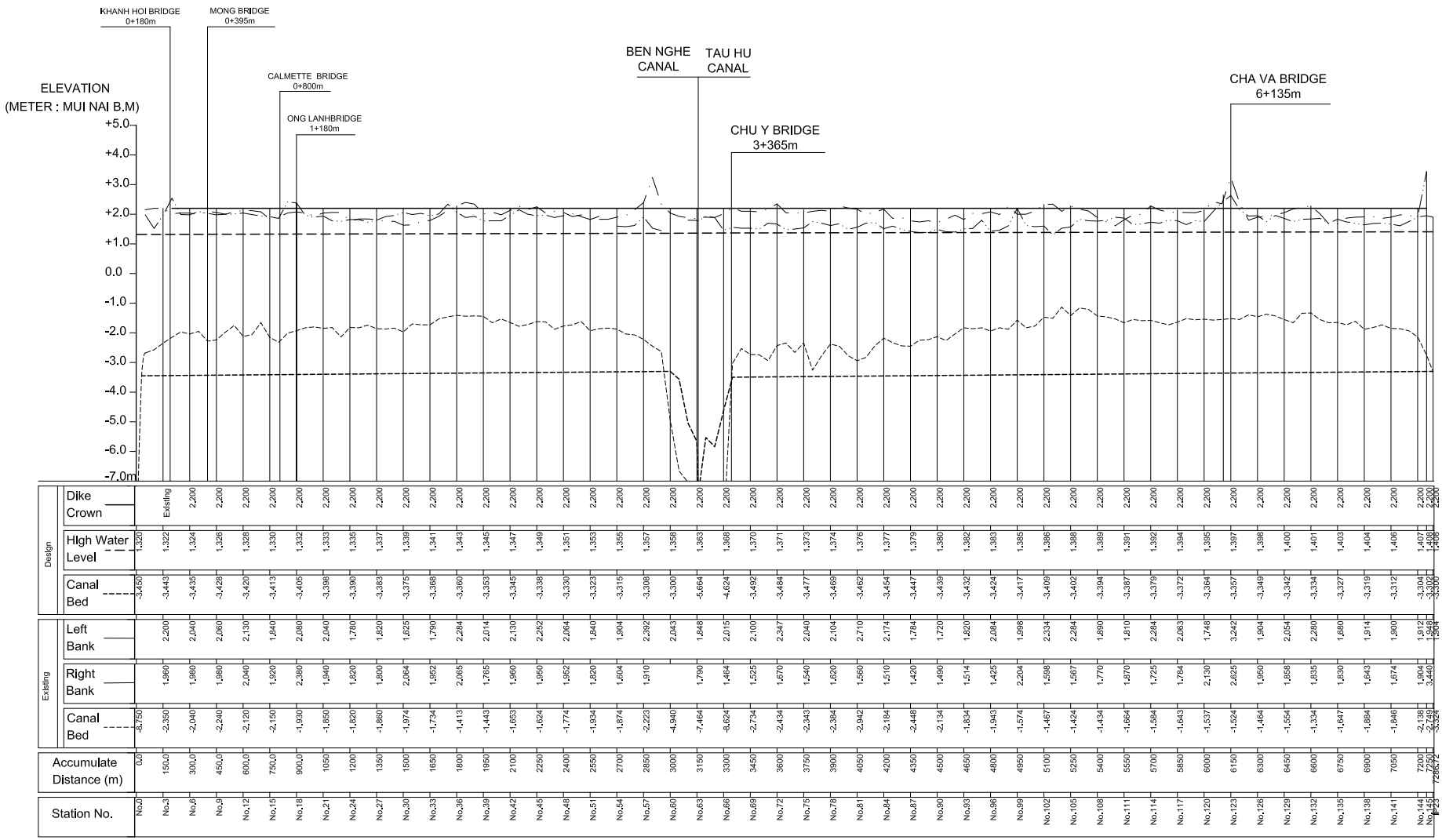
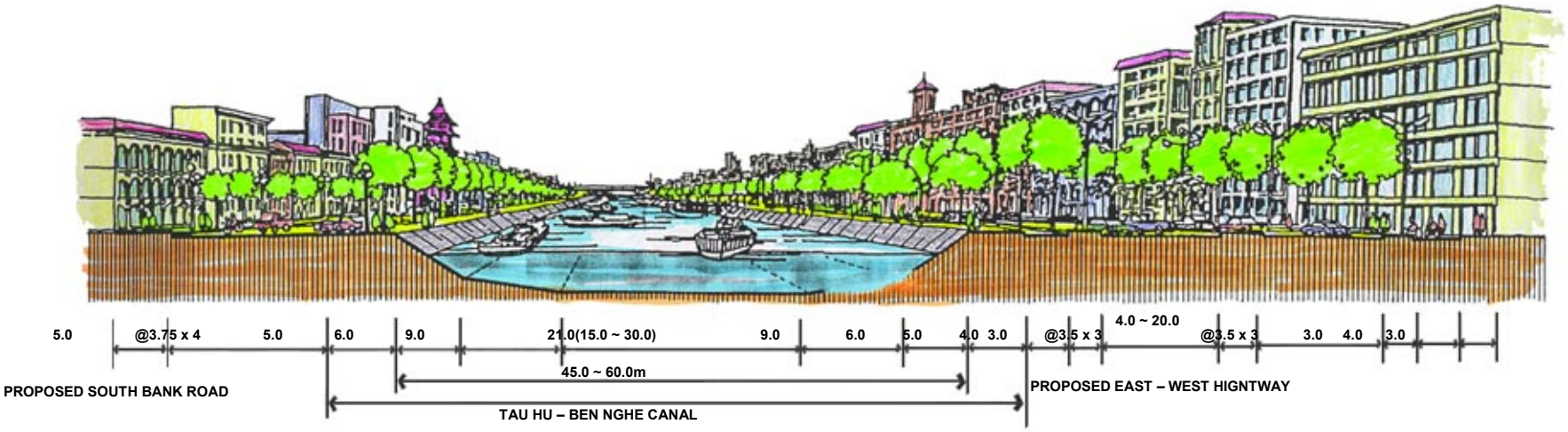
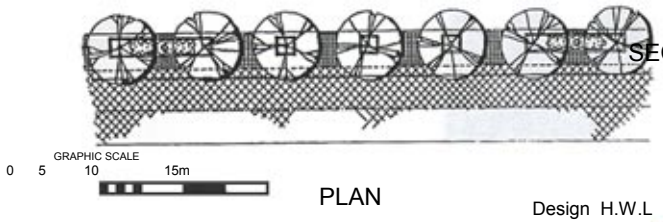


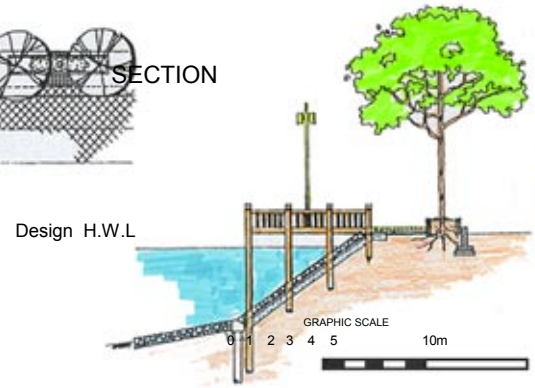
FIG. 6 PROPOSED LONGITUDINAL PROFILE OF TAU HU - BEN NGHE CANAL



Typical section of Tau Hu – Ben Nghe canal together with future development scheme of the East – West Highway and South Bank Road. Pavement of the canal shall have 5.0m of maintenance space on the born top, this space shall be used for pedestrian walk as well as sidewalk of the both of the Highway and the Road. This space shall be furnished with concrete block paving and canopy trees for shadow provision and street lightings.



PLAN



Planting of canopy trees along the canal

Medium size canopy trees are planed along the revetment born top space, interval of each planting tree location is 8.0m in general for consideration of future growth of the planed trees. 1.8m × 1.8m square planting box shall be applied for each planting location. Each interval of 24.0m rectangular formed planting box is applied as for a visual accent, are there turf grass, flowering lower shrubs are planted. In installed center of this planting space. Street pole light is installed for safety pedestrian's walk as well as aesthetic point of view.

Jetty as a temporary work on the revetment

Jetty and pontoon may be facilitated at some priority location of the canal side for supporting tourism activities, also for various type of loading and unloading commercial activities in time to time during and after the canal improvement project

FIG. 7 PROPOSED LANDSCAPE DEVELOPMENT SCHEME ALONG TAU HU – BEN NGHE CANAL

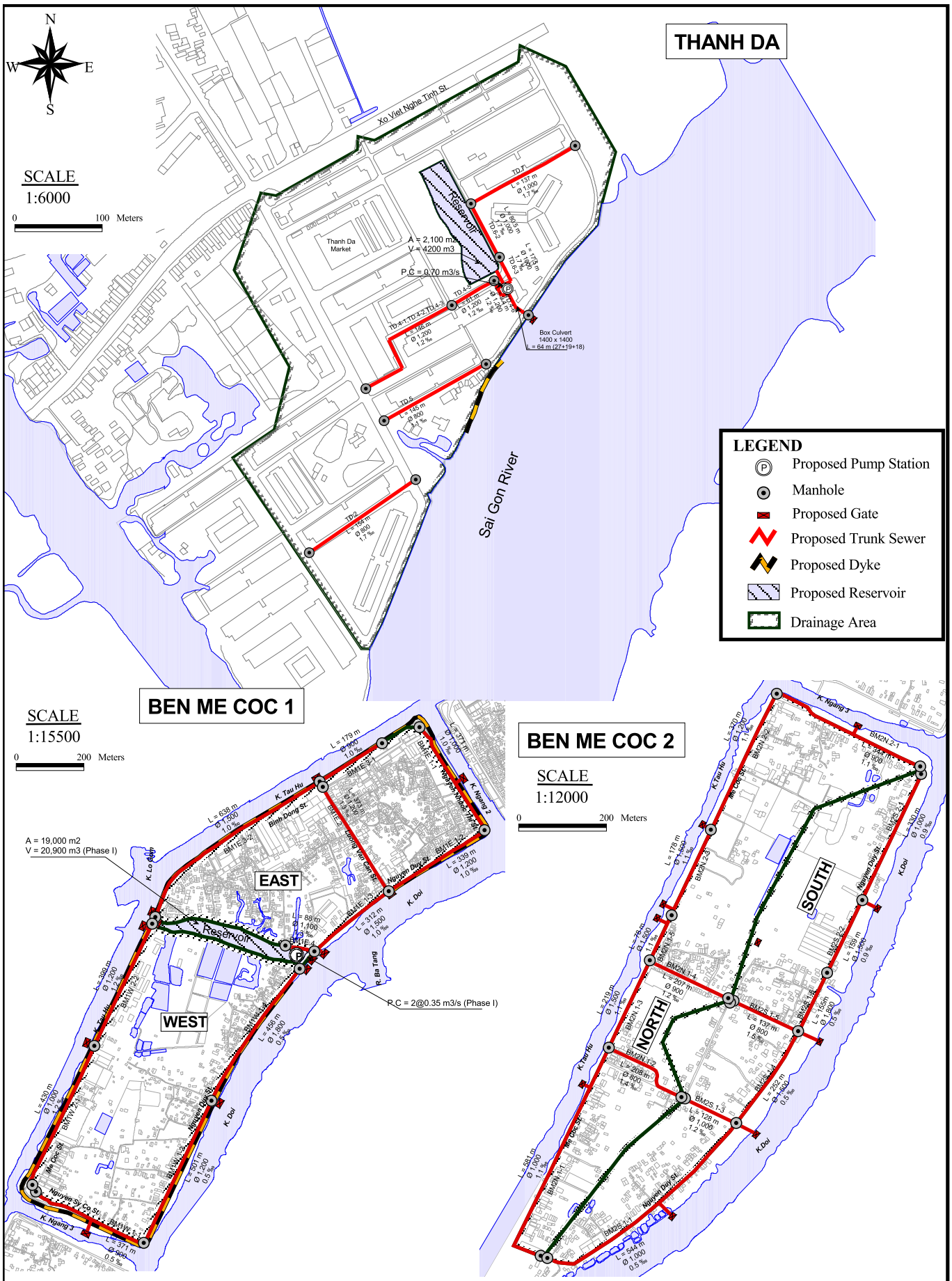


FIG. 8 PUMP DRAINAGE IMPROVEMENT FOR PHASE I PROJECT

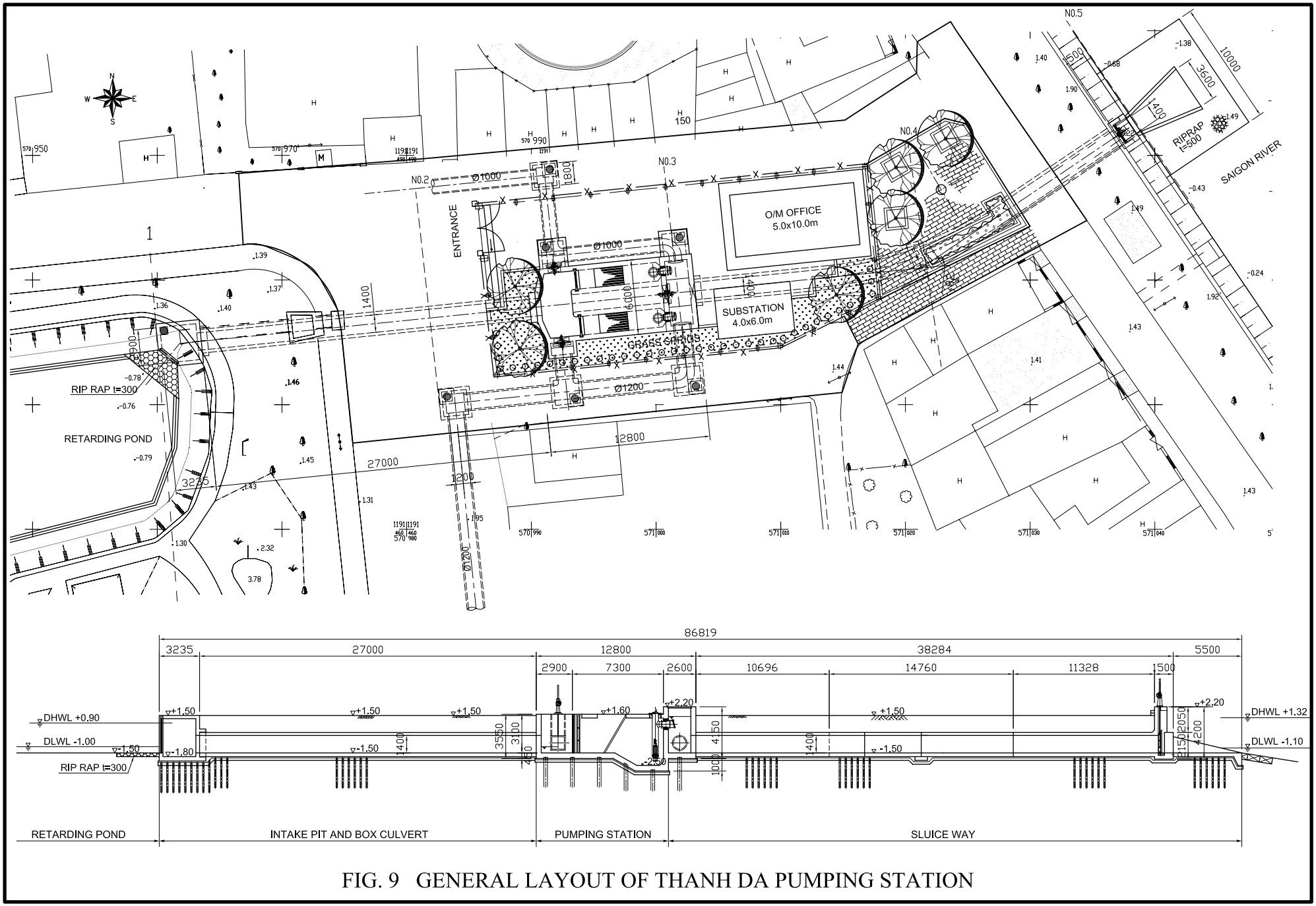


FIG. 9 GENERAL LAYOUT OF THANH DA PUMPING STATION

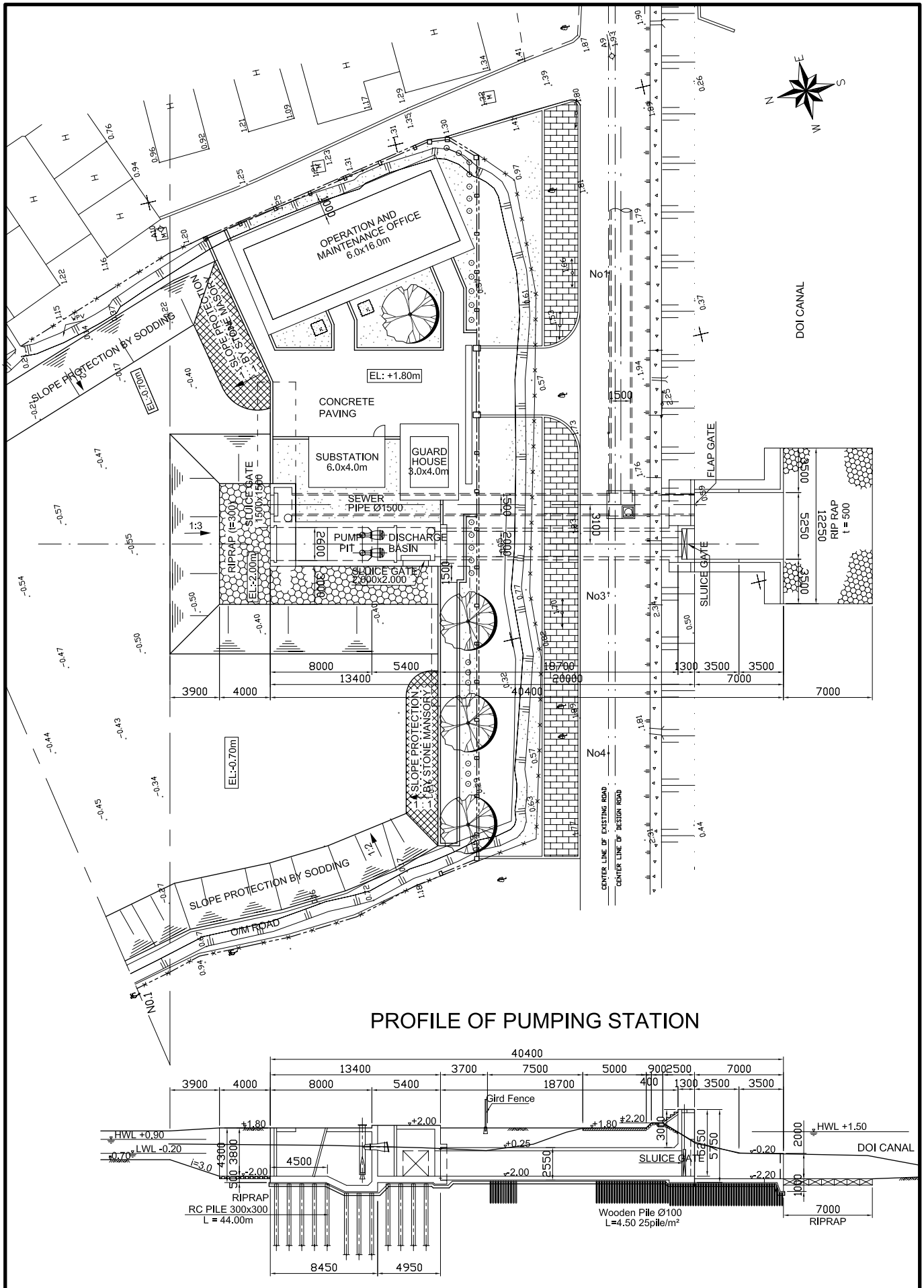


FIG. 10 GENERAL LAYOUT OF BEN ME COC (1) PUMPING STATION

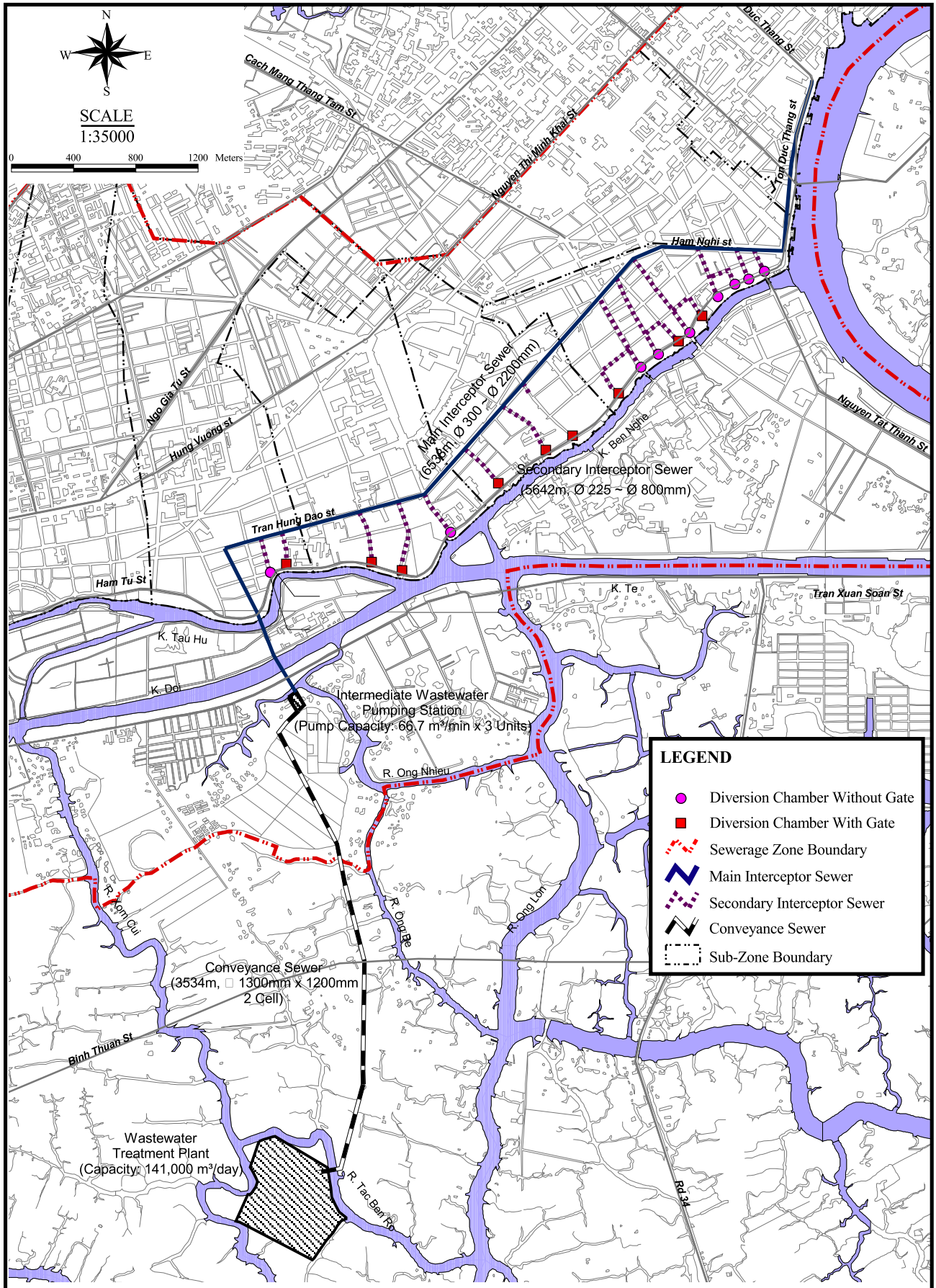


FIG. 11 LAYOUT OF INTERCEPTOR SEWER AND CONVEYANCE SEWER SYSTEM

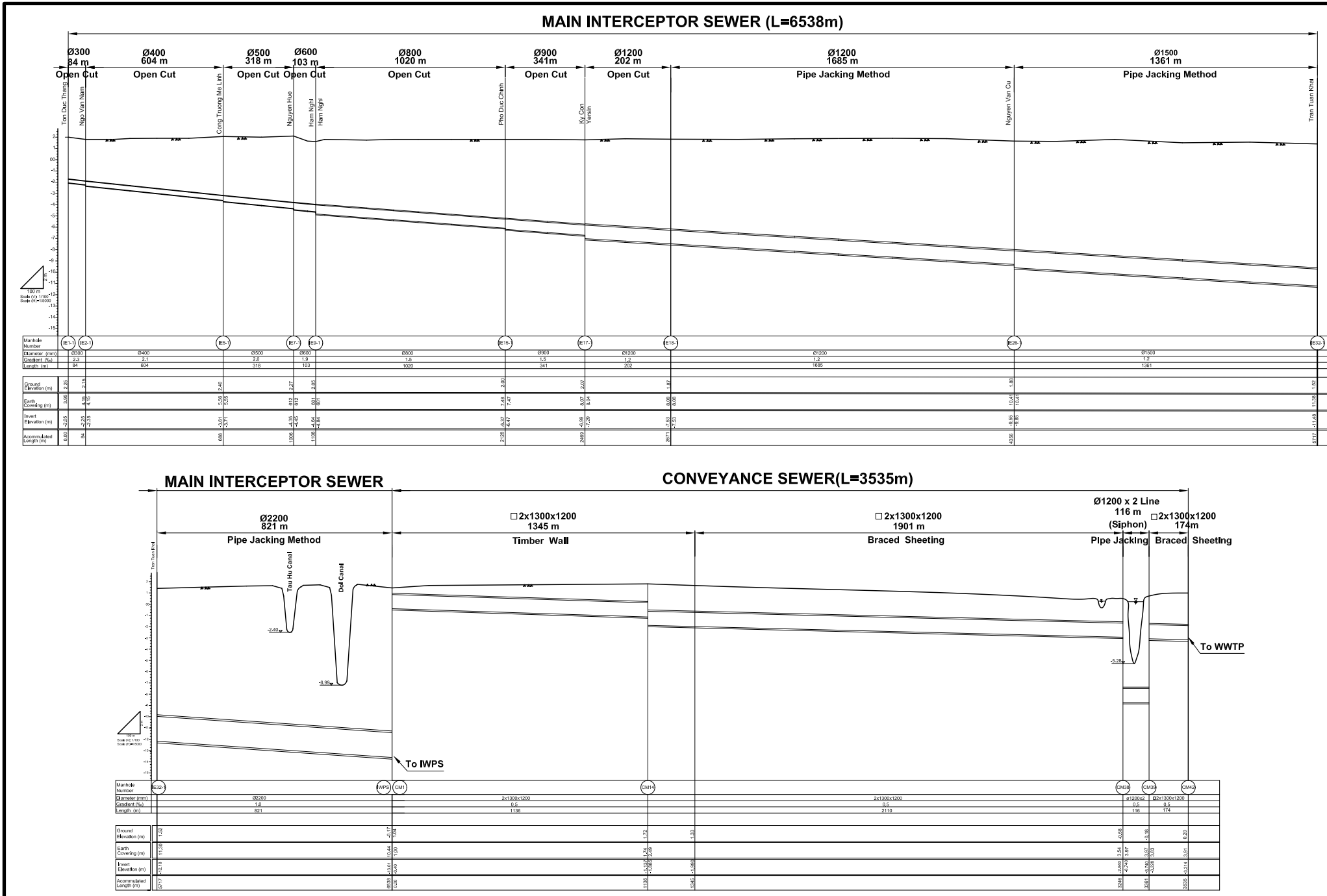


FIG. 12 PROPOSED LONGITUDINAL PROFILE OF MAIN INTERCEPTOR AND CONVEYANCE SEWERS

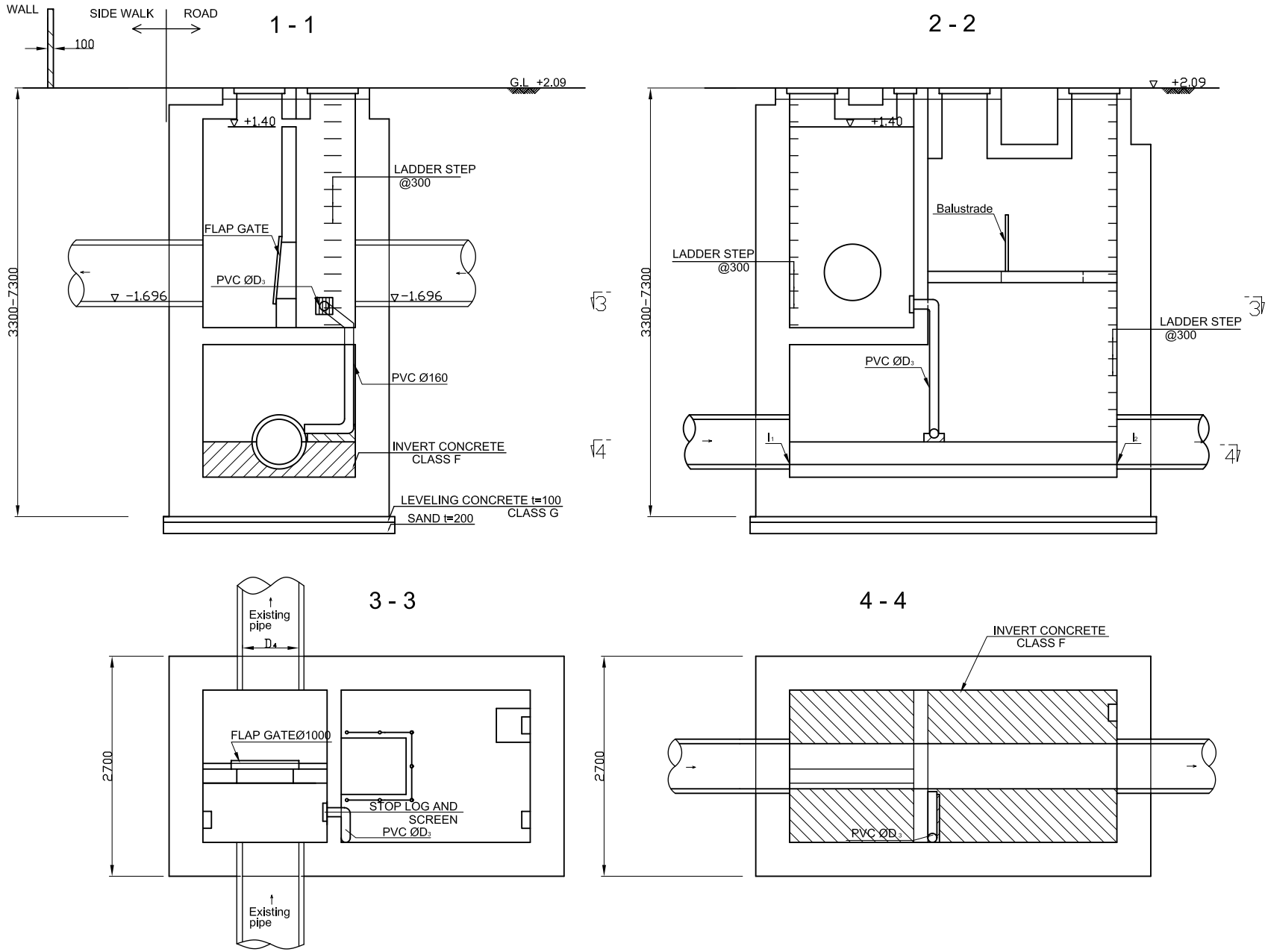


FIG. 13 TYPICAL PLAN AND SECTION OF DIVERSION CHAMBER IN MAIN INTERCEPTOR SEWER

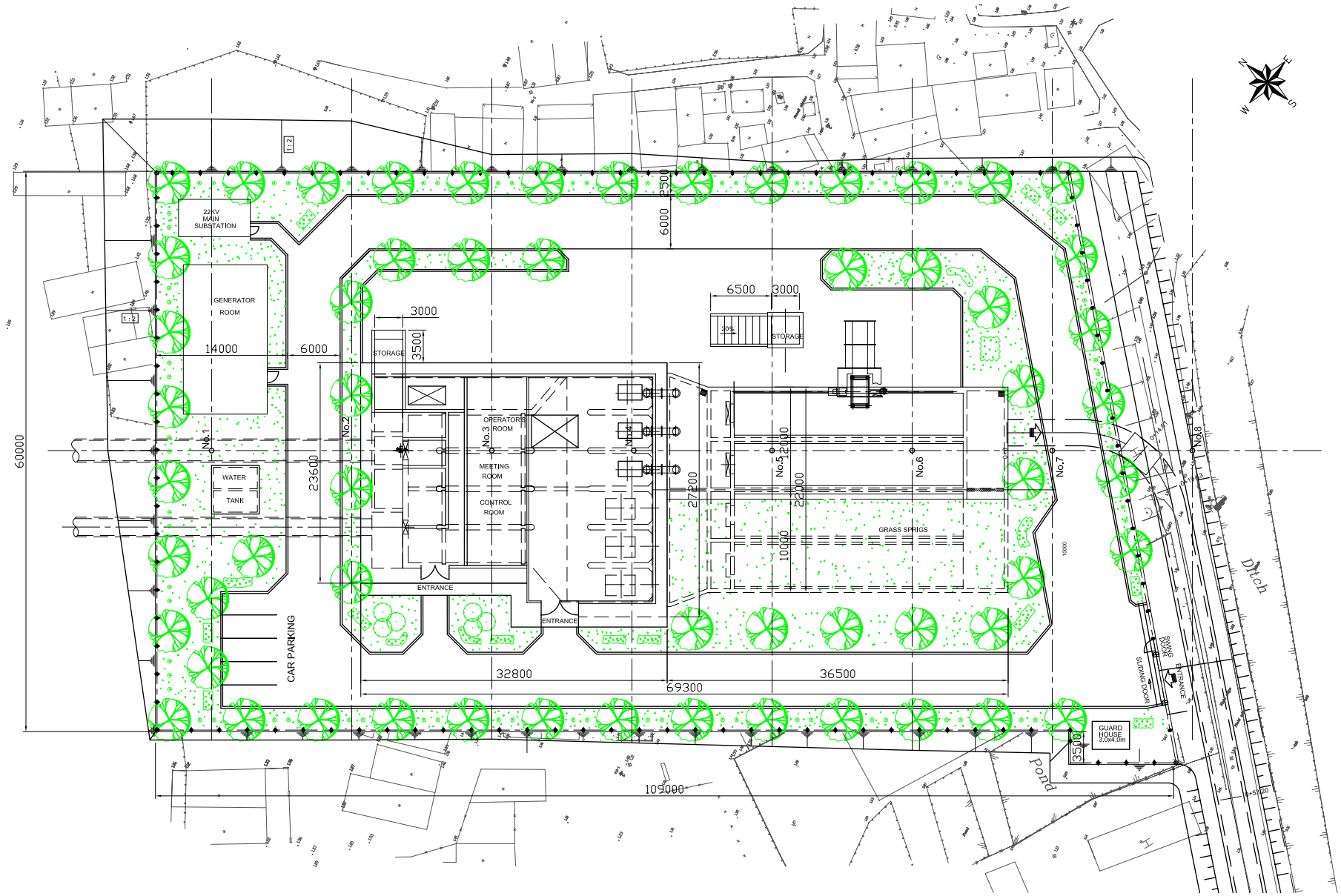


FIG. 14 GENERAL LAYOUT OF INTERMEDIATE WASTEWATER PUMPING STATION

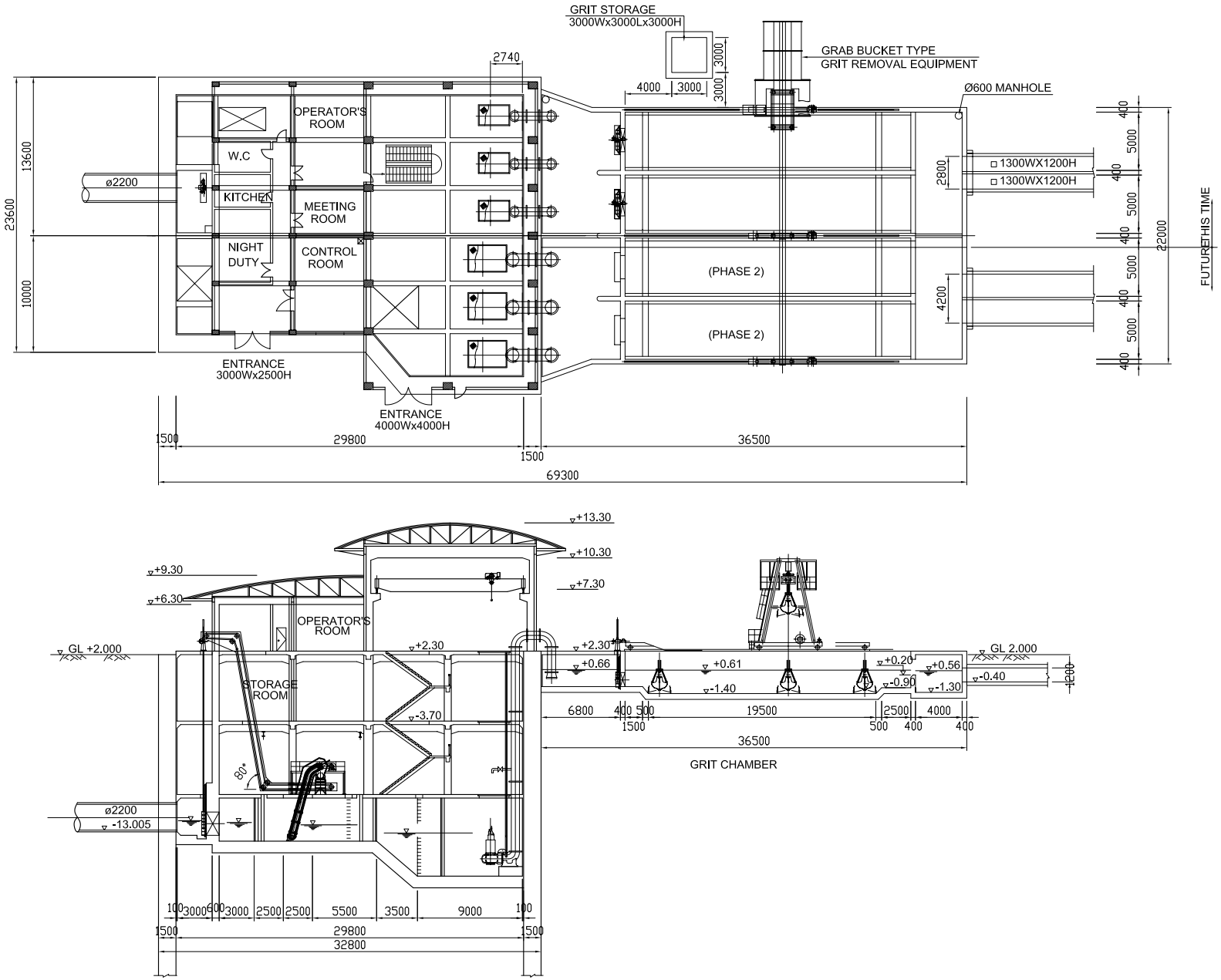


FIG. 15 PLAN AND CROSS SECTION OF INTERMEDIATE WASTEWATER PUMPING STATION

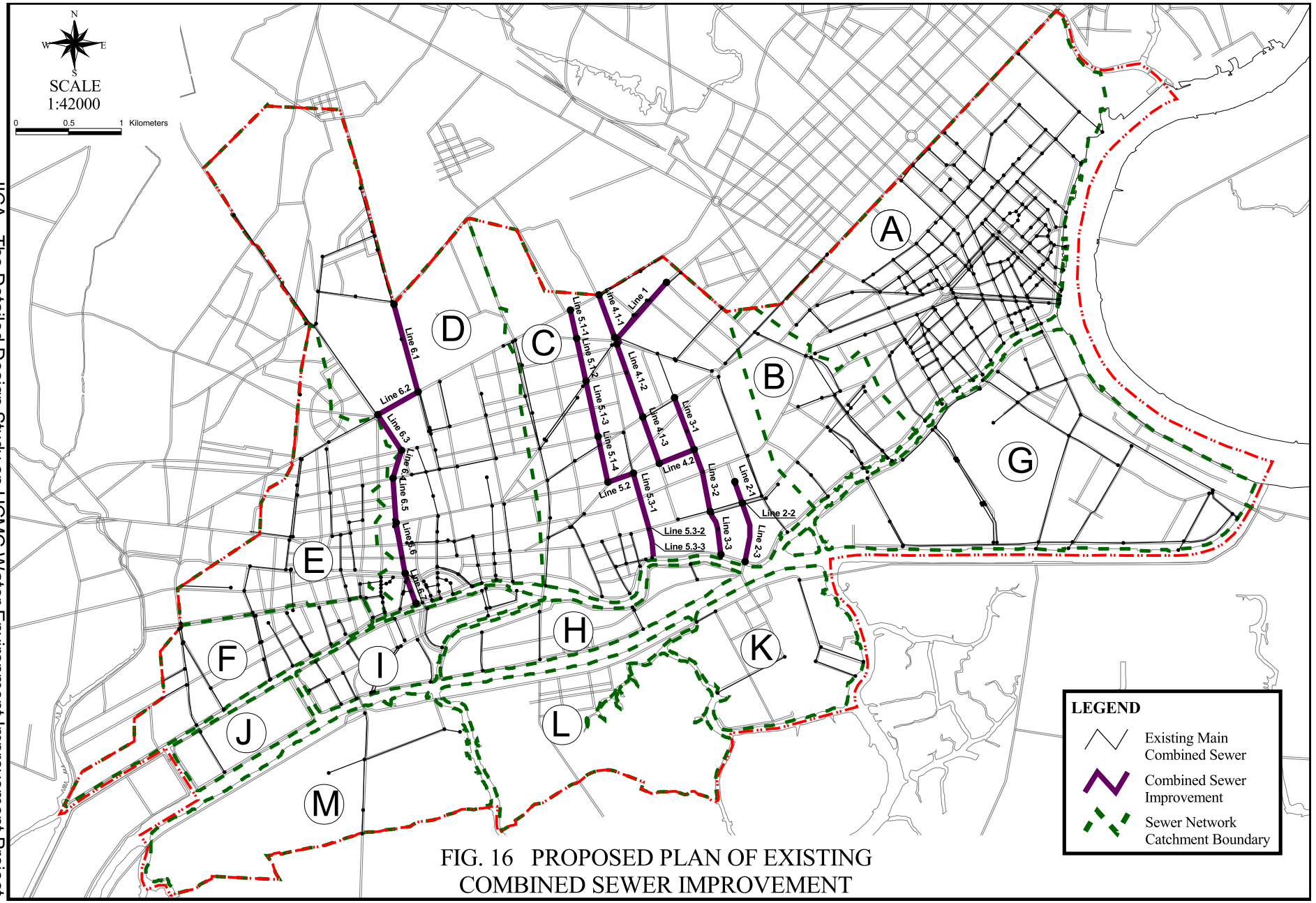


FIG. 16 PROPOSED PLAN OF EXISTING COMBINED SEWER IMPROVEMENT

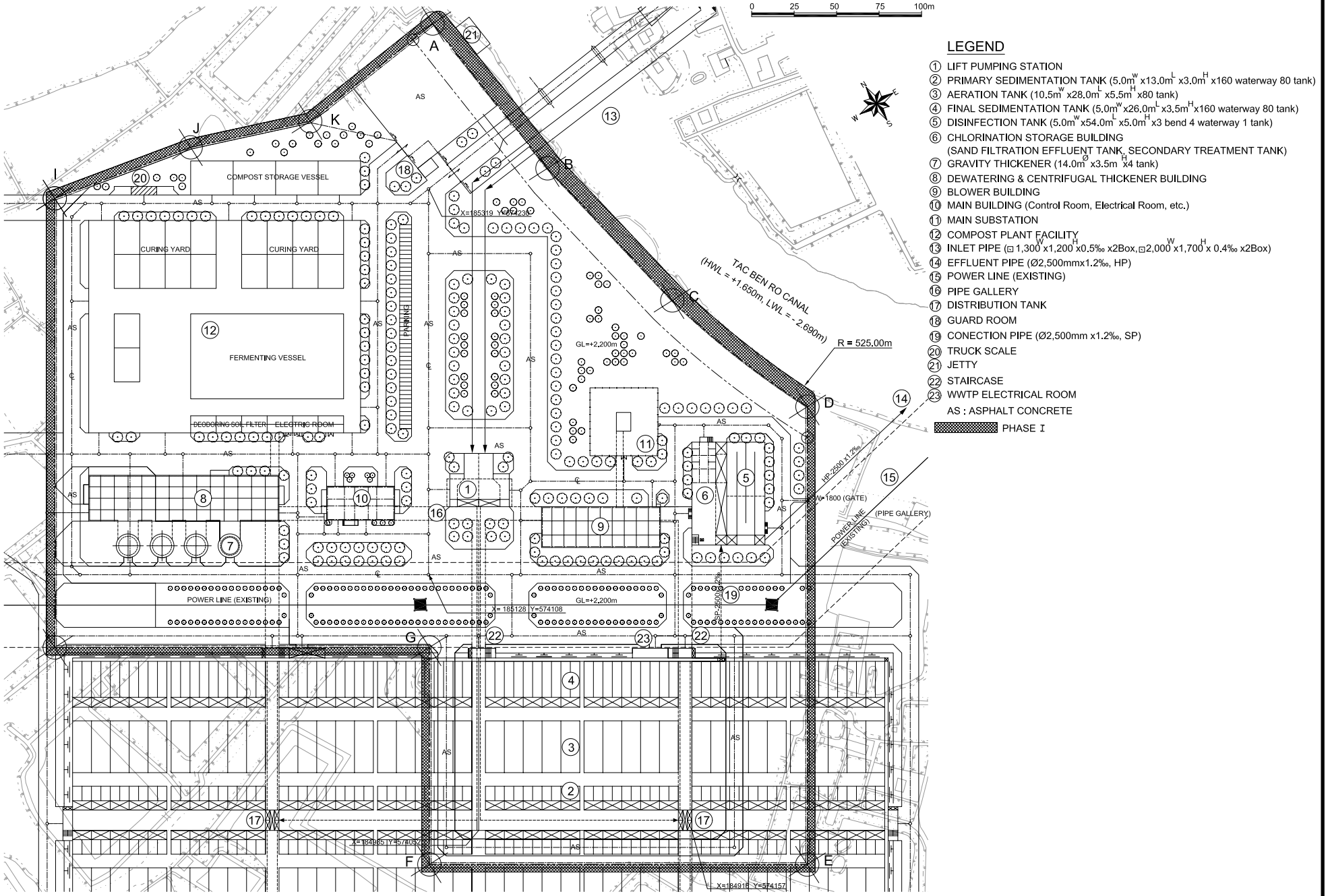


FIG. 17 GENERAL LAYOUT OF THBNDT WASTEWATER TREATMENT PLANT

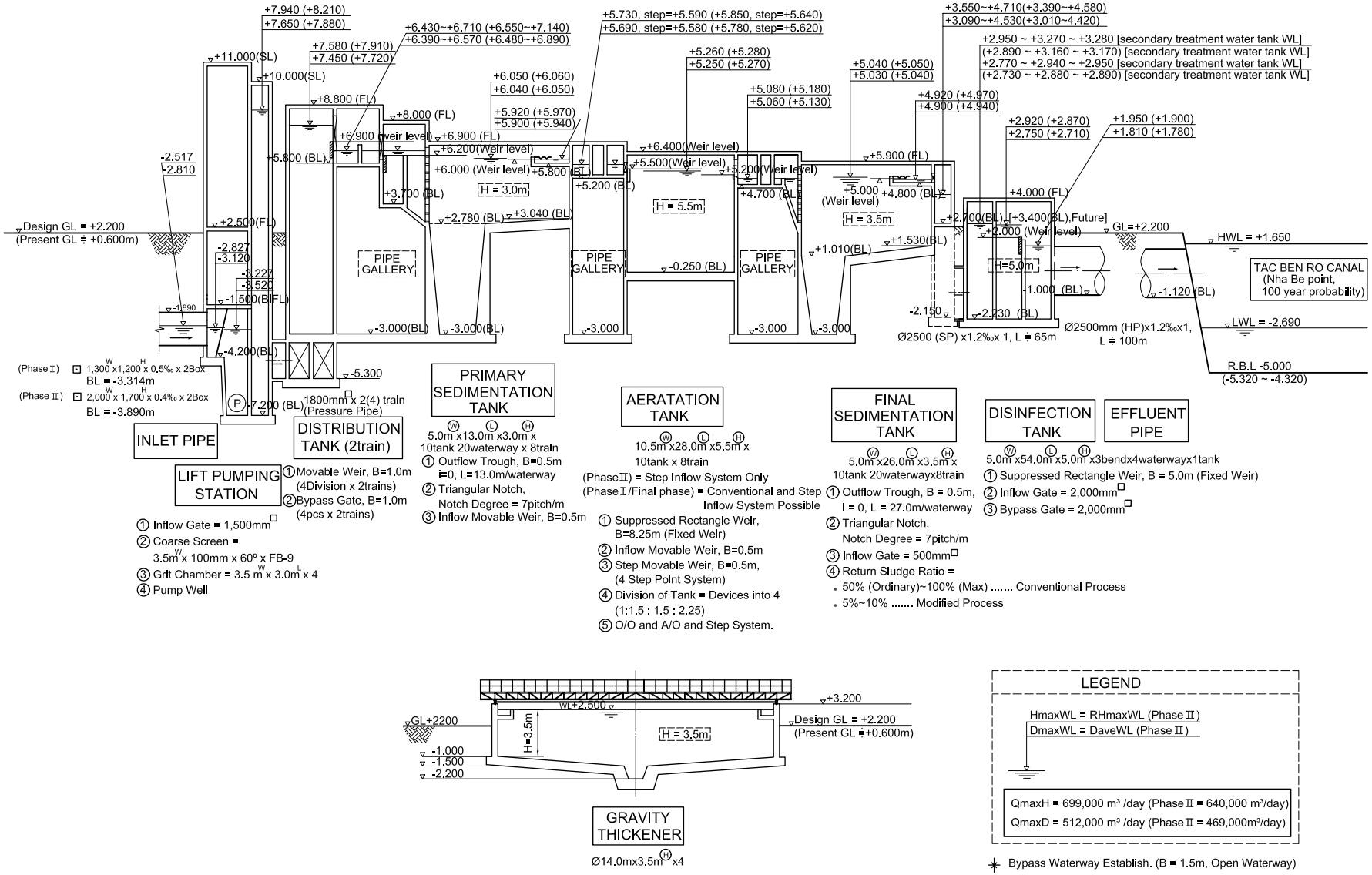


FIG. 18 HYDRAULIC PROFILE OF THBNDT WASTEWATER TREATMENT PLANT

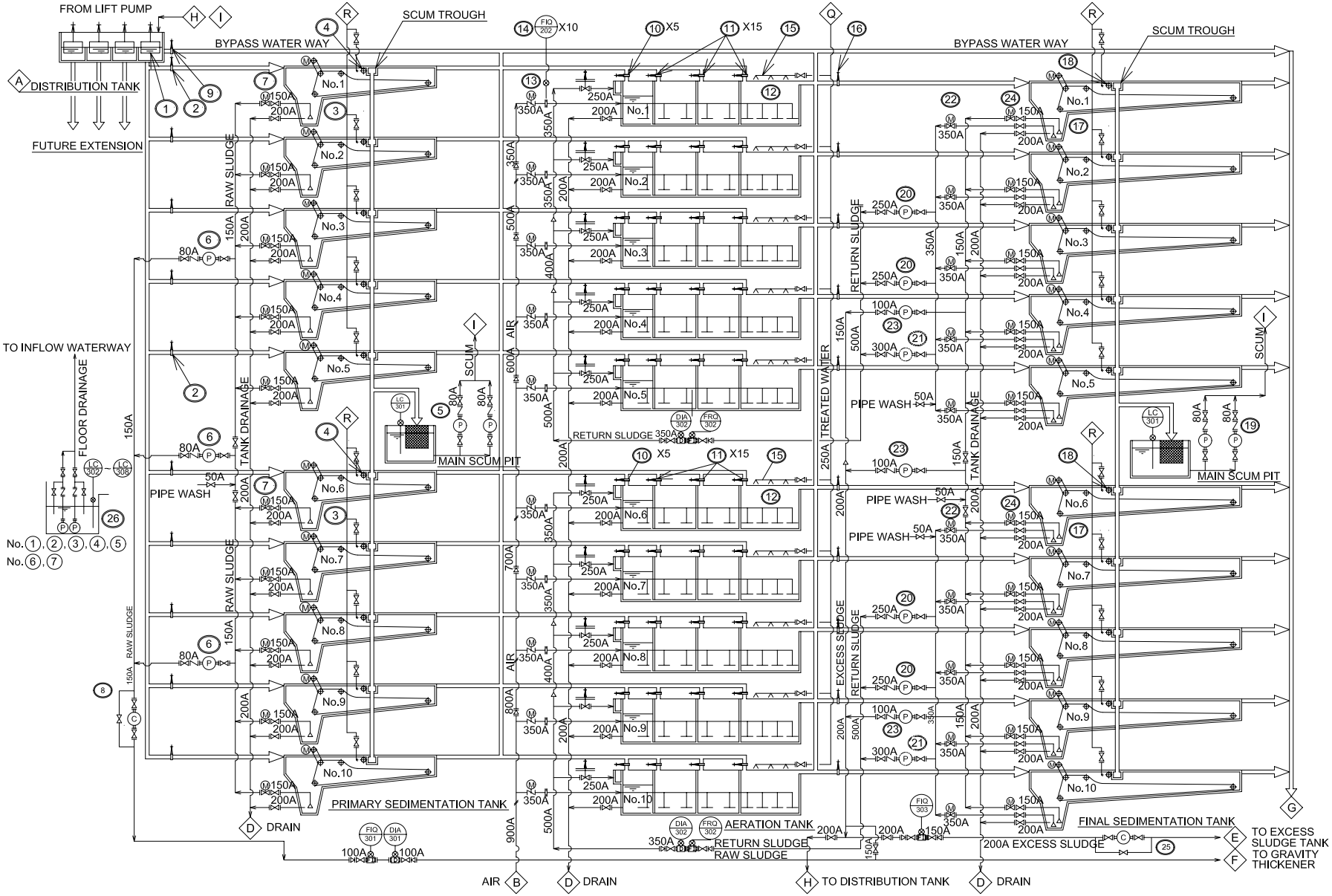


FIG. 19 FLOW SHEET OF WATER TREATMENT FACILITY

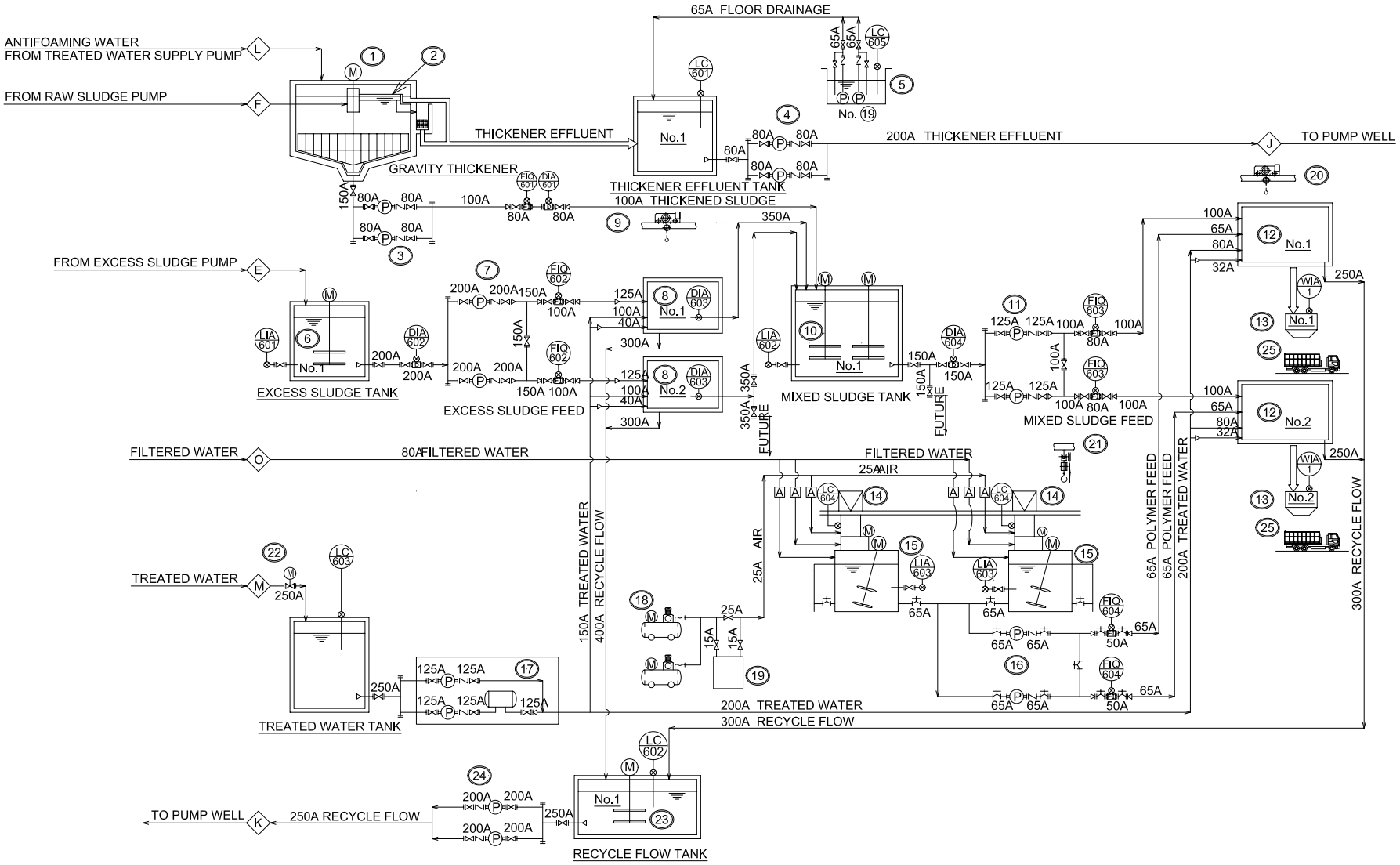


FIG. 20 FLOW SHEET OF SLUDGE TREATMENT FACILITY

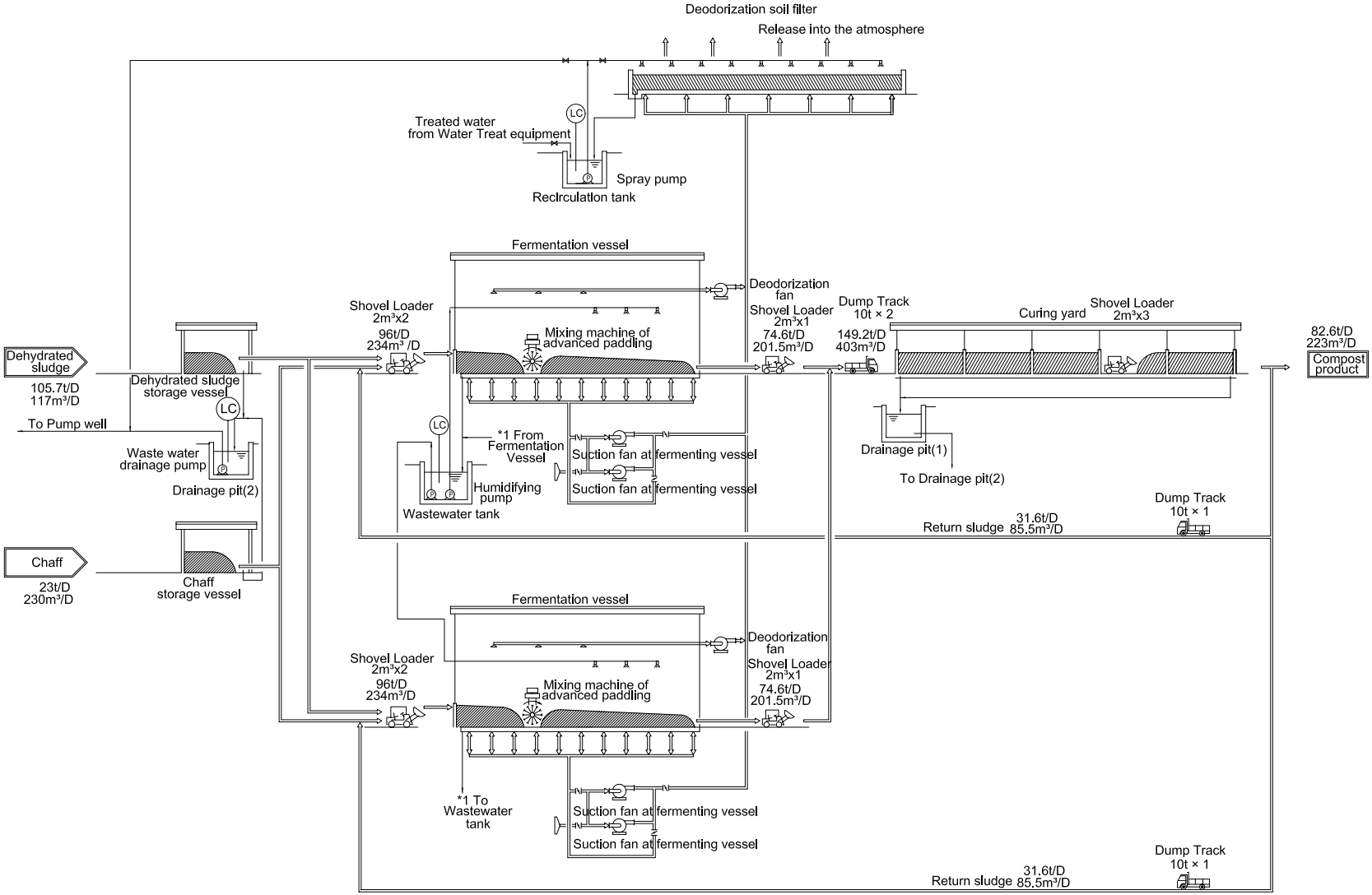


FIG. 21 FLOW SHEET OF COMPOST FACILITY